7-2008

# 11th International Coral Reef Symposium Abstracts

Bernhard Riegl (editor)
*National Coral Reef Institute, Nova Southeastern University Oceanographic Center*, rieglb@nova.edu

Richard E. Dodge (editor)
*Nova Southeastern University Oceanographic Center*, dodge@nova.edu

# ABSTRACTS

11th International Coral Reef Symposium 2008

FORT LAUDERDALE • FLORIDA • USA

# Reefs for the Future

July 7-11, 2008

Fort Lauderdale, Florida

# Contents

# Sponsors

## 11th ICRS Co-Sponsors

## Barrier Reef Sponsors

## Atoll Sponsors

## Fringing Reef Sponsors

# Sponsors (continued)

## Patch Reef Sponsors

The Henry Foundation

United States Coast Guard 1790

DARDEN RESTAURANTS

save our seas FOUNDATION

ICRAN International Coral Reef Action Network

WYLAND FOUNDATION

## Coral Colony Sponsors

AJH Environmental Services

Coral Cay Conservation Expeditions

Current publishing corp. currentpublishingcorp.com

National Geographic

Guy Harvey Research Institute

Florida Oceans and Coastal Council

RSMAS Rosenstiel School of Marine and Atmospheric Science University of Miami

JCRS Japanese Coral Reef Society

JM Family Enterprises, Inc.

PADI padi.com

Project AWARE www.projectaware.org

Southeast Florida Coral Reef Initiative *Acting above to protect what's below.*

United States Environmental Protection Agency

## Polyp Sponsors

Clean Caribbean & Americas

Coastal Planning & Engineering CPE

Creating Legacy *Make A Difference Now That Lasts For Generations* www.CreatingLegacy.com

Fathoms

The Florida Aquarium

Fulbright academy SCIENCE & TECHNOLOGY

GEF Lessons Learned

Legendary Key Largo Chamber of Commerce

OCEANA.ORG Protecting the World's Oceans

REEFBASE

Robert Allen Law INTEGRATING LAW INTO BUSINESS

Science AAAS

REEFBASE PACIFIC

Office DEPOT

The BILLFISH FOUNDATION CONSERVATION THROUGH RESEARCH EDUCATION AND ADVOCACY

Wildlife Conservation Society

WorldFish CENTER

# Mini-Symposium Co-Chairs

**Mini-Symposium 1: Lessons From the Past**
D. Hubbard, W. Ramirez (a); D. Hubbard, E.A. Shinn, W. Ramirez (b); D. Hubbard, L. Greer, C. Sherman (c), G. Stanley

**Mini-Symposium 2: Biotic Response to Ancient Environmental Change in Indo-Pacific Coral Reefs**
J. Pandolfi, K. Johnson, W. Renema, M. Wilson, K. Bromfield, L. McMonagle

**Mini-Symposium 3: Calcification and Coral Reefs - Past and Future**
C. Langdon, J. Kleypas, J. Horst

**Mini-Symposium 4: Coral Reef Organisms as Recorders of Local and Global Environmental Change**
M. McCulloch, P. Swart, B. Rosenheim

**Mini-Symposium 5: Len Muscatine Memorial Mini-Symposium on the Functional Biology of Corals and Coral Symbiosis: Molecular Biology, Cell Biology and Physiology**
S.K. Davy, V.M. Weis, A.A. Venn

**Mini-Symposium 6: Ecological and Evolutionary Genomics of Coral Reef Organisms**
M. Medina, M. A. Coffroth, J. Schwarz

**Mini-Symposium 7: Diseases on Coral Reefs**
K. Kim, D. Harvell, C. Page

**Mini-Symposium 8: Coral Microbial Interactions**
K. Ritchie, A. Kushmaro, J. Ward, M. Teplitski

**Mini-Symposium 9: Chemical Ecology on Coral Reefs**
V.J. Paul, K. Arthur, N. Lindquist, J. Pawlik

**Mini-Symposium 10: Ecological Processes on Today's Reef Ecosystems**
D. Lirman, P. Fong, W. Cooper

**Mini-Symposium 11: From Molecules to Moonbeams: How is Reproductive Timing Regulated in Coral Reef Organisms?**
J.R. Guest, A. Baird, A. Heyward, K. Clifton

**Mini-Symposium 12: Reef Resilience**
C. Birkeland, B.E. Brown, A. Hagan

**Mini-Symposium 13: Evolution and Conservation of Coral Reef Ecosystems**
S. Planes, C. Meyer, G. Bernardi

**Mini-Symposium 14: Reef Connectivity**
P. Barber, H. Galindo, B. Warner

**Mini-Symposium 15: Hydrodynamics of Coral-Reef Systems**
C. J. Hearn, C. D. Storlazzi, F.E. Pagán

**Mini-Symposium 16: Ecosystem Assessment and Monitoring of Coral Reefs – New Technologies and Approaches**
J. Hendee, D. Manzello

**Mini-Symposium 17: Emerging Techniques in Remote Sensing and Geospatial Analysis**
J. Goodman, S. Purkis, S. Phinn, and S. Kinimonth

**Mini-Symposium 18: Reef Status and Trends**
D. Souter, L. Jones, C. Loper, C. Wilkinson

**Mini-Symposium 19: Biogeochemical Cycles in Coral Reef Environments**
B. Casareto, Y. Suzuki, L. Charpy

**Mini-Symposium 20: Modeling Concepts and Processes on Coral Reefs**
D.R. Brumbaugh, C.V. Kappel, K. Broad

**Mini-Symposium 21: Social-ecological Systems**
T. Hughes, M. Nystrom, J. Cinner, S. Foale

**Mini-Symposium 22: Coral Reef Associated Fisheries**
T.R. McClanahan, N.V.C. Polunin, N.A.J. Graham, M.A. MacNeil

**Mini-Symposium 23: Reef Management**
M.E. Hatziolos, M. McField

**Mini-Symposium 24: Reef Restoration**
A. Edwards, B. Rinkevich, A. Moulding, R. Villanueva

**Mini-Symposium 25: Predicting Reef Futures in the Context of Climate Change: Is 500 ppm $CO_2$ and 2°C of Warming the 'Tipping Point' for Coral Reefs?**
O. Hoegh-Guldberg, A. Baker

**Mini-Symposium 26: Biodiversity and Diversification of Reef Organisms**
A. Kerr, G. Paulay, and M. Picho

# Plenary

## Lessons from the Past

Malcolm T. MCCULLOCH
ARC Coral Reef Centre of Excellence, Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200, Australia

Planet Earth is undergoing rapid environmental change at what is probably an unprecedented rate, even on geologic timescales of tens of millions of years. Coral reefs are at the forefront of these changes being extremely sensitive to the threats from both climate change and direct local human impacts on the marine environment. Locally, land-use changes in river catchments, wetlands, and estuaries, together with growing urbanisation of coastal zones, is leading to increased supplies of sediment and nutrients to inshore coral reefs. Degradation of water quality is also invariably accompanied by pressures from activities, such as trawling and overfishing. Further exacerbating the plight of coral reefs are the ever increasing effects from rapidly growing levels of anthropogenic CO2 emissions. This is not only causing global warming and the related impacts from coral bleaching, but is also directly changing the chemistry of the world's surface oceans by increasing the acidity, hence reducing the carbonate-ion concentration, upon which coral calcification is dependent. Sea levels are also rising at faster than predicted rates, although the effects on coral reefs are still relatively benign compared to those expected from catastrophic melting of the Greenland/West Antarctic ice sheets once critical CO2 thresholds are exceeded.
In addition to serving as immediate indicators of environmental change, corals also provide invaluable long-term information. Within the skeleton of long-lived massive corals, oxygen isotope and Sr/Ca, U/Ca ratios respond to changes in hydrologic and ocean temperature regimes. Increased sediment runoff and changes in water quality can be deduced from Ba, Mn, and rare earth element abundances. More recently it has been shown that boron isotopic variations preserved in coral carbonate skeletons mimic pH changes that control the distribution of carbonate/bicarbonate ions in seawater. Given that systematic measurements of seawater pH have only commenced during the past decade, coral-based pH records are essential to establishing the long-term response of coral calcification to increasing ocean acidity. Such records, however, also have some limitations since they are biologically mediated, hence coral calcification does not reflect a linear, passive response to external forcing. Furthermore, micro-scale variability within various skeletal components can mask larger-scale environmentally-driven signals. Despite these limitations, coral proxies are invaluable as in many cases they provide the only record of the natural 'baseline' and variability, against which the critical thresholds for irreversible human-induced environmental changes can be gauged. Such quantitative, scientifically-based data provides much needed guidelines to both reduce local human impacts on coral reef systems, and ensure their resilience to the poorly understood effects of global climate change.

## Coral Reef Fisheries: Three Thematic Challenges

Daniel PAULY
Sea Around Us Project, Fisheries Centre, University of British Columbia, Vancouver, Canada

This presentation is divided into three parts, each dealing with different sets of scientific challenges: (a) the identification of three types of coral reef fisheries, and the specific management regime each requires; (b) the estimation of global catches from reef fisheries, and (c) the potential impact of global warming on these catches.
Regarding (a), I see three types of major fisheries on reefs: (i) recreational fisheries in Florida, Australia and similar high-income areas; (ii) small-scale fisheries, such as traditional reef fishers and the fish suppliers of tourist resorts and the life-fish exporters, as well as a often competing and rapidly growing 'Malthusian' small-scale fisheries component, providing occupation of last resort to thousands of new entrants, often displaced coastal dwellers, e.g., in Southeast Asia or the larger Caribbean islands, and (iii) traditional reef fisheries, i.e., fisheries which are still managed under traditional-based rules in the South Pacific.
The question of how much fish is caught in coral reef fisheries is based on the assumption that, in the 21st century, it should be unnecessary to consult archives and unpublished or grey literature to derive time series of the world's coral reef catch, i.e., it should be part of global databases such as those maintained by the FAO. However, this is not the case, because coral reef fisheries are small-scale, and the FAO database covers mainly industrial fisheries. A series of authors have published independent estimates of the world catch from coral reef fisheries, but no consensus has emerged. An approach is presented here which documents an estimate, based on the assumed 'reefyness' assumed for various species in the catch reported to FAO by countries with coral reefs. The results, even less likely to generate a consensus, illustrate the need for country-specific catch reconstructions. An example is provided here, but these are discussed in more details in the presentations by Dirk Zeller and Jennifer Jacquet, who complement their catch reconstruction with fisheries-independent data, e.g., household food consumption data.
The third topic of this presentation is the future of coral reef fisheries, presently impacted by various stresses likely to increase in the next decades, such as increased turbidity and coastal development, and particularly global change-associated phenomena, illustrated here by quantifying the poleward shifts in the distribution range of reef-associated fish caused by warming at low latitudes, and their impact on the coral reef catches of 10 equatorial countries. This specific threat appears relatively small compared with the direct effect of warming (i.e., coral bleaching) and acidification, but it adds to what may be described, for coral reef systems, as 'death by a thousand cuts'.

## Photophysiology, Bleaching and Adaptation

Roberto IGLESIAS-PRIETO
Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Apartado Postal 1152, Cancún 77500 QR Mexico

During the last 200 million years scleractinian corals in symbioses with photosynthetic dinoflagellates have been responsible for the formation and maintenance of coral reefs. In these organisms, algal photosynthesis can provide more that a 100% of the basal metabolic requirements. The nutritional advantages that symbiotic invertebrates obtain from the translocation and consumption of algal photosynthates can explain why symbiotic corals possess significantly larger calcification rates relative to non-symbiotic invertebrates. In this context, algal photosynthesis is a key element in the formation of modern coral reefs. Considering the importance of algal photosynthesis for the well being of symbiotic corals, the study of the photobiology of these organisms has attracted significant attention. Symbiotic corals inhabit the entire photic zone and are subject to extraordinary variations in light intensity. I will review the characteristics of the photosynthetic apparatus of dinoflagellates and the physiological mechanisms employed by corals and their symbiotic algae to successfully harvest and utilize the available solar radiation. Based on comparative analyses of the differential responses of individual algal species to variations in growth irradiance in culture, or intact associations in nature, it has been postulated that the differential utilization of solar radiation is an important axis for niche diversification among reef-building corals. Recent analyses of the optical properties of intact coral surfaces using transmittance determinations indicate that due to the multiple scattering of solar radiation on the highly reflective aragonite skeleton, the specific absorption coefficients of the symbiotic algae are much higher that those obtained from freshly isolated algae, making symbiotic scleractinians one of the most efficient solar collector in nature. This efficiency results in significant competitive advantages, as symbiotic corals can collect the same amount of solar radiation as a green plant with approximately one order of magnitude less photosynthetic pigments concentrations. The role of the animal skeleton in modulating the absorption properties of the symbiotic algae has also profound implications for our understanding of the evolution of these organisms. Finally, I will discuss the role of multiple scattering of coral skeletons in the propagation of thermal stress, leading to coral bleaching and mortality.

## Population Connectivity Within and Among Reef Systems: Progress and Promising Directions

Robert COWEN
Marine Biology and Fisheries, University of Miami, RSMAS, Miami, FL

The study of population connectivity has evolved over the last decade to include a broad array of approaches to assess the scales and mechanisms over which successful larval dispersal operates among reef systems. Strong interest in this topic has been stimulated by a need to provide spatial management options to resource managers, often for resources that are in dire states. The major challenges in this effort are to provide a quantitative understanding of the processes and scales controlling successful larval dispersal and how connectivity influences the dynamics of the affected populations. Resolving the mechanisms controlling larval dispersal will involve a coherent understanding of the relevant physical processes and how organisms mediate the physical outcome. Multiple scales will be important, and therefore understanding how the processes are coupled across scales is essential. By the very nature of reef organisms initiating and ending their larval life within nearshore waters, new focus must be extended on the bio-physical processes operating within this environment. Identifying patterns will need to involve efforts that focus on a variety of species with different life histories across various environments. In concert, the problem is multidisciplinary, but one requiring interdisciplinary research effort. This talk will evaluate our progress to date, implications of mounting environmental challenges and suggest some promising new directions.

**Drivers of Coral Infectious Disease**

Drew HARVELL
Cornell University, Ithaca, NY

The rate of new infectious syndromes and disease outbreaks of gorgonian and scleractinian corals continues to increase. Evidence is developing that both global climate and local factors are contributing to this increase. The Coral Disease Working Group of the CRTR is investigating how these factors act synergistically to facilitate disease outbreaks, and developing tools and strategies for mitigating and managing disease impact. The focus of the Harvell laboratory is on understanding coral immunity to infectious agents, and most recently cellular and protein responses of Gorgonian sea fans to fungal infections. Our working hypothesis is that, in some cases, coral mortality during thermal anomalies is exacerbated by opportunistic pathogens whose virulence is enhanced by increased temperatures while host resistance is reduced. Required for testing this hypothesis is a tool for assessing coral immunity. Particularly promising is an assay measuring the temperature induced response of amoebocytes and production of prophenoloxidase in the Caribbean sea fan corals. Another important goal for the entire community is the development of practical management approaches for marine infectious diseases. This will require both the application of approaches developed to manage disease on land and new strategies that recognize the special biology of the coral holobiont.

# Oral Session

## 1-1

**The R/v Alpha Helix Symbios Expedition: A Retrospective Analysis Of A Milestone in Coral Reef Research**

**Christopher F. D'ELIA***[1], Abbie Rae HARRIS*2

[1]Environmental Science and Policy, University of South Florida St. Petersburg, Saint Petersburg, FL, [2]College of Marine Science, University of South Florida, Saint Petersburg, FL

In the spring of 1971, a team of more than 20 marine scientists arrived at Enewetak Atoll in the Marshall Islands to conduct the most comprehensive study of a coral reef yet undertaken: the Symbios Expedition, using the R/V Alpha Helix for logistical support. While many coral reef researchers are aware that this team-oriented research program made significant contributions to the understanding of coral reef metabolism and function, neither a history of the Expedition has been done nor a formal assessment has been made on its impact on the field. This is not surprising, because scientists rarely concern themselves with documenting the history of the science they conduct or assessing the results of their research programs vis a vis the funding provided. Thus, we are typically left with only vague notions as to the scientific impact that a given project had and the factors that contributed. Clearly, science builds upon prior knowledge, and researchers recognize contributions to this knowledge by literature citations in their publications. Recently, citation analysis tools have become available to assess publication impact quantitatively. Using one such tool, Citespace II, together with quantitative and qualitative information gathered from historical reference materials and extensive interviews, we provide here a retrospective assessment of the Symbios Expedition that demonstrates its scientific impact and suggests some of the reasons for its success.

## 1-2

**Caribbean Coral Reef Communities in the 1970's: An Ecosystem Baseline Data Set for Assessing Current Regional Reef Health**

**Randolph BURKE*[1]**, Walter ADEY[2]

[1]Botany, Smithsonian Institution, Mandan, ND, [2]Botany, Smithsonian Institution NHB, Washington D.C., DC

Currently a great debate ensues among scientists about how well developed Caribbean reef communities were before the "crash" and exactly what changes occurred. Since the late 1980's, Caribbean coral reefs have been repeatedly struck by hurricanes, diseases, high temperatures, over fishing, and locally, recreational and pollution disturbance. For these reasons most scientists consider these reefs to be currently in a state of collapse, but none have a Caribbean wide, historical data base on which to base their beliefs.

A regional database, circum-Caribbean and Bahamas, consisting of still photographs (3350 frames, 60 mm and 35 mm; underwater and low altitude aerial) were taken over a two-week period in 1976. SCUBA diver measured transects of coral reef community data were taken concurrently during rest and refueling stops. Additionally, approximately 12 km of 16 mm motion picture film and 1650 still photographs (60 mm and 35mm; underwater and aerial) were taken between 1972 and 1987. This material was collected to support work on regional coral reef structure and ecosystem dynamics that resulted in numerous publications, but much of this supporting data has not been published. Current concerns about Caribbean coral reef health provided an opportunity to revisit this data.

The capability of accurately relocating individual reefs was demonstrated by digitally overlaying 1976 digitized photos on exactly the same reef location captured in USGS Orthoimages and Landsat 7 images using Google Earth. More than 80% of the aerial photographs can be accurately relocated within a meter or less using Landsat imagery. The large format (60 mm) allows for size resolution of objects 0.5m and less. This provides historical data on the regional distribution of *Acropora palmata*, currently on the endangered species list. This data set is uniquely valuable for evaluating changes of shallow-water, Caribbean wide coral reef communities in the last three decades.

## 1-3

**Estimating Live Coral Cover in Fossil Reefs: A Microboring Approach**

**Halard LESCINSKY*[1]**, Benjamin TITUS[1], Avinash MINHAS[1], Dennis HUBBARD[2]

[1]Department of Life and Earth Sciences, Otterbein College, Westerville, OH, [2]Department of Geology, Oberlin College, Oberlin, OH

The recent widespread decrease in Caribbean live coral cover points out the need for a valid ecological baseline for understanding modern reefs. Here we show that live coral cover, comparable to that measured in modern reefs, can be estimated in fossil reefs using microboring abundance and taphograde analysis. Subaerially exposed reefs may contain well-preserved corals that are topped by beds indicative of rapid burial. Since microborers infest coral skeleton within weeks of exposure, microboring analysis provides an objective way to identify corals with little post-mortem exposure and thus buried horizons of these corals can be censused to determine live coral cover in fossil reefs. We applied this technique to the Holocene (5-9,000 ybp) Enriquillo Valley reef in western Dominican Republic. A mud-rich event bed, characterized by *Madracis auretenra*, is found draping over corals for 125m within the massive coral zone at Cañada Honda. Field-estimated taphograde correlated with microboring intensity. The best preserved corals (grade 1) had little or no microboring suggesting immediate burial, grade 2 corals had surficial boring ($\leq$50$\mu$) suggesting minimal (days to weeks) post-mortem exposure, while grade 3-6 corals had more extensive borings and post-mortem exposure. We conclude that live coral cover in the massive zone averaged between 51% (grade 1) and 81% (grades 1 and 2) and was consistent along the transect, despite changes in coral composition and inferred depth over the 125m length. Live coral cover (grades 1 and 2) estimated elsewhere in the reef in the absence of event beds yielded lower, but still high, values: mixed zone 56%, massive zone 65%, platy zone 67%. An exact modern equivalent to these reefs is unavailable, but our results suggest much higher live coral cover in the recent geologic past of the Dominican Republic than is found today in most of the Caribbean.

## 1-4

**Historical Changes in Coral Communities Along A Gradient Of Land Use in Bocas Del Toro, Panama**

**Katie CRAMER*[1]**

[1]Marine Biology, Scripps Institution of Oceanography, UCSD, La Jolla, CA

The recent and historically unprecedented shift in the dominant hermatypic coral species on many Caribbean reefs has broadly been attributed to human disturbances such as overfishing, climate change, and/or land development. This study explored the relationship between changes on reefs and patterns of human alteration of nearby terrestrial habitats by comparing current and past coral community structure over the last few centuries at sites in western Panamá spanning a distance of 50 km. Modern living coral assemblages were surveyed by standard line transects, whereas historical communities were analyzed from dead coral rubble encountered along transect lines on the reef surface and by excavation of 0.25m x 0.25m quadrats to 0.25m depth. Radiocarbon dating and amino acid racemization were used to date coral rubble to determine the timing of community changes between neighboring terrestrial and reef habitats and among different reef sites. Patterns of community change were more complex than previous results reported from analyses of 3-inch cores from some of the same reefs. *Acropora cervicornis* and massive faviids were common to abundant in rubble assemblages from several reefs but absent from others just 1-10km apart, suggesting great variability in community structure among sites before the beginning of intense human disturbance. In general, relative abundance of branching growth forms (*A. cervicornis* and *Porites* species) declined, while that of massive (*Montastrea* and *Colpophyllia* species) and platy (*Agaricia* species) growth forms increased. The extent of community change was highly variable among reef sites, suggesting the importance of local disturbances on reef communities. Areas nearer to sources of land runoff have changed more dramatically than those further from these disturbances, highlighting the important role of land use activities in the observed recent demise of Caribbean coral reef ecosystems.

## 1-5

**The Effects Of Geology, Oceanography And Anthropogenic Activities On The Coral Reef Ecosystems Of The Pacific Remote Island Areas**

**Joyce MILLER*[1,2]**, Jamison GOVE[1,2]

[1]NOAA PIFSC Coral Reef Ecosystem Division, Honolulu, HI, [2]Joint Institute for Marine and Atmospheric Research -- Research Corp. Univ. of Hawaii, Honolulu

A wealth of geologic, oceanographic, and biological data collected since 2000 provides a unique opportunity to understand the coral reef ecosystems of the Pacific Remote Island Areas (PRIA). These data were collected by the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service (FWS) during biennial cruises to seven PRIA: Howland, Baker, and Jarvis Islands, Kingman Reef, and Palmyra, Johnston and Wake Atolls. Detailed bathymetric maps show seven tiny, isolated peaks on anomalously shallow seafloor ranging in age from 120 to 83 Ma, but the four islands that have been dated were all formed about 70 Ma. Small submerged terraces from previous sea level stands can also be detected, providing insight into how sea level change may affect the PRIA in the future. From an oceanographic perspective, these islands and atolls are located in three distinct current regimes, providing an understanding of how current patterns affect the distribution and types of organisms found at each location. Oceanographic data also provide baseline information for understanding the effects of climate change, storms, and bleaching events. Although most of the islands are FWS National Wildlife Refuges and are currently uninhabited, anthropogenic effects from previous guano mining, military and construction activities, fishing, and shipwrecks also have recognizable impacts. Combining this information with biological data on the corals, algae, fish, and macroinvertebrates of the PRIA shows complex interactions that all influence the health of what are thought to be some of the least disturbed coral reef ecosystems in the world.

## 1-6

**Long-Term Records Of Reef Growth Under Terrigenoclastic Sediment Influence: Paluma Shoals, Central Great Barrier Reef, Australia**

**Suzanne E PALMER*[1]**, Chris T PERRY[2], Scott G SMITHERS[3]

[1]Environmental & Geographical Sciences, Manchester Metorpolitan University, Manchester, United Kingdom, [2]Environmental & Geographical Sciences, Manchester Metropolitan University, Manchester, United Kingdom, [3]Earth and Environmental Sciences, James Cook University, Townsville, Australia

Nearshore, turbid-zone reefs on the Great Barrier Reef (GBR) grow on the terrigenoclastic inner shelf and represent important analogues for understanding early-mid Holocene reef initiation on the GBR. They are recognised as ecologically and geologically significant, but knowledge of their development remains limited. The growth history of Paluma Shoals (Halifax Bay, north of Townsville) has been studied in detail to improve our understanding of inshore reef development. Paluma Shoals comprises two areas of active reef development. The reef structure displays distinct phases of reef initiation, reef accretion and reef 'turn-off', and the depositional sequence suggests 1) evidence for long-term reef accretion in association with terrigenoclastic sediment accumulation, and 2) phases of reef initiation, growth and burial influenced by nearshore sediment dynamics.

Reef growth began ~1200 cal years BP over coarse-grained, terrigenoclastic-dominated subtidal sands and/or Pleistocene clays. The reef sequence is up to 2.0-2.5m thick, comprising an unconsolidated framework of coral rubble within a terrigenoclastic-carbonate matrix. *In situ* massive corals (*Goniopora stokesi*, *Favites halicora*) within basal units are interpreted as shallow pioneer coral communities (the 'reef initiation' phase), now enveloped in mainly terrigenoclastic silts. Later reef growth was dominated by framework builders *Acropora pulchra, Turbinaria frondens* and *Montipora mollis*, infilled with fine- to medium-grained sands. Reef growth has been characterised by vertical accretion and then seaward progradation, followed by accumulation landward. Since ~250 years BP reef growth of the South Shoal exhibits little variation in framework builders and is characterised by well-established intertidal coral communities and carbonate-rich sands. In contrast, the Northern Shoal exhibits an increase of terrigenous sands, interpreted as a 'turn-off' phase in reef development driven by natural shoreline dynamics.

## 1-7

**Persistent Organic Pollutants And Trace Metals Associated With African Dust – Is There A Threat To Coral Reefs?**

**Virginia GARRISON*[1]**, Susan GENUALDI[2], William FOREMAN[3], Michael MAJEWSKI[4], Azad MOHAMMED[5], Staci SIMONICH[2]

[1]US Geological Survey, St. Petersburg, FL, [2]Oregon State University, Corvallis, OR, [3]US Geological Survey, Denver, CO, [4]US Geological Survey, Sacramento, CA, [5]University of the West Indies, St. Augustine, Trinidad and Tobago

Increasing quantities of African dust transit the Atlantic and impact the Caribbean and Americas. As part of an investigation into the effects of African dust on coral reef organisms and human health, we analyzed African dust for contaminants and compared levels of persistent organic pollutants (POPs) and metals between the source and downwind regions. Air samples from Africa (Mali) were found to contain a greater variety and a higher concentration of pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) than downwind sites in the Caribbean (Trinidad and the U.S. Virgin Islands). To date, nine pesticides, 17 PAHs, and nine PCB congeners have been identified in air samples from the African Sahara/Sahel (Mali) and the Caribbean. One pesticide and four PAHs were detected only in samples from Africa. Of the more than 100 priority pollutant and common-use pesticides screened for in the samples, five pesticides (chlorpyrifos, dacthal, endosulfan I, hexachlorobenzene, and components of chlordane) were detected in samples from all sites. DDE (a breakdown product of DDT) was identified in Mali, USVI, and Trinidad samples. To date, DDT and chlorinated dioxins and furans have been detected only in samples from Mali. Eight and five PCB congeners were detected in Mali and Caribbean samples, respectively; of those, four congeners were detected in samples from both regions. Similarly, greater numbers of PAHs were detected in Mali than at downwind sites. Trace-metal concentrations in both regions were similar to crustal composition with slight enrichment of lead in Mali. Many of the identified POPs and metals are toxic to corals and other marine organisms and can interfere with reproduction, fertilization, and/or immune function. POP and metal contaminants commonly occur as mixtures that are likely to exhibit synergistic effects. Contaminant concentrations are sufficiently high to be of concern – for both marine organisms and humans.

## 1-8

**Bioturbation, Taphonomic Bias And Time-Averaging in Tropical Molluscan Death Assemblages: Differential Shell Half-Lives in Great Barrier Reef Sediment**

**Matthew A. KOSNIK*[1]**, Quan HUA[2,3], Darrell S. KAUFMAN[4], Raphael A. WÜST[5]

[1]Department of Paleobiology, Smithsonian Institution, Washington, DC, [2]Australian Nuclear Science and Technology Organization, Menai, NSW, Australia, [3]Australian Nuclear Science and Technology Organization, Menai, Australia, [4]Department of Geology, Northern Arizona University, Flagstaff, AZ, [5]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia

Radiocarbon-calibrated amino acid racemization ages of 481 individually dated shells representing four molluscan taxa are used to quantify time-averaging and shell half-lives with increasing burial depth in the shallow-water carbonate lagoon of Rib reef, central Great Barrier Reef, Australia. The top 20 cm of sediment contain a distinct, essentially modern assemblage. Shells recovered at depths form 25 to 125 cm range in age from modern to 4,000 yrs old. They are age-homogeneous and significantly older than the surface layer. Taxon age distributions within layers indicate that the top 125 cm of lagoonal sediment is thoroughly mixed on a sub-century scale. The age distributions and shell half-lives of four taxa: *Ethalia*, *Natica*, *Tellina* and *Turbo* are found to be largely distinct. Shell half-lives do not coincide with any single morphological characteristic thought to infer greater durability, but they are related to a combined taphonomic score. These results illustrate the importance of bioturbation in tropical sedimentary environments, indicate that age estimates in this depositional setting are sensitive to specimen choice, and quantify a taxon-dependent bias in shell longevity and death assemblage formation.

## 1-9

**Coral Community Change Over A Cyclone Disturbance Gradient During The Quaternary in The Solomon Islands**

**Brian BECK*[1]**, Sean CONNOLLY[2], John PANDOLFI[1]

[1]ARC Centre of Excellence for Coral Reef Studies, University of Queensland, Brisbane, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook Univeristy, Townsville, Australia

Cyclones have a demonstrable impact on the short-term (<100 years) dynamics of coral communities, but we do not yet have a clear picture of the effects that such disturbances have on coral community dynamics over longer time scales (>100,000 years). It has been proposed that higher sea surface temperatures associated with projected changes in global climate might generate higher intensity storms with greater frequencies than in the recent past, and that these changes might adversely affect coral reefs. During the Pleistocene of the South Pacific, sea surface temperatures were higher than current temperatures. In this study, we investigated the effects of cyclones on coral communities over long time scales in the Solomon Islands. The Solomons have extensive raised reefs from the Pleistocene to the recent, and there has been a marked spatial gradient in cyclone frequency during this period; these characteristics allow an in depth look at how long-term community change is influenced by cyclone frequency. Taxonomic composition and diversity of coral communities were surveyed at several sites across a cyclone gradient, incorporating multiple levels of cyclone frequency and multiple stratigraphic ages, using a hierarchical sampling design. Coral diversity and growth form was examined over varying cyclone frequencies from the warm Pleistocene seas to the comparatively cooler seas of the Holocene. We found differences in the coral communities across cyclone gradients attributable to varying cyclone frequencies. These differences not only illustrate variation in community structure across a cyclone gradient within the same stratigraphic age, but also show how communities in similar cyclone frequency change with sea surface temperature change over time. These results are relevant in understanding how coral communities can change as sea surface temperatures and cyclone intensity varies.

## 1-10

**Reef slope failure in the northeastern corner of Male`, Maldives**

**Mahmood RIYAZ*[1]**, Kyung-Ho PARK[1]

[1]School of Engineering Technology, Asian Institute of Technology, Pathum Thani, Thailand

This study deals with the investigation of the reef slope failure occurred in the northeastern corner of Male`, Maldives on the 6th of February 2002. Malé is the capital of the Maldives with an area of 1.5m2 and a population of 130,000. Failed slope area was mapped and systematically investigated. Radiocarbon dates of rock samples from various depths were obtained. Aerial photograph and satellite image of Male reef 1969-2007 were compared to observe changes in the reef edge . The investigation shows that the reef-flat, cap-rock, consists of 2~3m thick slightly cemented coral rock and rubble, and beneath the cap-rock lays a 4~6m thick weakly cemented, highly erodible mixture of coral sand and coral rubble. Further down 10~30m deep the slope of 30o steep is built up by loose gravel and sand. The failure movement might have occurred during one single event and the rock mass was sliding 'en-block' which finally disintegrated into individual blocks in the block field. Radiocarbon dating of rock samples shows that the oldest is 8200 years at 20m depth, while the youngest is 6510 years at top reef, which indicates that with the rapid vertical reef growth the horizontal progression of reef played a more vital role in reef formation than the vertical growth. Aerial photographs and satellite images show four more reef failure areas on the northern side and concentrated in the areas of heavy weight and continuous vibration generation works. Due to the reef failure, the capping rock layer was removed and subsequently the weakly cemented highly erodible layer is exposed to further erosion. The eroded parts are expected to fall into atoll lagoon and cause further retreat of the reef edge. Proper remedial actions must be suggested for the overall stability and ground bearing capacity of the island.

## 1-11

**A 1500 Year Holocene Caribbean Climate Archive From The Blue Hole, Lighthouse Reef, Belize**

**Eberhard GISCHLER*[1]**, Eugene SHINN[2], Wolfgang OSCHMANN[1], Jens FIEBIG[1], Noreen BUSTER[3]

[1]Geosciences/Geography, Johann Wolfgang Goethe University, Frankfurt am Main, Germany, [2]College of Marine Science, University of South Florida, St. Petersburg, FL, [3]Florida Integrated Science Center, ETI Professionals Inc., St. Petersburg, FL

Aspects of historical climate change are becoming increasingly important in reef research. Common reefal climate archives include skeletons of corals and shells of mollusks among others. Pleistocene sinkholes in reefal limestone also have great potential as archives of climate data because they may act as sediment traps. Sediment cores (up to 6 m in length) from the bottom of the Blue Hole, a 125 m deep Pleistocene sinkhole located in the Lighthouse Reef Atoll, Belize, consist of undisturbed, annually layered biogenic carbonate muds and silts with intercalated coarser grained storm beds. Sedimentation-rate is 2.5 mm/yr on average, and the cores span the past 1500 yrs. Oxygen isotopes provide a late Holocene climate proxy: a high-resolution $\delta^{18}O$ time series traces the Medieval Warm Period, the Little Ice Age, and the subsequent temperature rise. Carbon isotopes ($\delta^{13}C$) decrease upcore and show the impacts of the decline of the Maya culture and the Suess Effect. Time series analyses of $\delta^{18}O$ and $\delta^{13}C$ reveal 88, 60, 52, and 32 year cyclicities, and suggest solar forcing. Storm event beds are most common during AD 650-850, AD 1000, AD 1200-1300, and AD 1450-1550. Major storm beds are rare during the past 500 years BP.

Holocene thickness in the Blue Hole is estimated to >20 m of annually layered sediment, given the average sedimentation rate of 2.5 mm/yr and the early Holocene marine inundation of the Lighthouse Reef lagoon. Because the Blue Hole probably formed not only during the previous but during several Pleistocene sea-level lowstands, we expect that similar, laminated sediments of previous Pleistocene highstands are present below the Holocene package. We plan to investigate this late Quaternary climate archive in a future larger scale core study.

## 1-12

**Environmental Factors Controlling Community Structure, Morphology And Linear Extension Of Mid-Holocene Reef Corals From Cañada Honda, Southwestern, Dominican Republic**

**David CUEVAS*[1]**, Clark SHERMAN[1], Wilson RAMIREZ[2], Dennis HUBBARD[3]

[1]Marine Sciences, University of Puerto Rico at Mayaguez, Lajas, Puerto Rico, [2]Geology, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico, [3]Geology, Oberlin College, Oberlin, OH

The Mid-Holocene Cañada Honda (CH) fossil reef, located in southwestern Dominican Republic, provides a unique opportunity to examine a well-preserved fossil coral reef that thrived in a high-sedimentation environment between 9.0 to 5.0 ky ago. Growth rates of fossil Montastraea faveolata and Siderastrea siderea were determined in order to make comparisons with growth rate data of these same species from modern coral reefs. Also, assessments of coral species abundance and distribution, morphology, age, as well as reef sediment composition were completed in order to determine the paleoenvironment of reef accretion.

The CH reef is characterized by the high abundance of sediment-tolerant coral species and their tendency to form almost monospecific stands. Individual colonies have a propensity to grow as encrusting, dome-shaped, platy-like forms and colonies of Montastraea faveolata commonly contain bands of sediment incorporated within their skeletons. Calibrated radiocarbon ages of fossil corals range from 9,256±137 to 6,737±94.5 BP. Correlation of radiocarbon ages with well-established Holocene sea-level curves indicates that most corals on this reef developed at depths greater than 15m. Growth rates in CH varied from 0.09-0.44 cm/yr and are relatively low compared with growth rates from modern reef sites, suggesting reduced light penetration caused by either coral growth at great depths and/or under conditions of high turbidity. Reef sediment is characterized by more than 85% carbonate material. A significant portion of the carbonate is allochtonous and was derived from nearby Neogene limestones.

Our investigations indicate that the CH reef persisted for at least 3,000 years under conditions of high sedimentation. The reef was able to survive under these conditions because of the high carbonate content of incoming terrigenous sediment that would have allowed better light penetration and that storms probably occurred sporadically providing intervening low-sedimentation periods during which reef corals could respond and grow back, "keeping-up" with sedimentation.

## 1-13

**Unusual Serpulid/Tufa Bioherms Cap Corals of a Mid-Holocene Fringing Reef, Dominican Republic: Paleoenvironmental and Climatic Controls**

**H. Allen CURRAN*[1]**, Kelsey WINSOR[1], Lisa GREER[2], Bosiljka GLUMAC[1]

[1]Geology, Smith College, Northampton, MA, [2]Geology, Washington & Lee University, Lexington, VA

Meter-scale mid-Holocene serpulid/tufa bioherms in the form of mounds and terraces cap corals of the exposed fringing reef bordering much of the Enriquillo Valley, Dominican Republic. Composition of these unusual bioherms resembles that of two other localities described in the literature: Miocene mounds of the Paratethys Basin of Ukraine/Poland and Late Triassic deposits in the western Tethys of Italy. Rarity of such bioherms and their similarities indicate that their formation was the result of convergence of specific environmental conditions. In each case, restricted waters of less-than-normal marine salinity reduced ecological competition and favored opportunistic serpulid aggregation, as well as concentrated calcium carbonate for tufa precipitation. In the Enriquillo Valley, limited hard substrate, wave action, calcium carbonate-rich spring waters entering at the surface of ancient Lago Enriquillo, and periods of lake-level stability also contributed to bioherm formation. These contributing factors were a result of larger-scale climatic conditions characteristic of the mid-Holocene Caribbean, as well as local geological constraints. Around 5 ka, slowed sea-level rise, increased precipitation and resultant fluvial sedimentation owing to northward migration of the Intertropical Convergence Zone (ITCZ), and possible regional tectonic uplift restricted the mouth of the ancient Enriquillo seaway. This caused the demise of the Enriquillo fringing coral reef, and later the dead coral colonies commonly served as substrate for development of serpulid/tufa bioherms. Repeated changes in Lago Enriquillo water level and salinity created conditions that supported not only bioherm formation, but also diverse molluscan and ostracode faunas found within many bioherms. In late Holocene time, drier conditions prevailed as the ITCZ moved southward and water levels of Lago Enriquillo receded, exposing this spectacular fringing reef-serpulid/tufa mound and terrace complex.

## 1-14

**Is Acropora Cervicornis A Canary in The Global Warming Coal Mine? Lessons From The Mid-Holocene Dominican Republic**

**Lisa GREER*[1]**, Julia JACKSON[2], H. Allen CURRAN[3], Tom GUILDERSON[4], William P. PATTERSON[5], Lida TENEVA[6], Elizabeth RHEA[7], Jenny SHULTIS[8]

[1]Geology, Washington and Lee University, Lexington, VA, [2]University of Texas-Austin, Austin, TX, [3]Smith College, Northampton, MA, [4]Lawrence Livermore National Laboratory, Livermore, CA, [5]University of Saskatchewan, Saskatoon, SK, Canada, [6]Lamont-Doherty Earth Observatory, Palisades, NY, [7]Washington and Lee University, Lexington, VA, [8]RCHS, Lexington, VA

The recent, well-documented decline of *Acropora cervicornis* throughout the wider Caribbean region has been cause for considerable alarm, with the decline interpreted as a warning of greater coral reef devastation in the future. Elevated sea-surface temperatures, white band disease, anthropogenic stress, and storm activity have all been cited as potential causes for the decline. In order to understand the optimal conditions and threshold environmental range for *A. cervicornis* growth, an extensive mid-Holocene fringing reef located in the Dominican Republic was examined for evidence of paleoenvironmental variability during *A. cervicornis* dominance over a >3000 year period. Over 50 radiocarbon and 234U/230Th dates from an 11 m vertical exposure of *A. cervicornis* indicate continual accumulation between ~9.5 to ~7.3 ka with only minor reversals (mixing events). The species continued to thrive at the site until at least ~5.8 ka. This time range was marked by increasing regional sea-surface temperature to a mid-Holocene thermal maximum (HTM), a time comparable to, if not warmer than, present. δ13C and δ18O data from the fossil *A. cervicornis* specimens indicate high-magnitude changes in precipitation during reef formation with no resulting break in coral accumulation. Taphonomy and morphology data suggest the species thrived under high sediment stress, variable bioerosion, and differential exposure to wave activity. High-resolution δ13C and δ18O data from modern *A. cervicornis* growing at comparable depths off Barbados (2007 collections) show stable isotope 'signatures' most similar to corals that grew at the height of the HTM. *A. cervicornis* from the Dominican Holocene can be characterized as a relatively hardy survivor during highly variable environmental conditions. The data and inferences derived from this study indicate that the cause for recent *A. cervicornis* decline is not strictly due to rising sea surface temperature.

## 1-15

**The Emperor Has No Coral—An Inconvenient Truth?**

**Eugene SHINN*[1]**, Barbara LIDZ[2]

[1]College of Marine Science, University of South Florida, St. Petersburg, FL, [2]U. S. Geological Survey, St. Petersburg, FL

The Emperor Has No Coral—An Inconvenient Truth?

High-resolution subbottom profiling, reef drilling, and mapping of benthic habitats along the Florida Keys reef track demonstrate that moribund non-accreting coral reefs outnumber live accreting reefs about 100 to 1, based on reef-tract area. Sub-circular patch reefs restricted mainly to turbid nearshore areas in the lower Keys compose the majority of living/accreting reefs. Linear offshore shelf-edge areas are not accreting, and Holocene coral accumulation during the past 6 ka is generally less than 2 m thick. The thickest accretions consist mainly of coral spurs rooted directly on a Pleistocene unconformity at the platform margin. Less than 2% of Florida reefs have kept pace with the rise in Holocene sea level and are generally located shoreward of the platform margin. Such coral growth, or lack thereof, presents a paradox. Growth rates of all common coral reef species, especially the rapidly growing acroporids, should have kept pace with the well-documented rise in sea level over the past 6 ka. Why did so few reefs keep pace or accrete to present sea level? That Holocene coral growth has experienced setbacks before has been confirmed by 14C ages of fossil Acropora cervicornis fragments that are so common in backreef sands. Carbon-14 data reveal two 500-year periods of non-growth centered on 4.5 ka and 3 ka. The present period of rapid coral demise has spanned only about 30 years. Thus, past periods of non-growth indicate times of environmental crises that predated modern human invasion of the Florida Keys. These observations challenge the highly popular notion that the present declines in Florida, and elsewhere, are anthropogenic in origin.

## 1-16

**New Ideas About Caribbean Coral-Reef Development: A View From Ye Shoulders Of Giants**

**Dennis HUBBARD*[1]**

[1]Geology, Oberlin College, Oberlin, OH

Three cores from Lang Bank described at the 1977 ISRS Meeting set the direction of the coral-reef discussion for the next three decades. A perceived lag in reef initiation led to ideas about "inimical bank waters" and their control on reef building. High accretion rates reported for many Caribbean sites led us to ask why reefs capable of outpacing even the most rapid sea-level rise could be left behind. A possible gap in accretion on Lang Bank at 8,000 CalBP raised interesting possibilities. Dirty water flowing off the newly flooded bank or a sudden jump in sea level provided solutions to Schlager's "paradox". Combined with assurances that reef accretion should mirror coral growth, we developed our prevailing models. More recent studies suggest that some of the foundational ideas upon which these paradigms are built may warrant reexamination. Closer analyses of Caribbean cores reveal little variation in accretion rates down the forereef. New Lang Bank cores show that *A. palmata* reefs not only continued to build, but thrived across the "reef gap" that was attributed to "inimical bottom waters" in Miami and later to a jump in sea level. This was verified at other Caribbean/Atlantic sites. Reef building can be generally characterized as transgressive between 11,000 and 7,000 CalBP due to a steady but rapid sea-level rise, and regressive thereafter, as it slowed below ca. 4m/ky. Superimposed on this pattern are two enigmatic lapses in *Acropora,* starting at ca. 6,000 and 3,000 CalBP, well after sea level rise had slowed relative to reef accretion. Paradoxically, these events created gaps in the Caribbean *Acropora* assemblage that were not associated with earlier, documented SL jumps. The presentations at the 1977 Miami meeting were a watershed for valuable thought, and the return to Fort Lauderdale provides a fitting opportunity to take the next step.

## 1-17

**Holocene Reef Development At The Flower Garden Banks: Recent Surprises**

**William PRECHT*[1]**, Ken DESLARZES[2], Emma HICKERSON[3], G.P. SCHMAHL[3], James SINCLAIR[4], Richard ARONSON[5]

[1]Applied Coastal and Environmental Services, Battelle Memorial Institute, Miami Lakes, FL, [2]Marine Sciences, Geo-Marine Inc., Plano, TX, [3]Flower Garden Banks National Marine Sanctuary, NOAA, Galveston, TX, [4]Gulf of Mexico Region, Minerals Management Service, New Orleans, LA, [5]Marine Sciences, Dauphin Island Sea Lab, Dauphin Island, AL

The first living colonies of *Acropora palmata* were discovered on the Flower Garden Banks (FGB) in 2003 and 2005. Those discoveries, coupled with a known history of bank flooding since the last glacial maximum, led us to predict that *Acropora*-dominated reefs underlie and form the structural foundation of the living reef community at the FGB. In June 2006, while scuba diving on the southeast corner of the East FGB, we examined an open cave at 21 m depth, which exposed a 3-m vertical section of the reef subsurface just below the living community. Within that exposure we discovered large branches and trunks of *A. palmata* (>1 m in height) in growth position. Radiocarbon dating of a branch from a colony at the top of the section yielded a date of 6330 ± 60 14Cyr (radiocarbon years before 1950), corresponding to a calibrated age of 6780 calbp. Follow-up surveys in June 2007 revealed an *A. palmata* dominated under story dating between 10-6 ky on both banks. The discovery of fossil *A. palmata* has profound implications for understanding the history of reef development at the FGB. The banks supported a shallow, warm-water, reef-coral assemblage up until ~6000 years ago. This community lagged behind rapidly rising sea level in the middle Holocene. As sea temperatures cooled in the late Holocene the reef was capped by a eurythermal deeper-water assemblage dominated by massive corals, which persists to this day. During our 2007 surveys we also found the first fossils of *Acropora cervicornis* on the East FGB. This species appears to have persisted (and flourished) until the Little Ice Age in deeper water on the flanks of the Bank. Follow-up studies are proposed to document and explain the turn-on and turn-off mechanisms for *Acropora* reef development on these isolated reef complexes.

## 1-18

**Response Of *acropora* To Warm Climates; Lessons From The Geological Past**

**Clare WHITE*[1,2]**, Brian ROSEN[3], Dan BOSENCE[1]

[1]Earth Sciences, Royal Holloway University of London, Egham, Surrey, United Kingdom, [2]Palaeontology, Natural History Museum, London, United Kingdom, [3]Zoology, Natural History Museum, London, United Kingdom

Predictions about the future responses of modern coral reefs to global climatic change lack data from the deeper past. The geological record offers a storehouse of information which documents how reef coral palaeodistributions have been highly sensitive to climate change, modulated by the availability of suitable habitats. The geological record of one individual taxon, *Acropora*, illustrates how an important reef coral genus has responded to climate change, and additionally tectonics, through its Cenozoic history.

We have reconstructed *Acropora's* changing spatio-temporal distribution using museum specimens, literature reviews and databases, and plotted the data on a time-series of palaeogeographic maps and on 'Boucotgrams'. Unlike *Acropora's* widespread low-latitude distribution today, with its centre of diversity in the Indo-West Pacific, this coral was absent from this region in the Paleogene to early Neogene, but was common in Europe. Here we highlight (1) latitudinal changes in distribution in response to major climatic trends, and (2) the relatively late arrival of *Acropora* in the Indo-West Pacific, apparently in response to tectonically-driven rearrangement of Tethyan and Indo-Pacific seaways and land-masses around the end of the Paleogene. Focusing on a particular section of this record, the high palaeolatitude (48°N) occurrences in the Middle-Late Eocene (~48-33Ma) of southern England and northern France, we use taphonomic and geochemical analyses to reconstruct the palaeoenvironmental setting. This confirms that *Acropora* existed in tropical-like climatic conditions in Northwest Europe during the Eocene. This individual coral genus's latitudinal expansion, compared with modern distributions, illustrates "coral creep" as a response to the hot greenhouse setting of the early Cenozoic, and periods of extreme climatic warming of the Eocene, with sea-surface temperatures and ρCO2 higher than present. Hence this work shows how the geological record can provide information to complement predictions on the fate of modern coral reef genera with respect to climate change.

## 1-19

**Abrupt Drowning And Cooling 8.2-8.4 Ka Observed In A 0.8-M Diameter And 24-M Long Core Through A Hawaiian Coral Reef, Oahu, USA**

**Eric GROSSMAN*[1]**, Jody WEBSTER[2], Christina RAVELO[3], Jim BARRY[4], Stewart FALLON[5], Yael SAGY[1], Bruce RICHMOND[1], Mike TORRESAN[6], David CLAGUE[7]

[1]Coastal and Marine Geology Program, US Geological Survey, Santa Cruz, CA, [2]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, [3]Ocean Sciences Department, University of California, Santa Cruz, Santa Cruz, CA, [4]Sea Engineering, Inc., Honolulu, HI, [5]Research School of Earth Sciences, Australian National University, Canberra, Australia, [6]Coastal and Marine Geology Program, US Geological Survey, Menlo Park, CA, [7]Monterey Bay Aquarium Research Institute, Moss Landing, CA

Sediment collected in a 0.8 m diameter, 24 m long core at 18 m depth offshore of Pearl Harbor provide a geologic archive of reef response to the Holocene sea-level transgression on the island of Oahu, Hawaii. CHIRP seismic reflection data reveal a 5-15 m thick reef complex buried below the seafloor within a paleostream valley. An olivine-rich, black sand and rounded basalt cobble unit, inferred as an early Holocene delta occurs at the base of the core overlying a soil-stained, caliche-encrusted limestone dated to 124 ka. 14-C ages indicate a shallow-water coral reef assemblage comprised of encrusting *P. lobata* and branching coralline algae *P. gardineri* accreted until 8.4 ka, then was abruptly replaced by a mono-specific *P. compressa* reef between 8.4 and 8.2 ka and added 10 m to the reef by about 4.9 ka. Approximately, 4.5 m of carbonate-rich sand buried this reef complex and comprises the modern seafloor substrate at the site. The abrupt transition from shallow-water to deeper-water coral assemblages at 8.4-8.2 ka is coincident with rapid climate change observed in other reefs, lakes, and sedimentary records throughout the tropics. Reconstruction of paleowater depths at this transition indicates a rapid rise in sea level of at least 3 m, helping to explain preservation of a drowned erosional notch surrounding many shorelines of Hawaii at -24 m like a bath-tub ring. High-resolution measurements of δ18O and Sr/Ca ratios from three *P. compressa* corals 8.7-8.3 ka, indicate cooler surface water temperatures than today and a slight cooling during this event. Abrupt sea-level rise of several meters could explain the transition in coral community structure, the dominance of mono-specific *P. compressa*, and colder sea surface temperatures.

## 1-20

**Evidence of rapid sea-level rise from reef backstepping during the Last Interglacial highstand.**

**Paul BLANCHON*[1]**

[1]Inst. of Marine Sciences & Limnology, National University of Mexico, Cancun, Mexico

Investigation of reef development during the Last Interglaciation has focussed on flights of exhumed terraces in neotectonic terranes. But the timing of climatic cycles has taken precedence over reef response to sea-level change. As a result, we have no clear picture of highstand reef development nor sea-level changes that controlled it.

Here I report the facies architecture of a highstand reef from the NE Yucatan Peninsula that affords significant insight into reef development and sea-level behaviour during the Last Interglaciation. Excavations for a theme park (Xcaret) have exposed two coeval reef-tracts that are offset and at different elevations. The lower-tract crops-out along the coast and the crest facies reaches an elevation of +3.0 m amsl. One hundred metres in-land, the crest of the upper-tract reaches +5.7 m amsl. Crests in both tracts were true breakwaters, each consisting of large colonies of A. palmata and boulder-sized fragments with a suite of surf-zone encrusters. Lower-tract frameworks are occluded by crustose corallines, but those in the upper-tract remained open and were infiltrated by abraded sand during forced shoreface regression. This infiltration is clear evidence that the upper-tract was younger than the lower, and that reef backstepping occurred.

Backstepping was not related to shelf flooding to the north, because that had occurred during lower-tract development. But backstepping was accompanied by increased sediment flux that shifted lagoonal biofacies to a sediment-tolerant assemblage. Similar changes occurred in the strand-plain sequence to the north, but here it involved a switch from low- to high-energy coastal sedimentation. This energy switch and reef backstepping are both consistent with a +3 m sea-level jump at the end of the Last-Interglacial highstand.

## 1-21

**Coral Reef Development Along The Windward Platform Margin Since The Plio-Pleistocene: Southern Exuma Cays, Bahamas (Dedicated To Robert F. Dill, 1927-2004)**

**Paul J. HEARTY*[1]**, Donald F. MCNEILL[2]

[1]GeoQuEST Research Centre, School of Earth and Environmental Sciences, University of Wollongong, Australia (paulh@uow.edu.au), Wollongong, NSW, Australia, [2]MGG-RSMAS, University of Miami, Miami, FL

The surface geology and two 33-m cores from the Exmas contain 11 limestone-paleosol "couplets" (C1 to C11 – older to younger), revealing depositional cycles extending back to the Plio-Pleistocene. The couplets are composed of marine limestone and *terra rossa* paleosol-karst exposure surfaces. Amino acid racemization and paleomagnetic reversals provide a functional chronostratigraphy for the couplets. At the base of the more bankward Core #2, couplets C1 to C3 contain the coral *Stylophora*, generally associated with the Plio-Pleistocene. The overlying C4 complex consists of several meters of dense reddish paleosols and thin intertidal lenses. These C4 paleosols bracket the Brunhes-Matayuma boundary (0.78 Ma; MIS 19?), and collectively equate with the "Big Red Soil" recognized on Bermuda and Hawaii. This interval comprises a succession of much lower highstands reflecting more interglacial continental ice from 0.5-1.0 Ma. Younger units C5 through C11 were deposited 0.5 Ma to present, and record lesser-known middle Pleistocene sea levels (MIS 15 @ -15 m, MIS 13 @ -7 m, and MIS 7 @ -18 m). In contrast, important interglacials during MIS 11 and 9 left little sedimentary evidence, probably due to deep flooding of the platform, and the dearth of early Pleistocene antecedent topography on which to "hang" deposits.

Sea-level cycles across the Plio-Pleistocene show a general progression from reefal components to predominantly non-skeletal sands. Plio-Pleistocene highstands (3.0? - 1.0 Ma) are obscured below present sea level by subsidence. Corals are a key component of units C2, C3, C4 in Core #2 and unit C6 in the more seaward Core #1. A long period of subaerial exposure from 1.0-0.5 Ma was followed by several important mid to late Pleistocene highstand carbonate accretionary events during which the platform margin extended to its present position over 3 km eastward.

## 1-22

**Mid-Brunhes First High Amplitude Transgression(s): Platform Top and Siliciclastic Shelf Contemporaneous Re-flooding Recorded on the Slopes of Great Bahama Bank and Central Belize Barrier Reef**

**Andre DROXLER*[1]**, Brooke E. CARSON[2]

[1]Earth Science, Rice University, Houston, TX, [2]Shallow Marine Stratigraphy Team, Chevron Energy Technology Company, Houston, TX

Last 5 My ice volume variations recorded in stacked, globally distributed, benthic oxygen records, clearly show a systematic late Pliocene and early Pleistocene ice volume increase following an early Pliocene sea level highstand estimated to be 15 to 25 m higher than current sea level. This systematic ocean base-level fall was terminated by two mid Brunhes high amplitude transgressions at the MIS 16-15 and MIS 12-11 glacial to interglacial deglaciations. On the slopes of Great Bahama Bank (GBB) and central Belize Barrier Reef (BBR), a series of five-six stacked and contemporaneous highstand wedges are observed and identified as being linked to the MIS 15-13, 11, 9, 7, 5, and 1 interglacial stages. Each package is defined by high concentration and/or mass accumulation rates of bank derived fine aragonite sediment bounded by intervening late glacial intervals enriched in Mg calcite cement corresponding to marine hardgrounds on the western margin of GBB and intraclasts-rich levels with coarser grain concentrations on the slope off the BBR. The highstand wedges are overlying an interval in both areas with lower bank-derived aragonite concentration and/or mass accumulation rates, higher pelagic calcite concentrations, and overall lower sedimentation rates. Based upon these observations, the two mid-Brunhes major MIS 16-15 and MIS 12-11transgressions correspond to first a partial and then a full re-flooding of GBB top and the siliciclastic fluvial plain established at lower base level during the late Pliocene and early Pleistocene sea level regression in Belize. These two mid-Brunhes transgressions have most likely triggered also the onset of modern barrier reefs along the Queensland and New Caledonia margins, the Florida Keys, and globally modern atolls. The MIS 12-11 transgression marks the first time interglacial atmospheric CO2 concentrations reached late Brunhes values between 280-295 ppm which has been suggested to be related to the global neritic carbonate re-establishment.

## 1-23

**Late Miocene To Recent Coral Community Dynamics in The Gulf Of California**

**Ramón LÓPEZ-PÉREZ*[1]**

[1]Instituto de Recursos, Universidad del Mar, Puerto Angel, Mexico

Hermatypic coral studies in the Gulf of California have focused mainly on the distribution, abundance, ecology, and biogeography of modern species, but relatively few of these works have studied fossil corals. Miocene to Pleistocene coral communities in the Gulf of California were targeted in order to assemble a detailed geologic and taxonomic framework for already known and new coral bearing units. In general, coral bearing units are small and represent single spatio-temporal growth episodes ranging in age between late Miocene to late Pleistocene. Identification of recently collected specimens reveals that previously recognized coral species probably represent ~ 50 % of the Gulf of California fauna. Cluster analysis, multidimensional scaling and analysis of similarity of presence/absence and relative abundance data demonstrated that Gulf of California coral reef assemblages experienced larger temporal differences in species composition and relative abundance than expected by chance. Coral species originated and were added to the species pool during late Miocene-early Pliocene and Pleistocene. Gulf of California assemblages consisted of locally originated Caribbean-like species between late Miocene and late Pliocene when extinction peaked at the Plio-Pleistocene transition. During the Pliocene assemblages consisted of a mix of extinct and living species co-occurring within and among localities, but immediately after the demise of pre-turnover taxa, living Indo-Pacific immigrant species dramatically increase in number and relative abundance ruling out ecological replacement as the key factor in pre-turnover species extinction. The turnover is unique in that pre-turnover species origination resulted from the formation of the Gulf of California, and instead of reducing species richness, the extinction event triggered the long-distance colonization of species. More data and better resolved age dates are necessary to understand the cause of faunal turnover, and the relative importance of biological and environmental factors in the faunal change.

## 1-24

**Caribbean Coral Reef Types From A Mixed Siliciclastic-Carbonate Setting: Miocene-Pliocene Of The Dominican Republic**

**Donald MCNEILL*[1]**, James KLAUS[2], Ann BUDD[3]

[1]Marine Geology & Geophysics, Rosenstiel School - University of Miami, Miami, FL, [2]Department of Geological Sciences, University of Miami, Coral Gables, FL, [3]Department of Geoscience, University of Iowa, Iowa City, IA

Geologic models of ancient Caribbean coral reefs that occur in predominantly siliciclastic settings have developed and diversified since the 3rd Coral Reef Symposium in 1977. The objective of this study is to characterize the styles of reef development in these mixed siliciclastic-carbonate settings from the exceptionally well-preserved fossil reef deposits in the Cibao Basin, northern Dominican Republic. Building on the mixing classification of Mount (1984), we recognize three main styles (geometries) of "in situ" carbonate (reef) deposition within siliciclastics. These include: 1) late Miocene stacked patch reefs-these reefs occur as isolated patches approximately 20-30 m thick and 300-400 m wide as part of a shallow clinoformal shelf. Lowered sea level and initial transgression provided conditions favorable to patch reef initiation and development; 2) late Miocene-early Pliocene bedded coral in mud-these reefs occur as either thick beds (3-6 m thick) of mud with abundant coral and coral fragments scattered throughout, or as distinct, cyclic coral beds (0.5-1 m thick) interbedded with mud beds (<1 m thick). Corals beds first accumulated as part of a prograding shelf clinothem (corals in mud matrix), and then under progressive deepening water depths during transgression (cyclic coral-mud beds); and 3) early Pliocene-late Pliocene reefal clinothems-coral-rich clinothems with well-defined foresets and topsets associated with transgression and highstand. Siliciclastic muds in these reefal clinothems occur predominantly as a matrix component and as occasional <1-m thick distinct beds. Our findings suggest that these reef geometries are closely tied to the prevailing sea level regime. On a Caribbean-wide basis, many Miocene to middle Pleistocene mixed-system reefs assessed have similar geometrical configurations that mimic these "in situ" mixing types.

## 1-25

**Paleoecology Of Mio-Pliocene Free-Living Corals in The Northern Dominican Republic And Neogene Evolutionary Patterns Of The Caribbean Region**

**James KLAUS*[1]**, Ann BUDD[2], Donald MCNEILL[3], Scott ISHMAN[4]

[1]Department of Geological Sciences, University of Miami, Coral Gables, FL, [2]Department of Geoscience, University of Iowa, Iowa City, IA, [3]Rosenstiel School of Marine and Atmospheric Science, Marine Geology and Geophysics, University of Miami, Miami, FL, [4]Department of Geology, Southern Illinois University, Carbondale, IL

Periods of accelerated origination and extinction have played a disproportionate role in shaping the structure and ecology of Cenozoic coral communities in the Caribbean region. This is most evident in the late Pliocene faunal turnover event in which approximately 80% of Mio-Pliocene corals became extinct and more than 60% of species now living in the region originated. Free-living meandroid corals were particularly hard hit during this interval; only two species survive in the region today, *Manicina areolata* and *Meandrina brasiliensis*. Diversity patterns based on new collections and compiled records from the Caribbean region show that the diversity of free-living meandroid corals increased throughout the Neogene. Two free-living meandroid corals are known from the early Miocene, and diversity accumulated slowly during the middle and late Miocene. During the latest Miocene and early Pliocene diversity more than doubled from 11 to 24 species, before falling abruptly between 2 and 1 Ma from 22 late Pliocene species to the two modern species. To better understand the ecology of free-living corals as well as their pattern of abrupt origination proceeding catastrophic extinction, over 1,300 free-living coral specimens were collected from 21 localities in the northern Dominican Republic ranging in age from 6.2 to 3.4 million years ago. Preliminary results integrating benthic foraminifera and other environmental indicators suggest that unlike modern *M. areolata* and *M. brasiliensis*, which are typically associated with very shallow water grassflat environments, free-living corals of the northern Dominican Republic had a much wider habitat range from grassflats to deeper forereef environments. Given these environmental constraints we evaluate the patterns of origination and extinction within the context of Neogene paleoceanographic events.

## 1-26

**Cenozoic Photic Reef And Carbonate-Ramp Habitats: A New Look Using Paleoceanographic Evidence**

**Pamela HALLOCK*[1]**, Luis POMAR[2]

[1]College of Marine Science, University of South Florida, St Petersburg, FL, [2]Departament de Ciencies de la Terra, Universitat de les Illes Balears, Palma de Mallorca, Spain

Understanding biological and geochemical processes associated with modern coral reefs is essential to interpreting fossil reefs and carbonate sedimentation. Yet recognizing the limitations of uniformitarianism is equally crucial. Cenozoic carbonate-producing ecosystems emerged from the remnants of Cretaceous biotas, evolving in the warm alkaline oceans of a Greenhouse world, then modifying in response to developing Icehouse conditions. The latter included stronger latitudinal and bathymetric temperature gradients, declining carbon dioxide concentrations in the atmosphere and declining calcium concentrations and alkalinity in the oceans. Paleocene-Eocene photic-dependent carbonates tended to be dominated by calcitic coralline red algae and larger benthic foraminifers (LBF), with aragonitic corals and calcareous green algae more restricted temporally and spatially. Conceptual models suggest that episodic changes in ocean circulation and thermocline stratification that accompanied high latitude cooling during the Cenozoic provided impetus for turnover in chlorozoan biotas. For example, comparison of Eocene through Miocene paleotemperature data on surface to thermocline gradients with the history of LBF assemblages indicates that the latter were most diverse and productive when deeper waters were warmest and gradients were weakest. Higher extinction rates corresponded with times when surface to thermocline gradients increased. In contrast, zooxanthellate corals, while relatively diverse in the Eocene, were restricted as reef builders. As Icehouse conditions emerged, aragonite production by corals and calcareous algae became more widespread, with a setback in the early and middle Miocene when coralline algae again dominated. Moreover, the proliferation of reef-building coralline algal taxa into shallow-water habitats in the late Miocene paralleled the emergence of shallow-water corals and new clades of zooxanthellae, indicating co-evolution of these critical reef taxa. Implications of these observations support the hypothesis that deeper photic-zone (30-100 m) carbonate systems will survive anthropogenically driven changes in ocean chemistry.

## 1-27

**Photosymbiosis is a Major Theme in the History of Mesozoic to Cenozoic Reef Systems**

**George STANLEY JR.*[1]**, B. VAN DE SCHOOTBRUGGE[2]

[1]Paleontology Center, University of Montana, Missoula, MT, [2]Institute of Geosciences, Goethe University Frankfurt, Frankfurt, Germany

Symbiotic partnerships between photosynthetic dinoflagellates (zooxanthellae) and corals provide enhanced nutrition and calcification and partly explain the reef phenomenon. They elucidate the success and failure of many reefs today and in the geologic past. Here, we review the geologic record of 240 million years of hexacoral evolution. It reveals the origin of the group from soft-bodied anemone-like ancestors of the Paleozoic, the first appearance of calcifying scleractinians in Middle Triassic time, and their subsequent rise to dominance. Middle Triassic corals did not diversify or move into roles of reef building until Late Triassic time, some 14 ma later. The co-occurrence of these early scleractinians with the earliest dinoflagellates represented by suessiacean cysts and their subsequent expansion into roles of reef-building in the Late Triassic, coincides in space and time. Furthermore, stable isotopes confirm photosymbiosis in Late Triassic (Carnian-Norian) corals. We propose that this was the time of their coevolution with zooxanthellae. The end-Triassic mass extinction disrupted this ecological relationship, and a lengthy Early Jurassic post-extinction recovery led to coral reefs of the Middle to Late Jurassic. The Cretaceous records high diversity among corals but a subordinate role relative to rudistid bivalves. This is best explained by differential responses to climate warming, especially during the Late Cretaceous greenhouse time. The end-Cretaceous mass extinction removed the last surviving rudistids. Zooxanthellate corals later resumed dominance on Paleogene reefs. The coral expansion among Neogene reefs led to ecologically modern coral reefs. The resilience of Miocene-Holocene corals in the face of major oceanographic and climate change is explained by the ecological flexibility of the zooxanthellae-coral symbiosis, especially the ability of corals to switch clades of zooxanthellae in response to environmental change. This may not have been the case in older zooxanthellate corals.

## 1-28

**Early Cenozoic Recovery Of Caribbean Reef Coral Communities**

**Thomas STEMANN*[1]**

[1]Department of Geography and Geology, The University of the West indies, Kingston, Jamaica

There is some controversy over the extent to which the K-T extinctions affected coral reef communities at global and regional scales. Recent collections from latest Maastrichtian successions indicate that diverse Caribbean reef coral communities persisted up until the very end of the Cretaceous. The fate of this reef fauna is unclear, however, because early Cenozoic Caribbean reef corals are so poorly known.

The present study examines new collections of early Cenozoic corals from Jamaica that provide insight into Caribbean reef communities immediately following the K-T boundary. Extensive sampling from sites in three units in the Paleocene of eastern Jamaica yields an average of <5 coral species from each sample site and total sampled richness that is lower than at any time in the Cenozoic or late Cretaceous. Less than 5% of the Jamaican Cretaceous corals range into the Cenozoic. Coral abundance and richness rises slightly in the early - middle Eocene but remains low compared to typical levels found in later Cenozoic units. Endemism is high in the early Cenozoic but ecologic diversity is low with communities composed only of thin branching colonies or small solitary corals. Dense accumulations of reef corals including large massive, branched and plate shaped colonies do not become common until the late middle Eocene.

The results here are similar to reports from throughout the Caribbean and suggest significant coral species turnover regionally at the K-T boundary followed by a protracted recovery time. This contrasts markedly with the rich faunas recorded from Europe, Africa and Asia in the Paleocene –middle Eocene. After significant extinctions at the end of the Cretaceous, coral community recovery is slow in the Caribbean and faunas in this region remain species poor and ecologically simple considerably longer than elsewhere in the world.

## 1-29

**Evolution Of The Coral Reef Ecosystem Under A Jurassic Perspective: From Mixotrophy Towards Superoligotrophy**

**Reinhold LEINFELDER*[1]**, Ulrich STRUCK[1]

[1]Museum of Natural History Berlin, Berlin, Germany

Scleractinian reefs rapidly evolved and expanded during the Jurassic. Many Jurassic scleractinian calical structures were nearly as complex as in modern star or brain corals and thus appear modern. However, a much greater variety of coral reef types and coral reef settings existed than today. During the Jurassic, the adaptation to nutrient restriction by photosymbiosis was only one of several adaptational strategies, including other adaptational pathways to terrigeneous and even brackish settings. Many mid and late Jurassic corals exhibit good indicators for the existence of photosymbionts (integrated calical growth shapes, depth zonation, typical growth banding with high and low-density bands and, in some examples, non-linear clustering of C/O stable isotopes). Nevertheless, even density-banded corals and most pure coral reefs mostly grew under terrigeneous influence. On the other hand, typical low-nutrient settings such as the 1000 km broad Arabian shelf or intra-tethydian platforms were dominated by stromatoporoid sponges with or without scleractinian corals. Taxa distribution shows provincialism of many stromatoporoids. Jurassic coral taxa distribution data are not yet statistically significant but also point to differences between near-coast and intra-ocean platforms, indicative of splitting of the coral reef window into a mesotrophic to mildly oligotrophic subset dominated by mixotrophic corals and a superoligotrophic subset dominated by stromatoporoids together with strongly photosymbiontic corals.

The Bahia Almirante coral reefs from Panama may represent a “Jurassic-type” modern example for mixotrophy of corals. These reefs are adapted to both reduced salinity and to sewage-related, slightly elevated nutrients. This is shown by the C/O and N stable isotope pattern, signalling that certain phototrophic coral species consumed considerable proportions of zooplankton and, possibly, even terrigeneous plant debris.

## 1-30

**$Co_2$-Concentrating Mechanisms, Harmful Blooms, And Late Devonian Reef Extinction 375 Million Years Ago**

**Robert RIDING*[1]**

[1]Earth and Planetary Sciences, University of Tennessee, Knoxville, Knoxville, TN

Late Devonian Mass Extinction caused the largest change experienced by reef biotas in the entire Phanerozoic. Stromatoporoid-coral communities that had dominated metazoan reefs since the mid-Ordovician disappeared. In the extinction’s immediate aftermath they were replaced by microbial reefs. By the Early Mississippian rimmed shelves had given way to ramps dominated by carbonate mud mounds. The Mass Extinction selectively eliminated shallow marine organisms, including acritarch phytoplankton as well as reef biotas.

Here I suggest induction of $CO_2$-concentrating mechanisms (CCMs) in marine phytoplankton as a factor in Late Devonian Mass Extinction. CCMs help maintain photosynthesis when levels of dissolved inorganic carbon are low. Late Devonian decline in atmospheric $CO_2$ level was sufficient to induce CCMs in aquatic algae and cyanobacteria. This is likely to have had several geologically recognizable effects. Firstly, CCMs promote phytoplankton productivity and bloom conditions by helping to overcome carbon limitation. Productivity enhances organic matter burial, and harmful blooms kill shallow-water reefs and pelagic organisms. Secondly, conditions favouring photosynthetic groups with effective CCMs can promote community restructuring, resulting in extinction of some phytoplankton groups. Thirdly, cyanobacterial CCMs can stimulate calcification, both in the water column as ‘whitings’, and in benthic mats as *in situ* microbial carbonates.

The Late Devonian marine realm underwent marked changes in addition to Mass Extinction. Organic carbon-rich sediments, microbial carbonates, and carbonate mud mounds significantly increased in abundance. These, at first sight disparate, developments all have potential links to CCM induction in phytoplankton. Harmful blooms could have contributed to extinction of shallow marine metazoans, and increased phytoplankton productivity would have increased organic carbon-rich sediments. Phytoplankton community restructuring could have led to acritarch extinction. Combination of increased microbial productivity and enhanced cyanobacterial calcification would have promoted both microbial carbonate and carbonate mud mound development. These possibilities do not exclude the likely involvement of additional causative factors.

## 2-1

**Hopping Hotspots: Global Shifts in Marine Biodiversity**

**Willem RENEMA*[1]**, David BELLWOOD[2], John PANDOLFI[3], JC BRAGA[4], K BROMFIELD[3], R HALL[5], KG JOHNSON[6], Peter LUNT[7], CP MEYER[8], L MCMONAGLE[9], RJ MORLEY[10], A. O'DEA[11], John TODD[6], FP WESSELINGH[12], MEJ WILSON[13]

[1]Nationaal Natuurhistorisch Museum Naturalis, Leiden, Netherlands, [2]2School of Marine and Tropical Biology, JCU, Townsville, Australia, [3]Centre for Marine Studies, Brisbane, Australia, [4]Universidad de Granada, Granada, Spain, [5]SE Asia Research Group, London, United Kingdom, [6]NHM, London, United Kingdom, [7]Murphy Oil, Kuala Lumpur, Malaysia, [8]UC Berkeley, San Francisco, CA, [9]University of Durham, Durham, United Kingdom, [10]Palynova, Cambridge, United Kingdom, [11]STRI, Panama, Panama, [12]NNM Naturalis, Leiden, Netherlands, [13]Curtin University, Perth, Australia

Hotspots are a dominant feature of global biodiversity patterns. Many coral reef groups reach their greatest diversity here . Recent fossil and molecular evidence reveal at least three marine biodiversity hotspots during the past 50 million years. These hotspots have moved across almost half the globe, with their timing and locations coinciding with major tectonic events. The birth and death of successive hotspots highlights the link between environmental change and biodiversity patterns. The molecular and fossil evidence from a range of taxa rejects the notion of Pleistocene origins of the modern marine IAA fauna and flora, and point to the presence of a high diversity of extinct and extant lineages from at least the Miocene onwards. Fossil data further establish that the IAA has not always been the centre of marine biodiversity, but that earlier 'centers of marine biodiversity' occurred in at least two additional places during the past 50 Million years. The future of modern biodiversity hotspots can now be placed in a historical context.

## 2-2

**Evolution Of Carbonate Factories For The Last 100 Million Years Based On Investigations On Shallow-Water Carbonate Deposits On Seamounts in The Northwestern Pacific Ocean**

**Yasufumi IRYU*[1]**, Hideko TAKAYANAGI[1], Tsutomu YAMADA[1], Motoyoshi ODA[1], Tokiyuki SATO[2], Shun CHIYONOBU[1], Akira NISHIMURA[3], Tsutomu NAKAZAWA[3], Satoshi SHIOKAWA[4]

[1]Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, Sendai, Japan, [2]Institute of Applied Earth Sciences, Faculty of Engineering and Resource Science, Akita University, Akita, Japan, [3]AIST (Advanced Industrial Science and Technology ), Tsukuba, Japan, [4]JOGMEC (Japan Oil, Gas and Metals National Corporation), Kawasaki, Japan

Evolution of carbonate factories for the last 100 million years were delineated by investigating lithology, biotic and abiotic compositions, and depositional ages of shallow-water carbonates collected from 25 sites on 21 seamounts in 6 sea areas (Amami Plateau, Daito Ridge, Oki-Daito Ridge, Urdaneta Plateau, Kyushu-Palau Ridge, and Ogasawara Plateau) in the northwestern Pacific Ocean. There are significant differences among Cretaceous, Eocene, and Oligocene to Pleistocene shallow-water carbonates. The shallow-water carbonate deposits examined in the present study can be roughly divided into three types based on their composition: Cretaceous, Eocene, and Oligocene to Pleistocene types. The Cretaceous type is characterized by abundant occurrence of rudists, microencrusters, solenoporacean algae, and calcareous sponges. The Eocene type includes shallow-water carbonates predominated by *Halimeda* or nummulitid and discocyclinid larger foraminifers. The Oligocene to Pleistocene type includes abundant corals, nongeniculate and geniculate coralline algae, and miogypsinid, lepidocyclinid, and amphisteginid larger foraminifers. These indicate that carbonate factories comparable with modern coral reefs were initiated in the Oligocene, which corresponds to the timing of the transition from Calcite II to Aragonite III. These changes in the composition of the shallow-water carbonates from the Cretaceous onward is in accordance with those shown in previous studies, which have been considered to reflect a shift in seawater chemistry. Our investigation shows that large amounts of shallow-water carbonates were deposited on the seamounts in Oligocene, although it was a relatively cool period in the Cenozoic. Whereas Early Miocene shallow-water carbonates are limited, although it was a relatively warm period. These suggest that deposition of shallow-water carbonates on seamounts in the northwestern Pacific Ocean was not necessarily controlled by climatic conditions but related with volcanism and tectonics which served foundations for reef/carbonate-platform formation.

## 2-3

**The Influence Of Global And Regional Environmental Change On Cenozoic Carbonates in The Indo-Pacific**

**Moyra WILSON*[1]**

[1]Applied Geology, Curtin University, Perth, Australia

The SE Asian carbonate record allows insight into the poorly known response of equatorial marine systems to regional and global change during the Cenozoic. There is a marked change from larger benthic foraminifera to corals as dominant producers in SE Asia around the Oligo-Miocene boundary. The Early Miocene acme of coral development in SE Asia lags Oligocene coral development in the Caribbean and Mediterranean. Changing $CO_2$, oceanography, nutrient input and precipitation patterns are inferred to be the main cause of this lag. Moderate, although falling level of $CO_2$, $Ca^{2+}$ and Ca\Mg when combined with the reduced salinities in humid equatorial waters probably all contributed to reduced aragonite saturation hindering reefal development compared with warm more arid regions during the Oligocene. By the Early Miocene, atmospheric $CO_2$ levels had fallen to pre-industrial levels. Although this was a relative arid phase globally, in SE Asia palynological evidence indicates the Early Miocene experienced everwet, but more stable and less seasonal conditions than periods before or after. Tectonic convergence truncated deep through-flow of cool nutrient-rich currents from the Pacific to Indian Ocean around the beginning of the Miocene, thereby directly, and perhaps indirectly (though less seasonal conditions) reducing nutrients. Aragonitic reefs were promoted where previously the waters had been more acidic, more mesotrophic, more turbid, and less aragonite saturated. Extensive reefal development resulted in an order of magnitude expansion of shallow carbonate areas through buildups and pinnacle reefs in the Early Miocene. Tectonics via increased habitat partitioning and reducing distances to other coral-rich regions may also have contributed to enhanced reefal development. Implications of this study are that with anthropogenically induced environmental changes it will be the diverse reefs of SE Asia that are likely to be amongst the first and hardest hit as oceanic aragonite saturation decreases and terrestrial nutrient runoff increases.

## 2-4

**Scleractinian Coral Diversity in The Oligocene Of Sabah, Borneo.**

**Laura MCMONAGLE*[1,2]**

[1]Earth Sciences, Durham University, Durham, United Kingdom, [2]Palaeontology, Natural History Museum, London, London, United Kingdom

The modern Indo-West Pacific is characterised by the highest global species diversity in reef-corals and associated biota, but the origins and long-term history of this important biodiversity hotspot remain poorly studied, with most work on the corals derived from collections made in the late 19th Century. The extant biota may have appeared during a diversification event that took place slightly before the Oligocene-Miocene boundary, marked by a change in the style of carbonate deposition in the region. This may also have coincided with a reduction in the deep-water throughflow between the Pacific and Indian Oceans and marine incursions in the area. To better constrain the timing, magnitude, and environmental context for this diversification, a previously undescribed reef-coral fauna has been documented from extensive new collections taken from Oligocene patch-reef facies in the Gomantong Formation of Sabah, Malaysia. Study of nannofossil assemblages suggests that sections range from biozone NP23 (Early Oligocene) to NP25 (Late Oligocene), with the majority falling within nannofossil zone NP24 (late Early to early Late Oligocene). This study has more than doubled the number of coral species previously known from the Oligocene of Borneo, and suggests that the apparent paucity of Paleogene corals from SE Asia could be a result of sampling bias, rather than true lack of diversity. These results show that coral diversification was already underway by the Early Oligocene, rather than occurring at the Oligocene/Miocene boundary. This would indicate that if changes in the Indonesian Throughflow caused increased diversification, then these changes occurred earlier than has so far been suggested. Alternatively it could mean that other factors controlled reef-coral diversification in the Indo-West Pacific during the Oligocene.

## 2-5

**Differential response of Southeast Asian and Caribbean reef ecosystems to global environmental change during the Oligocene/Miocene Transition**

**Kenneth JOHNSON*[1]**

[1]Palaeontology Department, Natural History Museum London, London, United Kingdom

The paleoceanographic record contains several intervals during the Cenozoic in which apparently rapid global change in the open ocean also had effects on tropical coastal marine ecosystems. One example is the Oligocene/Miocene transition (OMT) that occurred approximately 25-20 Ma. This interval is associated with the termination of a Late Oligocene warm interval by a 'snap' glaciation and development of a stable globally-cooler climate phase during the Early Miocene. These changes are contemporaneous with the initial constriction of deep water connections across the Indonesian Throughflow as Australia collided with Eurasia. A database of specimen-based occurrences of reef corals was assembled from both new and existing collections to document the history of coral diversity and the regional extent of reef development in the Caribbean and Southeast Asia during the OMT. All specimens were examined to verify taxonomic identifications and collections were placed within a consistent stratigraphic framework. During the Late Oligocene there was widespread reef building by a moderately diverse biota in the Caribbean. Both diversity and the extent of reef building had crashed by the Early Miocene in response to increased regional surface productivity. In contrast, there was little reef building and low diversity of reef builders in the Late Oligocene of SE Asia. Instead both reef-building and reef-coral diversity in the region increased during the OMT. Therefore, the effects of global change caused a decline in reef-coral diversity and reef-building in the Caribbean but an increase in reef building and radiation of reef-corals in Southeast Asia. The fact that regional biotic responses were out of phase in Southeast Asia and the Caribbean indicates that the ecological signal of global environmental change is modulated by local to regional-scale biotic and oceanographic history.

## 2-6

**Indo-Pacific Coral Growth Forms Through The Miocene To The Pliocene**

**Kate BROMFIELD*[1]**, John PANDOLFI[1]

[1]University of Queensland, Brisbane, Australia

One of the most intriguing questions for the evolution of the modern Indo-Pacific coral reef fauna is the antiquity of modern branching-dominated coral assemblages. The Miocene (21-6 Ma) of the Indo-Pacific is a period of pronounced first occurrences of reef coral species, and a complete reorganisation of coral communities has been proposed; from a Miocene fauna dominated by massive growth forms, to reef domination by corals with branching morphologies in the Pliocene. Many genera of modern reef corals (order Scleractinia), are thought to date from the early Pliocene (5.6-3.2 Ma), around 5.3 Ma. This study tested the Miocene/Pliocene growth form transition hypothesis from uplifted reefs at three sites along a longitudinal gradient: Vanua Balavu (16.9-6.7 Ma) in Fiji; New Britain (14.8-12.3 Ma) in Papua New Guinea; and Selayar (5.8-1.4 Ma) in Indonesia.

The collection includes 121 coral species, fifteen of which are new, though now extinct. The highest percentage (25%) of newly recorded, extinct species occurred in the late Pliocene (5.8-3.4 Ma) reef deposits of Selayar. Newly described extinct species from the Miocene deposits of Fiji and Papua New Guinea averages 6%. The data shows no significant change in either the relative abundance or the presence versus absence of growth forms among the three sites and times. Miocene assemblages contained 27% abundance of branching individuals and the Pliocene contained 23%. This challenges the premise that reefs underwent a transition from those dominated by massive forms to those dominated by branching forms during this period. However, our study corroborates the previously proposed model of an origination event in reefal corals in the early Pliocene.

## 2-7

**Biodiversity And Biogeography Of Mollusca During The Cenozoic: A Database Approach To The Assessment Of Spatial Patterns And Their Relationship To Global Environmental Change**

**Austin HENDY*[1]**

[1]Geology and Geophysics, Yale University, New Haven, CT

A focal point in the Phanerozoic trajectory of global biodiversity has been its apparent rapid increase since the end-Cretaceous extinction. The interval stimulates additional interest through the availability of chronologically well-constrained information on changing global paleoenvironments. This knowledge aids understanding of how the Cenozoic diversification of marine invertebrate faunas was influenced by developing global paleogeography, major tectonic shifts, and related climatic transitions.

An extensive dataset (http://paleodb.org) of fossil molluscan occurrences permits analysis of how spatial components of global biodiversity vary through the Cenozoic, specifically how faunas are partitioned biogeographically and how these biogeographic units relate to one another. On a global scale, sampling-standardized diversity appears to have increased at most only 50% over the course of the Eocene-Pleistocene, showing small drops during the Early Oligocene and a slight decline since the Middle Miocene. Nevertheless, there is remarkable stage-to-stage independence in the shape of diversity curves at the regional scale, reflecting both regionally distinct environmental controls and variable data quality, related to reduced sample size. A multivariate analysis of global biogeography reveals that provinciality has increased only slightly during this interval, peaking in the Plio-Pleistocene, although this patterns is strongly influence by spatial sampling intensity. A strengthening latitudinal gradient of diversity is observed through the Neogene, reflecting an increased in not only tropical diversity but also a decline in the richness of faunas from temperate and polar latitudes.

Fluctuations in regional endemism and biogeographic similarity between regions appear related to the opening and closing of major oceanic gateways. Nevertheless some aspects of global and regional diversity patterns reflect Cenozoic-scale climatic transitions, expressed by an Early Oligocene decline. The influence of deteriorating global climate through the Neogene appears to be offset by a steepening latitudinal diversity gradient and an associated increased late Neogene provinciality.

## 2-8

**Molluscan Biodiversity in Shallow Carbonate Platforms (Indonesia)**

**Frank WESSELINGH*[1]**

[1]Geology, Naturalis, Leiden, Netherlands

A pilot study into the spatial distribution of mollusc taxa in the shallow carbonate platform, the Spermonde Archipelago (Sulawesi, Indonesia) is presented. The very high species numbers and the unresolved taxonomical status of the far majority of these mollusc species should cripple such a documentation. However, by using taxa groups with an as low as possible taxonomic rank, very clear distribution patterns and associations are found. This study shows that molluscan associations probably are a very good tool for study of communities, facies and biodiversity in ancient carbonate platform settings as well.

## 2-9

**Escaping The Heat: Range Shifts Of Reef Coral Taxa In Coastal Western Australia**

**Benjamin GREENSTEIN*[1]**, John PANDOLFI[2]

[1]Geology, Cornell College, Mount Vernon, IA, [2]Centre for Marine Studies and Department of Earth Sciences, University of Queensland, Brisbane, Australia

One of the most critical challenges facing ecologists today is to understand the changing geographic distribution of species in response to current and predicted global warming. Coastal Western Australia is a natural laboratory in which to assess the effect of climate change on reef coral communities over a temporal scale unavailable to studies conducted solely on modern communities. Reef corals composing Late Pleistocene reef assemblages exposed at five localities along the west Australian coast were censused and the results compared to coral occurrence data published for the modern reefs offshore of each locality. The resulting comparative data set comprises modern and Late Pleistocene reef coral communities occurring over approximately 12º of latitude. This gradient includes the zone of overlap between the modern Dampierian and Flindersian Provinces.

Modern reef coral communities show a pronounced gradient in coral composition over the latitudinal range encompassed by the study, while the gradient in community composition is not as strong for Pleistocene communities. Tropical-adapted taxa contracted their ranges north since Late Pleistocene time, emplacing two biogeographic provinces in a region in which a single province had existed previously.

Beta diversity values for adjacent communities also reflect this change. Modern reefs show a distinct peak in beta diversity in the middle of the region; the peak is not matched by Pleistocene reefs. Beta diversity is correlated with distance only for comparisons between modern reefs in the north and the fossil assemblages, further supporting change in distribution of the biogeographic provinces in the study area. Coral taxa present in modern communities clearly expanded and contracted their geographic ranges in response to climate change. Those taxa that distinguish Pleistocene from modern reefs are predicted to migrate south in response to future climate change, and potentially persist in "temperature refugia" as tropical reef communities farther north decline.

## 2-10

**Ecological Dynamics Of Pleistocene Reefs During Sea-Level Lowstand**

**John PANDOLFI*[1]**, Danika TAGER[2], Jody WEBSTER[3], Don POTTS[4], Willem RENEMA[5], Juan-Carlos BRAGA[6]

[1]Cente for Marine Studies and School of Physical Sciences, University of Queensland, St. Lucia, Australia, [2]Centre for Marine Studies, University of Queensland, St. Lucia, Australia, [3]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, [4]Earth & Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, [5]Nationaal Natuur Historisch Museum, Leiden, Netherlands, [6]Estratigrafía y Paleontologia, Universidad de Granada, Granada, Spain

Reef ecosystems built during sea level rise have shown remarkable persistence in coral community structure but little is known of the ecological characteristics of reef communities during periods of low sea stands or sea level falls. We sampled the relative species abundance of coral, coralline algae and foraminifera communities from eight submerged carbonate reefs in the Huon Gulf, Papua New Guinea, that formed during sea level fall and lowstand over the past ~416 ky. We found that dissimilarity in coral species composition increased significantly with time on these reefs. However, neither coral diversity nor the taxonomic composition of foraminifera and coralline algae assemblages vary significantly over time. The taxonomic composition of coral communities from lowstand reefs was significantly different from that of highstand reefs previously reported from the nearby Huon Peninsula. We interpret the community composition and temporal dynamics of lowstand reefs as a result of shifting energy regimes in the Huon Gulf, and differences among low and highstand reefs as a result of variation between the Huon Gulf and Huon Peninsula environments. Regardless of these trends our study represents the first glimpse into the ecological dynamics of coral reefs during low sea level stands when habitable reef area was much less than present day. One major issue associated with present climate change is a possible order of magnitude reduction in coral reef habitat as low latitude reefs succumb to mortality events associated with temperature-induced bleaching events. Reduced areal extent of Pleistocene coral reefs during sea level lowstand may provide an analogue for such a future scenario.

## 2-11

**Spatial and Temporal Variations in Pleistocene Coral Assemblages in the South and Central Ryukyu Islands**

**Marc HUMBLET*[1]**, Yasufumi IRYU[1]

[1]Institute of Geology and Paleontology, Tohoku University, Sendai, Japan

In order to study spatial and temporal variations in Pleistocene coral assemblages in the South and Central Ryukyus, taxonomic composition and morphology of corals were investigated using the quadrat method in Irabu-jima (South Ryukyus), Okinawa-jima (southern Central Ryukyus), and Kikai-jima (northern Central Ryukyus). Cluster analysis was conducted to identify groups of taxa which tend to co-occur (coral associations) and groups of quadrats with similar taxonomic compositions. We recorded 40 genera and 84 species in Irabu-jima, 35 genera and 72 species in Okinawa-jima, 33 genera and 65 species in Kikai-jima. The cluster analysis produced 4 coral associations in Irabu-jima, 6 in Okinawa-jima and 4 in Kikai-jima. Some of these associations contain taxa indicating a specific depth range, while others, composed exclusively of cosmopolitan taxa, do not point to any particular reef zone. The analysis of taxonomic similarities among quadrats resulted in the segregation of 2 groups of quadrats in Irabu-jima, 5 in Okinawa-jima and 4 in Kikai-jima. In the cluster diagrams, the segregation of coral assemblages indicative of a same reef zone into distinctive groups or single branches reflects within-reef-zone variability. Upper reef-slope assemblages display a high spatial variability in taxonomic and morphological compositions over several meters to several kilometers. Conversely, middle to lower reef-slope assemblages display a low variability in taxonomic and morphological composition over meters to tens of meters. Temporal changes in Pleistocene coral assemblages within several-meter-thick sections of coral limestone reflect various types of coral successions. Transitions from one reef zone to another are likely due to sea-level fluctuations. Small-scale abiotic and/or biotic disturbances may result in successions of distinctive coral assemblages with overlapping depth ranges reflecting within-reef-zone variability.

## 2-12

**Reef Building At High Latitudes (34° N, Japan)**

**Hiroya YAMANO*[1]**, Kaoru SUGIHARA[2], Tsuyoshi WATANABE[3], Michiyo SHIMAMURA[4], Kiseong HYEONG[4]

[1]Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Japan, [2]Fukuoka University, Fukuoka, Japan, [3]Hokkaido University, Sapporo, Japan, [4]Korea Ocean Research & Development Institute, Ansan, Korea, Republic of

At Iki Island, Japan (33° 48' N), the world's highest-latitude coral-reef formation has been observed (Yamano et al., 2001, Coral Reefs, 20, 9-12). Following the discovery at Iki Island, we set up an international project funded by JSPS and KOSEF under the Japan-Korea Basic Scientific Cooperation Program in order to examine high-latitude corals around Japan and Korea. In the project, another reef-like mound structure over 5-m thickness was found at Tsushima Island, ca. 40 km north of Iki Island. We took two cores from the structure, which indicated that the inside of the mound was dominated by corals and mud. Similar as the coral reef at Iki Island, faviid corals, also dominant in modern coral community at Tsushima Island, were observed most frequently and abundantly throughout the cores. These characteristics are significantly different from those at tropical reefs that are dominated by acroporid corals. It is the highest latitude reef-like mound structure formed over a few thousands of years. We describe the distribution, timing of the formation and the growth rate of the mound in combination with those of the coral reef at Iki Island. We also discuss the significance of reef building at high latitudes in terms of geological reef evolution.

## 2-13

**Millennial-Scale Episodes Of Reef Accretion And Degradation Determined By U-Series Dating Of Coral Death Assemblages in Moreton Bay, Se Queensland, Australia.**

**Matt LYBOLT*[1]**, Jian-xin ZHAO[2], David NEIL[3], Yue-xing FENG[2], Ke-fu YU[2], John PANDOLFI[4]

[1]Centre for Marine Studies, University of Queensland, St. Lucia, Australia, [2]Centre for Microscopy and Microanalysis, University of Queensland, St. Lucia, Australia, [3]School of Geography Planning and Architecture, University of Queensland, St. Lucia, Australia, [4]Centre for Marine Studies / Department of Earth Sciences, University of Queensland, St. Lucia, Australia

The sub-tropical marginal reefs of Moreton Bay were characterized by diverse mid-Holocene communities that dramatically declined in the absence of major anthropogenic disturbance. We examined the nature and timing of changes in surficial coral death assemblages from Moreton Bay reefs to gain insight to the interplay of local and global changes. Corals were selected throughout the Bay across a depth range from 1 m above high tide to 5 m below low tide. Uranium-series age determinations (n=57) were made by Uranium-series thermal ionization mass spectrometry. The oldest sample was found atop *in situ* reef accretions at the highest elevation sampled, so Moreton bay reefs initiated before 6.82 ka and sea level must have reached its Holocene maximum prior to that time. Since the oldest cohort of corals was not buried by younger ones we conclude that coral accretion since 5.5 ka has been minimal. Coral accretion occurred in discrete episodes rather than continuously, and depths of accretion, corrected for palaeo-sea-level, became deeper through the Holocene. Major coral accretion episodes are 0-0.3 ka (19% of samples dated), 1.3-1.7 ka (11%), 4.3-4.7 ka (11%), and 5.5-6.8 ka or older (51%). Conspicuous episodes with no accretion are 0.4-1.1 ka and 4.7-5.5 ka. Sea-level fell from its Holocene high in a series of oscillations which coincide with episodes of accretion (stable/rising) and no accretion (falling). Greater extremes of temperature and salinity would result from a lower volume of water in the Bay, and decreased tidal volume would increase the residence time of river-discharge amplifying the sea-level-driven episodes. The hyposaline wedge associated with increased flooding since ENSO re-establishment ~3.5 ka likely forced younger accretions into deeper water. Because European colonization coincides with an episode of accretion we have an excellent opportunity to isolate historical causes of reef decline from novel anthropogenically-induced causes of decline.

## 2-14

**Holocene To Recent Foraminifera Assemblages Of Moreton Bay, Queensland, Australia: Assessing Modern And Historical Estuarine Habitats, Degradation And Foraminiferal Responses To Environmental/faunal Changes**

**Yogeeta Roshni NARAYAN*[1,2]**

[1]Earth Sciences, University of Queensland, Brisbane, Australia, [2]Centre for Marine Studies, University of Queensland, Brisbane, Australia

Moreton Bay (MB) is internationally (Ramsar), nationally (EPBC Act) and State (Marine Parks and Fisheries Habitat Reserves) recognized for its biodiversity, socio-economic and historical significance. The Bay and its large (21,220 km$^2$) catchment area are on the doorstep to Queensland fastest developing urban centre. The increasing population pressures and coastal development, coupled with the effects of climate change, have raised concerns over current conservation and management of critical habitats (i.e. seagrass meadows, fringing reefs) and biodiversity. At present, the MB Marine Park is undergoing assessment of the Bay's diverse habitats, compiling existing knowledge of the Bay's ecosystem and assessing the sustainability of ongoing activities. Investigations of the foraminiferal (foram) assemblages, which span the mid-Holocene (~6,500 years before present, ybp), through European colonization (~200 ybp) to the Recent, is timely with the above Action Plan.

The mid-Holocene was a time of climatic optimum. Coral communities flourished and were dominated by the fast-growing *Acropora* species. Since the mid-Holocene, oscillations in climate and the environment have influenced species diversity and composition. European settlement introduced anthropogenic inputs, furthering deterioration of habitats from increased sedimentation and pollution. This study aims to; 1) assess decadal changes in diversity and distribution of forams since the 1970's (Geological Survey of Queensland datasets); 2) survey assemblages from the Holocene through European colonization and correlate with concurrent coral community studies; and 3) evaluate sea-grass associated forams as a proxy for historical seagrass distribution and changes in water quality, in the last 200 years. Adequate understanding of the faunal changes, overtime, whether influenced by natural and/or anthropogenic impacts, is crucial in understanding long-term habitat degradation and providing baseline studies for future ecosystem management. Moreton Bay is an exceptional location for such a study and foraminfera play a valuable role in decadal and millennial scale investigations of biotic change in estuarine environments.

## 2-15

**Historical Collapse Of Acroporid Corals At Pelorus Reef, Inshore Great Barrier Reef**

**George ROFF*[1]**, Tara R CLARK[2], Jian-xin ZHAO[2], John M PANDOLFI[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]Centre for Microscopy & Microanalysis, University of Queensland, Brisbane, Australia

Since European settlement of the Queensland coastline in the mid-18th century, extensive changes in land usage within in the Great Barrier Reef (GBR) catchment region have occurred, resulting from increases in grazing, agriculture and land clearance. Evidence is accumulating that inshore reefs of the GBR are undergoing persistent phase shifts, with losses of previously dominant acroporid communities and local removal of coral species. Despite this, considerable difficulty exists in determining the extent and magnitude of the decline, primarily due to a lack of historical data on coral communities. To address this issue, we conducted palaeoecological reconstructions of coral communities through surveys of modern coral communities in conjunction with extensive collections of in-situ surface coral rubble (death assemblages) at Pelorus Reef (central GBR). Comparisons of sites with low modern coral cover (<5%) revealed a remarkable disparity between the composition and diversity of modern coral communities and death assemblages, with substrate dominated by extensive in-situ dead acroporid rubble. High-precision U-series dating of acroporid fragments by thermal ionization mass spectrometry revealed that the majority of acroporid mortality occurred much earlier than previously assumed, following the onset of European Settlement (~1860 AD) and prior to 1950 AD. In contrast, one site with a high cover of modern dominant coral genera (Pavona & Goniopora spp.) with in-situ death assemblages showed remarkable similarity in community composition and diversity, implying temporal stability of community structure. Representative dating of corals from the death assemblage using the high precision U-series method supports this, with mortality bracketed to within the last two decades. Our results suggest a long-term decline on previously dominant acroporid corals on the inshore reefs began long before the advent of monitoring in the late 1980's.

## 2-16

**Traits Of Surficial Carbonate Sediments At Reef Islands: Implications Of Climate Change To Island Fauna.**

**Mariana FUENTES*[1]**, John DAWSON[1], Scott SMITHERS[1], Mark HAMANN[1]

[1]EES, James Cook University, Townsville, Australia

Predicted intensification of climatic processes and changes in sea level and sea surface temperature, can greatly impact reef islands, their reef platform and its resident reef building organisms. This can affect island morphology and structure, as well as production, transportation and delivery of sediment to islands, potentially distressing island stability and the fauna that depend on them. Assessing the overall vulnerability and impacts of climate change to different reef islands is complex. Not only does an islands' sensitivity vary greatly, but also islands can be affected by a variety of natural and climate change stressors, which may also differ on temporal and spatial scales. Thus it is necessary to collect site specific data. Sedimentological traits from seven islands in the Great Barrier Reef (GBR) were characterised, these islands are not only the most important rookeries for the nGBR green turtle population, but also significant rookeries for seabirds. Sedimentological traits were used to investigate how these islands may adjust as impacts of climate change affect surrounding reefs and reef organisms. Differences in carbonate sediment structure were identified between each rookery. Distinctions include: i) highest concentrations of foraminifera at Bramble Cay; ii) significantly more molluscs at Milman Island, Sandbank 7 and Sandbank 8, iii) significantly more coral and coralline algae at Raine Island and Sandbank 8; and iv) Dauer Island being the only island with terrigenous material. Dissimilarities indicate that each site may be affected differently by climate change progresses. Affects of climate change to the islands studied here, which are used as nesting grounds for sea turtles and birds, will affect their populations through loss off eggs and reduction of optimal nesting habitat. This paper highlights the importance of understanding reef island vulnerability to climate change for an effective management of fauna that dependent on them.

## 3-1

### A Tropical Surface Water Calcium Carbonate Saturation History For The Late Pleistocene

**Bradley OPDYKE*[1]**, Stephen EGGINS[2]

[1]Research School of Earth Science, Australian National University, Canberra ACT, Australia, [2]Research School of Earth Science, The Australian National University, Canberra ACT, Australia

Knowing the history of the surface water calcium carbonate saturation in tropical waters is critical to understanding the dangers posed to Coral Reefs by declining saturation states in the future due to increased CO2 inputs from anthropogenic sources. We present here the first paleo- saturation record from the Indo-Pacific Warm pool region, specifically the Timor Sea, south of the Island of Timor. Near surface dwelling (0-50m) planktonic foraminifera Globigerinoides ruber were measured for the time intervals spanning 6-63Ka and 130 to 110Ka. Mg and Sr were measured employing a novel approach; laser ablation inductively coupled mass spectrometer (LA-ICP-MS). This method allows for precise determination of the chemistry of foraminifera tests in depth profiles of their trace element content. A stratigraphy was constructed from the MD 982167 core.

From each layer sampled, fifteen to twenty G. ruber per were analysed and the average value determined. In was discovered that Sr/Ca increases in Globigerinoides ruber at higher surface water saturation state and Sr/Ca peaks at 1.6 (mmol/mol) in the Early Holocene (8ka) and dips to 1.5 (mmol/mol) during colder time intervals back to Stage 5e (128ka) where the ratios return to Holocene values. Coral Reefs, also respond strongly to changes in temperature and calcium carbonate saturation state. Combining these data with paleotemperature data will allow us to predict where and how vigorously coral reef communities would have thrived going back in time. These paleo-saturaturation data not only allow us to put future changes of the chemistry of the surface sea water in context but will allow more accurate modeling of coral growth histories around the globe.

## 3-2

### The Darwin Point: a Conceptual and Historical Review

**Richard GRIGG*[1]**

[1]Oceanography, University of Hawaii, Honolulu, HI

The term “Darwin Point” is defined as the geographic or depth limit (threshold) beyond which vertical growth or net accretion of reef building corals is zero or negative. Consequently, coral reefs and/or atolls that exist at, below or beyond a Darwin Point threshold would be expected to undergo drowning under conditions of constant sea level. If present ecological conditions were to change, for example, due to a rise or fall in sea-level, or geophysical uplift or subsidence, or due to Global Climate Change, the geographic location or depth limit of a Darwin Point would correspondedly change. In this paper, the history of the Darwin Point concept is reviewed and several examples are given of reefs and atolls that have drowned having exceeded a Darwin Point threshold. Such appears to be the case for: 1) guyots beyond the northwestern end of the Hawaiian Archipelago, 2) atolls that crossed equatorial latitudes due to plate movement in the Pacific during Cretaceous Time, and 3) many drowned reefs extant at the present time; a result of sea-level rise since the last Glacial Maximum 21,000 years ago.

## 3-3

### Declining Coral Calcification in Massive Porites in Two Nearshore Regions Of The Northern Great Barrier Reef

**Timothy F COOPER*[1,2]**, Glenn DE'ATH[1], Katharina E FABRICIUS[1], Janice M LOUGH[1]

[1]Australian Institute of Marine Science, Townsville, Australia, [2]School of Marine and Tropical Biology, James Cook University, Townsvile, Australia

Temporal and spatial variation in skeletal density, linear extension and calcification rate in massive *Porites* from two nearshore regions of the northern Great Barrier Reef (GBR) were examined over a 16 year study period. Calcification rates declined by approximately 21% in the two regions, which are ~450 km apart. This is a function primarily of a decrease in linear extension (~16%) with a smaller decline in skeletal density (~6%). These changes were linear over time. Averaged across colonies, skeletal density declined over time from 1.32 g $cm^{-3}$ (SE = 0.017) in 1988 to 1.25 g $cm^{-3}$ (0.013) in 2003, equivalent to 0.36% $yr^{-1}$ (0.13). Annual extension declined from 1.52 cm $yr^{-1}$ (0.035) to 1.28 cm $yr^{-1}$ (0.026), equivalent to 1.02% $yr^{-1}$ (0.39). Calcification rates (the product of skeletal density and annual extension) declined from 1.96 g $cm^{-2}$ $yr^{-1}$ (0.049) to 1.59 g $cm^{-2}$ $yr^{-1}$ (0.041), equivalent to 1.29% $yr^{-1}$ (0.30). Mean annual seawater temperatures had no effect on skeletal density but a modal effect on annual extension and calcification with maxima at ~26.7ºC. There were minor differences in the growth parameters between regions. A decline in coral calcification of this magnitude with increasing seawater temperatures is unprecedented in recent centuries based on analysis of growth records from long cores of massive *Porites*. This talk will discuss the decline in calcification within the context of known environmental controls on coral growth. Although these findings are consistent with studies of the synergistic effect of elevated seawater temperatures and *p*CO2 on coral calcification, further data on seawater chemistry of the GBR are required to better understand the links between environmental change and effects on coral growth.

## 3-4

### Declining Calcification Rates Of Bermudan Brain Corals Over The Past 50 Years

**Anne COHEN*[1]**, Nicholas JACHOWKSI[2], Ross JONES[3], Struan SMITH[4]

[1]Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]Stanford University, Palo Alto, CA, [3]Bermuda Institute of Ocean Sciences, St Georges, Bermuda, [4]Georgia State University, Atlanta, GA

We used ScionImage (freeware) to quantify greyscale variability in CT-scan images of twenty colonies of the brain coral Diploria labyrinthiformis, collected live from four sites on Bermuda. The average colony age, determined from counts of annual high/low density couplets, was 45 years, spanning the time period 1959-2004 AD. A 233 yr-old colony, collected live, was also included in the analysis. 6cm-wide slabs, cut from the center of each colony were scanned alongside a series of Ca-hydroxyapatite standards of known density. The CT images (*.dicom) were manipulated to expose the appropriate (upward) orientation and slice thickness, in our case, 7.5 mm. Using ScionImage, greyscale variability (x-ray intensity) was quantified along a minimum of 10 tracks down the length of each colony, averaged and converted to density (g/cm3) using the standard calibration. Skeletal extension rates were determined from the distance (in mm) between successive high-density bands, and calcification rates as the product of extension and density.

Our data indicate that skeletal extension and calcification rates of D. labyrinthiformis across the reef declined significantly between 1959 and 2004. On average, annual skeletal extension rates decreased by more than 25%, from 4.2 (±0.2) mm/yr to 3.1 (±0.1) mm/yr, while annual calcification rates decreased by 25%, from ~4 g/cm2/yr to 3 g/cm2/yr. The last 45 years of growth of the 233-yr old coral reproduced these trends, indicating that ontogenetic processes were not a factor in the trends observed in the younger colonies. That documented changes in oceanographic conditions in the subtropical North Atlantic over the past 50 years - including rising SST, changes in circulation patterns linked to NAO and decreased saturation state of the surface ocean - may have individually or collectively influenced the skeletal growth of Bermuda’s corals, will be discussed.

## 3-5

**Reduced Skeletal Growth in The Scleractinian Coral *porites Lutea* From Southern Thailand – A Consequence Of Climate Change Over The Last Two Decades?**

**Jani TANZIL*[1]**, Barbara BROWN[1], Sandy TUDHOPE[2], Hansa CHANSANG[3]

[1]Newcastle University, Newcastle, United Kingdom, [2]Edinburgh University, Edinburgh, United Kingdom, [3]Phuket Marine Biological Centre, Phuket, Thailand

Of the few studies that have examined in situ coral growth responses to climate change, none have done so in equatorial waters already subject to relatively high temperatures (average >27°C). Comparison of coral growth of *Porites lutea*, a major reef building coral in the eastern Andaman Sea, sampled from eight sites on an inshore-offshore gradient around Phuket, South Thailand were made at two time periods (Dec 1984–Nov 1986 and Dec 2003–Nov 2005). Results revealed a significant decrease in coral calcification (~11%) and linear extension rates (~18%) in recent samples compared with those collected in the mid 1980s, while skeletal bulk density remained unchanged. Over this period, sea temperatures (SST) in the area have risen at a rate of 0.16°C per decade (current temperature range 28-30°C) and regression analyses of coral growth data, acquired at regular intervals over the period 1984-2005, suggest a link between rising temperature and reduced linear extension. These results contrast with earlier studies from reefs at higher latitudes, where sea temperatures are lower (average ~25–27°C) and where a positive relationship between linear extension and SST was found. The apparent sensitivity of linear extension in *P. lutea* to increased SST suggests that corals in the Andaman Sea may already be subjected to temperatures beyond their thermal optimum for calcification.

## 3-6

**Simulation And Observations Of Reef Corals Calcification Associated To Ocean Warming**

**Juan P. CARRICART-GANIVET*[1]**, Aimé RODRÍGUEZ-ROMÁN[2], Susana ENRÍQUEZ[2], Guillermo HORTA-PUGA[3], José D. CARRIQUIRY-BELTRÁN[4], Roberto IGLESIAS-PRIETO[2]

[1]El Colegio de la Frontera Sur, Unidad Chetumal, Chetumal, Q. Roo, Mexico, [2]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología, UNAM, Cancún, Q. Roo, Mexico, [3]Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Tlalnepantla, Edo. México, Mexico, [4]División de Geociencias Ambientales, Instituto de Investigaciones Oceanológicas, UABC, Ensenada, Baja California, Mexico

Reefs achieve positive carbonate balances when the calcification rates of reef-building corals and other organisms are larger that the rates of physical and biological erosion. We characterize the effects of short-term exposures to different temperatures on the calcification rates of the scleractinian Montastraea faveolata. Calculations of calcification rates under a modeled sea surface temperature (SST) future scenario for the West Atlantic indicate that increases in SST will result in significant reductions in coral calcification. Analyses of historical variations in calcification rates during the last 20 years of M. faveolata, growing in Veracruz, southern Gulf of Mexico, and massive Porites, growing in Rib Reef, Central Great Barrier Reef, are consistent with the experimental data, indicating negative associations with temperature. We found evidence that the local ocean warming trends have already resulted in significant reductions in calcification of both species, indicating that increases in temperature alone would severely compromise the abilities of corals to form and maintain reefs and their services. The observed reductions in calcification rates of M. faveolata in Veracruz are larger that the predictions of the physiological model, suggesting that other forcing processes in addition to increases in SST are responsible for the observed reductions in calcification. We show that relative small changes in the optical properties of the seawater are sufficient to explain the observations.

## 3-7

**Raman Spectroscopy of the Initial Mineral Phase of Coral Skeleton**

**Brent CONSTANTZ*[1]**

[1]Geological and Environmental Sciences, Stanford University, Stanford, CA

Recent studies suggest that the mineralogy of the scleractinian skeleton has been phenotypically plastic over geological time, varying with ocean chemistry, and dominated by physiochemical processes, under low levels of biologic control. Isotopic studies have demonstrated that scleractinian corals strongly fractionate carbon and oxygen from seawater during their skeletal mineralization process. Skeletal chemical studies have shown that that minor and trace elements in coral skeleton are also out of equilibrium with seawater. Furthermore, the degree of chemical fractionation is highly variable throughout the skeleton, but relatively consistent within particular anatomical structures. Mineralization of the scleractinian exoskeleton is initiated at centers of calcification located at the calcioblast ectodermal interface with the skeleton. The initial mineral phase of scleractinian coral skeletal has long been assumed to be the orthorhombic polymorph of calcium carbonate, aragonite. Past work has included crystallographic analysis using selected area electron diffraction of ion thinned specimens and various microanalytical chemical analyses that have shown that the initial mineral phase at the centers of calcification differs chemically and crystallographically from the aragonite fiber bundles comprising most of the skeleton. Due to the intricate microstructural anatomy, most studies have failed to properly locate the centers of calcification, and sample preparation artifacts have further complicated our understanding of the crystallographic character of the centers of calcification. Raman microscopy allows live coral skeleton to be observed in the physiologic state, controlling for both microstructure as well as mitigating sampling artifacts. Results to date indicate that highly unstable amorphous phases predominate the initial phase of mineralization in the scleractinian centers of calcification. These findings help explain why the crystallographic identity of the centers of calcification have to date been unclear. The new information from Raman microscopy has important implications with respect to the potential impact of ocean acidification on scleractinian skeletal formation.

## 3-8

**Daily Banding in Coral Septa.**

**Ian SANDEMAN*[1]**

[1]Biology, Trent Umiversity, Peterborough, ON, Canada

Fine banding has previously been described from different regions of coral skeletons. If present in septa, daily growth increments have the potential to provide, with a non-destructive technique, a record of recent growth. Sections of septa from eight coral species were mounted on glass microslides with thermo-setting resin, ground (10-20μ), and polished on both sides. With phase contrast optics, alternating light and dark laminations are apparent in the crystalline areas of the sections. The separation of the bands varied from 2-4μ in *Agaricia agaricites* to 10-15μ in *Meandrina meandrites*. In some septa (e.g. *M. meandrites*) banding is robust, in others banding was confined to the central part of the septa (e.g. *Montastrea*) and in some species banding was not seen at all (e.g. *Acropora cervicornis*). Small *A. agaricites* colonies were held in seawater with alizarin R (20mg/L) for two periods separated by four days. Two lines of stained skeleton confirmed that the laminations are diurnal and indicated that the darker bands (optically denser) are formed during the day and the lighter bands at night. Ground polished and stained sections of fixed *A. agaricites* mounted in epoxy resin showed, particularly in areas with high calcification, many bunches of spherical bodies (Golgi apparatus?) in the calicoblastic layers. These bodies are probably involved in the secretion of the organic matrix. A model of calcification is presented which suggests a mechanism by which the banding is produced. Following Vago et al (1997) physical extension takes place in the evening as a new layer of matrix is secreted and during the day calcium carbonate is deposited in the new matrix layer. In large septa the series of laminations representing several months of growth can be followed.

## 3-9

**Are Abiogenic Processes Sufficient To Describe The Formation Of Coral Skeletons?**

**Michael HOLCOMB*[1]**, Anne COHEN[1], Rinat GABITOV[2], Jeffrey HUTTER[3]

[1]Woods Hole Oceanographic Inst., Woods Hole, MA, [2]California Institute of Technology, Pasadena, CA, [3]The University of Western Ontario, London, ON, Canada

Microscale analytical and imaging techniques were used to compare morphological features and chemical signatures of abiogenic aragonites precipitated experimentally from seawater, and the aragonitic skeleton of scleractinian corals. Morphological features shared between abiogenic aragonites and coral aragonites include the spherulitic morphologies of the crystal bundles, the occurrence of granular crystals in nucleation regions and fibrous crystals in growth regions, and the presence of fine bands, composed of granular crystals, oriented perpendicular to the direction of fibrous growth. Fusiform-shaped crystals, morphologically similar to those found in corals, were also produced experimentally. Under experimental conditions, crystal morphology appears linked to saturation state. Only under highly supersaturated conditions were fusiform crystals formed (Omega > 25), at slightly lower saturation states, granular crystals with morphologies similar to those found in the centers of calcification of coral skeletons were produced. Aragonite fibers with morphologies similar to those found in fiber bundles in coral skeletons were produced at moderate supersaturation states, while at the lowest saturation states (Omega 4-5), the aragonite fibers formed were much broader and more widely separated than those found in coral skeletons. In both abiogenic aragonites and coral skeletons, the granular nucleation regions are characterized by high Mg/Ca ratios compared with the fibrous growth regions. Further, abiogenic aragonite and coral skeletons show similar patterns of fluoresence when stained with acridine orange, with regions of granular crystals appearing to fluoresce more intensely. These data suggest that many features of coral skeletons are also characteristic of abiogenic aragonite grown from seawater. Based on these observations, cycles in the saturation state of the coral's calcifying fluid is proposed as a plausible explanation for many of the features observed in coral skeletons.

## 3-10

**Coral Skeletons: From Calcium Carbonate To Intricate Architecture**

**Elizabeth GLADFELTER*[1]**

[1]Marine Policy Center, Woods Hole Oceanographic Institution, Woods Hole, MA

A coral skeleton is an intricate architecture of aragonite forming a scaffolding to support the soft tissues of the animal. Our understanding of the inorganic and organic chemical processes that result in these beautiful and elaborate structures is still evolving. This is due partly to the fact that many studies of coral skeletal growth and calcification are complicated by the role of zooxanthellae in enhancing rates of calcification. Another important aspect is reconciling the physical (and temporal) scales at which various studies were conducted. Some recent papers have emphasized the role of an organic matrix in coral calcification, while others have focused on the essentially inorganic processes of crystal nucleation and growth that can be produced without organic input. A model of biomineralization must address the chemistry operative between collections of inorganic atoms (e.g., nucleation centers; crystal faces) and the multiple arrays of molecules arranged across organic surfaces (e.g., insoluble proteins, lipid membranes). We need to understand how molecular-based interactions are integrated into higher levels of organization and dynamics.

In this work, I examine two key elements of a biomineralization model: (1) the morphology and site of deposition and growth of the various types of crystals that compose the skeleton; and (2) the role of organic macromolecules in controlling the synthesis, construction and organization of the architecture of the skeletal form. The result is a model of biomineralization of corals that recognizes the production of the skeleton as an example of "organized-matter chemistry" involving chemical composition, synthesis and emergence of organized architectures and complex forms. This model identifies critical areas for further research to better understand this crucial process, i.e. coral calcification, in coral reefs.

## 3-11

**Large-Scale, In-Situ Measurements Of Coral Reef Community Metabolism Using An Integrated Control Volume**

**Cameron MCDONALD*[1]**, Robert DUNBAR[2], Jeffrey KOSEFF[1], Stephen MONISMITH[1], Ove HOEGH-GULDBERG[3], Matthew REIDENBACH[4]

[1]Civil and Environmental Engineering, Stanford University, Stanford, CA, [2]Geological and Environmental Sciences, Stanford University, Stanford, CA, [3]Center for Marine Studies, University of Queensland, Brisbane, Australia, [4]Department of Environmental Sciences, University of Virginia, Charlottesville, VA

In-situ, ecosystem level measurements of inorganic carbon fluxes in a coral reef are critical to understanding how the reef functions and interacts with the surrounding ocean; furthermore, ongoing monitoring of this community metabolism will be essential to assess the effects of ocean acidification on reef health and net community calcification. Traditional methods for measuring reef metabolism have had some limitations, for example: constraints on location and flow regime, and lack of spatial or temporal resolution. The method presented here utilizes a combined Eulerian-Lagrangian control volume approach wherein carbon system parameters are monitored in place, under natural flow conditions. This enables calculation of inorganic carbon fluxes on time-scales of minutes to hours in almost any reef sub-environment. A 20m by 40m Integrated Control Volume was deployed on the fore-reef of Heron Island, Australia (23° 27' S, 151° 55' E) as a test of the ICV concept. Carbon system parameters were measured continuously by pumping seawater from 6 different depths at each corner of the volume. To measure seawater fluxes the hydrodynamic field within and adjacent to the ICV was characterized using 1200 kHz Acoustic Doppler Current Profilers, high frequency (25 Hz) Acoustic Doppler Velocimeters, and thermistor strings set at different distances down the reef slope. We measured clear gradients in carbon system parameters, vertically, along the flow, and also in the cross-shelf direction. The most consistent gradients were in the cross-shelf direction with total dissolved inorganic carbon (TDIC or ΣCO2) lower inshore during the day and higher at night. Night sampling showed a strong respiration signal. Periods of both net dissolution, and net calcification were observed. The ICV method shows promise for in-situ monitoring of reef metabolism; potentially allowing determination of the relationships between primary production, carbonate saturation state, and rates of net community calcification.

## 3-12

**Studies Of The Calcfication Rate Of The Coral Reefs in The Bight Of Parguera, Puerto Rico**

**Chris LANGDON*[1]**, Jorge CORREDOR[2]

[1]MBF, Uni. of Miami/ RSMAS, Miami, FL, [2]Dept. of Marine Science, Uni. of Puerto Rico, Mayaguez, Puerto Rico

Little is known about how the calcification of coral reefs in the Caribbean has changed in the past 30 years. As a result it is not possible to document how this important reef-building and sustaining process has changed in response to increasing sedimentation, eutrophication, outbreaks of disease, collapse of Diadema, overfishing, bleaching events and increasing ocean acidification. With the saturation state of the surface ocean currently declining at a rate of -0.013 to -0.025 units $y^{-1}$ we can expect a decrease in calcification of 0.4 to 0.8% $y^{-1}$. If a warming rate of 0.02 to 0.06°C $y^{-1}$ is factored in based on IPCC's low emission (B1) and higher emission (A1F1) scenarios the rate of decline could increase to 0.9 to 2.2% $y^{-1}$ and these calculations only consider the direct effect of temperature on calcification. Corals also exhibit a thermal threshold of 2-3°C above the normal summer ambient temperature at which point calcification abruptly shuts down. In response to a clear need to establish both a baseline and to better understand the response to climate change a study of the community calcification of the coral reefs in the Bight of Parguera, Puerto Rico has been undertaken. Results indicate that in May 2007 salinity normalized total alkalinity (NTA) decreased from 2278 uEquiv $kg^{-1}$ offshore to 2247 at the outer rank of reefs to 2130 at the reefs closest to shore. With a detailed knowledge of bathometry and the residence time of the waters the spatial distribution of NTA could be turned into a map of the community calcification of the region. If the average draw down of NTA relative to offshore source water is taken as 74 uEquiv $kg^{-1}$, the mean water depth as 3 m and the average residence time as 14 days then the average community calcification rate would be 8 mmol $CaCO_3$ $m^{-2}$ $d^{-1}$ or about 30% of the average complete reef-system rate established by Kinsey (1985).

## 3-13

**Dissolution of Calcium Carbonate in Coral Reefs**

**Hajime KAYANNE*[1]**, Atsushi WATANABE[2], Makoto TERAI[1], Shoji YAMAMOTO[1], Tatsuki TOKORO[1], Ken NOZAKI[3], Ken KATO[3], Akira NEGISHI[3]

[1]Department of Earth and Planetary Science, University of Tokyo, Tokyo, Japan, [2]Hydroshperic Atmospheric Research Center, Nagoya University, Nagoya, Japan, [3]National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan

Acidification of the ocean by anthropogenic $CO_2$ absorption leads to decrease in the saturation state of calcium carbonate, and thus calcification in the ocean. Dissolution of calcium carbonate is predicted to occur in the high-latitude ocean, where aragonite saturation state will become under-saturated during the 21st century. On the other hand, coral reefs distributed in the tropical ocean have high saturation state, and is not thought to be dissolved by the acidification. However, on-site continuous monitoring of alkalinity in reef water at Shiraho Reef in the Ryukyu Islands showed that dissolution actually occurred during nighttime as shown by increase in total alkalinity. Even during the time of the dissolution, aragonite saturation state never decreased below one. When the aragonite saturation state decreased below 3, net calcification becomes 0 and dissolution occurred below this value. During nighttime, aragonite saturation state in pore water of the reef sediment decreased below 2, which is lower than the saturation state of the water column but still over-saturated for aragonite. We thought magnesian calcite contributed to the dissolution, as it is generally soluble than calcite and aragonite but little information has been obtained so far. We conducted a laboratory experiment to examine its dissolution. Magnesian calcite started to dissolve under aragonite saturation state of 2.0. Based on the field monitoring and laboratory experiment, we hypothesided that saturation state decreases below this threshold value in pore water of the sediment, and magnesian calcite starts to dissolve even at present condition. The results suggest that coral reefs are more soluble than has been thought and may act as a large buffer against $CO_2$ increase.

## 3-14

**Use Of Replicated Coral Reef Mesocosm Studies To Establish The Potential Impact Of Ocean Acidification.**

**Paul L. JOKIEL*[1]**, Ku'ulei S. RODGERS[1], Ilsa B. KUFFNER[2], Andreas ANDERSSON[3], Fred T. MACKENZIE[4], Evelyn F. COX[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]Florida Integrated Science Center, U. S. Geological Survey, St. Petersburg, FL, [3]Bermuda Institute of Ocean Sciences, St. George, Bermuda, [4]Department of Oceanography, University of Hawaii, Honoloulu, HI

A mesocosm facility designed to conduct long term controlled experiments on the consequences of ocean acidification on coral reefs has been developed at the Hawaii Institute of Marine Biology. The facility uses replicated continuous flow coral reef mesocosms flushed with unfiltered sea water from the adjacent reef in Kaneohe Bay, Oahu, Hawaii. The mesocosms are located in full sunlight and experience diurnal and annual fluctuations in temperature and sea water chemistry characteristic of the adjacent reef. In the initial long term (10 month) experiment the treatment mesocosms were acidified to midday pCO2 levels exceeding control mesocosms by approximately 365 µatm, which is a level expected later in this century. Under these conditions crustose coralline algae (CCA) developed 25% cover in the control mesocosms and only 4% in the acidified mesocosms. Free-living associations of CCA known as rhodoliths that were held in the control mesocosms increased at the rate of 0.6 g buoyant weight yr-1 while those in the acidified experimental treatment decreased in weight at a rate of 0.9 g buoyant weight yr-1. CCA play an important role in the growth and stabilization of carbonate reefs, so future changes of this magnitude could have great impact on these systems. Coral calcification decreased by 14% to 26% under acidified conditions. Coral rate of calcification per unit of linear extension decreased by 6% to 8% in the acidified treatment, indicating that corals were laying down a somewhat more fragile skeleton at higher pCO2. On the other hand, various other calcifying organisms such as barnacles and oysters showed little or no response to the acidified treatment. No differences were observed in coral gamete production by Montipora capitata and coral recruitment by Pocillopora damicornis. Advantages and disadvantages of the mesocosm approach are discussed.

## 3-15

**Nutrient Loading Affects the Relationship Between Coral Calcification and Aragonite Saturation State**

**Pascale CUET*[1]**, Marlin ATKINSON[2], Aline TRIBOLLET[3], James FLEMING[2], Daniel SCHAR[2], James FALTER[2]

[1]ECOMAR, Universite de la Reunion, Saint-Denis, France, [2]Hawaii Institute of Marine Biology, Kaneohe, HI, [3]IRD, Marseille, France

Coral calcification (G) is proportional to the ambient sea water saturation state of aragonite (ΩA). It has also been established that G is reduced by high nutrients, but it is not apparent how nutrient loading and ΩA interact. Experiments were conducted to determine the effect of nutrient loading on the ″G - ΩA relationship″. Coral communities comprised of *Montipora capitata*, *Porites compressa* and *Pocillopora damicornis* were placed in a wave flume in which temperature, light, water motion, nutrient loading and initial ΩA were controlled. The flume was closed over 4 to 5 day periods, resulting in a decrease in ΩA from 4 to 1. Gross primary production and community respiration were respectively 320 ± 37 and 406 ± 55 mmolC m-2 d-1. Independent of the nutrient loading, we observed a decrease in the calcification rate with a decrease in ΩA, with no net 24H - calcification occurring at ΩA ≈ 1 - 1.5. Calcification rate of the high nutrient loading (1 mmolP m-2 d-1 and 24 mmolN m-2 d-1), however, was 2 times higher than the low one (0.06 mmolP m-2 d-1 and 0.3 mmolN m-2 d-1) at ΩA = 3 (respectively 186 and 100 mmolCaCO3 m-2 d-1). The range in calcification was similar to that in the field, and the high nutrient loading was near the upper limit of nutrient uptake. Our results are contrary to the established view that nutrients reduce calcification, and indicate that there is an optimal nutrient loading that enhances calcification. It is likely that constant nutrient uptake is required to offset nutrient release from basic metabolism. The high nutrient corals showed a relatively high calcification at ΩA between 2 and 4. Therefore, further experiments should simulate nutrient loading of the field to improve our understanding of the G - ΩA relationship.

## 3-16

**Aragonite Saturation State And Seawater Ph Do Not Predict Calcification Rates Of The Reef-Building Coral Madracis Mirabilis.**

**Christopher JURY*[1]**, Robert WHITEHEAD[2], Alina SZMANT[3]

[1]Biology and Marine Biology, University of North Carolina Wilmington, Wilmginton, NC, [2]Center for Marine Science, University of North Carolina Wilmington, Wilmington, NC, [3]Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC

The calcification rate of corals has been found to decrease under experimental conditions with reduced seawater aragonite saturation state (Ωarag), but it is unclear how this relates to changes in seawater chemistry due to anthropogenic CO2 enrichment. The reduction of carbonate concentration ([CO32-]) has been suggested to drive this response, but physiological data suggest that bicarbonate ion (HCO3-) and not CO32- serves as the carbon source for coral calcification. Reduced pH has also been suggested as the cause of reduced coral calcification but no study to date has adequately separated the effects of these two parameters. This study tested whether seawater pH, [CO32-], or both affect rates of calcification in corals. *Madracis mirabilis* nubbins were incubated in one of four treatment chemistries (produced by manipulation of pCO2 and total alkalinity): 1) pHT = 8.06, [CO32-] = 260 µmol kg-1 (control), 2) pHT = 7.77, [CO32-] = 150 µmol kg-1 (low pH, low [$CO_3^{2-}$]; 3x pre-industrial pCO2 conditions), 3) pHT = 7.77, [CO32-] = 260 µmol kg-1(low pH, normal [$CO_3^{2-}$]), and 4) pHT = 8.06, [CO32-] = 150 µmol kg-1(normal pH, low[$CO_3^{2-}$]). Relative to the controls, Treatment 2 resulted in a ca. 10 % increase in calcification; Treatment 3 in a ca. 21 % increase in calcification; and Treatment 4 in ca. 43 % reduction in calcification. The results indicate that rates of calcification in the coral *Madracis mirabilis* are not correlated to either seawater pH or [CO32-]. Instead, calcification is better correlated with [HCO3-] in all experimental treatments. These results imply that projected changes in Ωarag or pH may not offer appropriate models of coral responses to ocean acidification and that not all corals may be negatively affected by acidification.

## 3-17

**The Effect Of Depressed Aragonite Saturation State On Larval Settlement, Post-Settlement Survivorship, And Growth Of The Brooding Coral *porites Astreoides* And The Broadcast-Spawning Coral *montastrea Faveolata***

**Rebecca ALBRIGHT*[1]**, Benjamin MASON[1], Chris LANGDON[1]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

In conjunction with the projected increases in *p*CO2 of the coming century, adult coral growth and calcification are expected to decrease significantly. However, no published studies have investigated the effect of elevated *p*CO2 on earlier life history stages of corals. As coral recruitment, post-settlement survivorship, and growth are critical to reef persistence and resilience, it is of timely importance to better understand the repercussions on such factors. Larvae and gametes of *Porites astreoides* and *Montastrea faveolata* (respectively) were collected from reefs in Key Largo, Florida, fertilized (*M. faveolata*) and settled and reared in controlled saturation state seawater. The effect of treatment water on settlement and post-settlement growth was examined. Three treatment levels were targeted based on present (380 ppm) and projected *p*CO2 scenarios for the years 2065 (560 ppm) and 2100 (720 ppm). Corresponding saturation states of treatment water were obtained using 1M HCl additions: $\Omega = 3.19 \pm 0.13$ (control), $2.59 \pm 0.08$ (mid), and $2.16 \pm 0.12$ (low). Larvae were introduced to their respective treatments and allowed one week to settle onto pre-conditioned limestone tiles. Percent settlement was determined by examination under a dissecting microscope. Settled larvae were placed in flow-through treatment aquaria (25°C) and growth rates were analyzed over the course of twenty-one days, using high magnification photographs and SPOT© Softwareto monitor changes in total surface area (mm2). Results indicate that saturation state had no significant effect on percent settlement of *P. astreoides* or *M. faveolata* larvae. Skeletal extension rates of *P. astreoides* spat exhibited a positive correlation with saturation state, while tissue growth rates of *M. faveolata* spat were not significantly affected.

## 3-18

**Monitoring Oceanic And Coastal Variability in Carbonate Chemistry: Tracking Ocean Acidification in The Greater Caribbean Region**

**Dwight GLEDHILL*[1]**, R WANNINKHOF[2], F.J. MILLERO[3], C. M. EAKIN[4], C. LANGDON[3], J. HENDEE[2], T.R.L. CHRISTENSEN[1], A.E. STRONG[4], W.J. SKIRVING[4], J.A. MORGAN[1], G. LIU[1], S.F. HERON[4]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]NOAA OAR AOML, Miami, FL, [3]Rosenstiel School, University of Miami, Miami, FL, [4]NOAA Coral Reef Watch, Silver Spring, MD

The surface oceans serve as an important natural sink for increasing atmospheric carbon dioxide (CO2) concentrations. As this CO2 reacts with seawater it reduces pH (acidification) and redistributes inorganic carbon species. Ocean acidification decreases the availability of carbonate ions that are vital to biocalcification processes, including those of prominent reef building organisms. Mapping and monitoring the distribution of such changes provides an important context for understanding the potential impacts of ocean acidification and identifying the most susceptible regions. Using satellite remote sensing and modeled environmental parameters, we have extended *in situ* observations obtained from Volunteer Observing Ships (VOS) and multiple geochemical surveys to derive estimates of the oceanic changes in sea surface carbonate chemistry throughout the Greater Caribbean Region. The results reveal considerable spatial and temporal variability throughout the region transposed over a strong secular decrease in aragonite saturation state (Ωarg) at a rate of ~ $-0.12 \pm 0.01$ Ωarg decade-1 ($r2 = 0.97$, $P<0.0001$). This rate is comparable to that estimated from recent geochemical models for Atlantic subtropical surface waters and as recorded at the nearby Bermuda Atlantic Time-Series station. Sustained observations of CO2 partial pressure (pCO2) from autonomous systems deployed at two reef sites in the region reveal considerable seasonal variability relative to oceanic waters as a consequence of benthic metabolic activity. We will present an examination of these seasonal variations in carbonate chemistry for the Greater Caribbean Region in both oceanic and coral reef occupied coastal waters.

## 3-19

**Remote Sensing Of Changes in Carbonate Production On Reefs: The Florida Keys**

**Christopher MOSES*[1]**, David PALANDRO[2], Serge ANDREFOUET[3], Frank MULLER-KARGER[4]

[1]College of Marine Science, University of South Florida, Saint Petersburg, FL, [2]Florida Fish & Wildlife Research Inst., Saint Petersburg, FL, [3]Institut de Recherche pour le Développement (IRD), Noumea, New Caledonia, [4]Univ. Massachusetts Dartmouth, New Bedford, MA

Using satellite remote sensing, it is possible to scale-up *in situ* observations of carbon and carbonate production on coral reefs from habitat scales ($10^{-1}$-$10^{0}$ km$^2$) to regional ($10^{3}$-$10^{4}$ km$^2$) estimates. Multi-spectral satellite imagery from Landsat, with 30 m spatial resolution, is both sufficiently accurate and cost effective for performing such scaling-up exercises. Using a time series of Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) spanning 18 years from 1984-2002, it is possible to quantify changes in the spatial extent of reef habitats (e.g., dense live cover) in the Florida Keys. This study focused on the shallow (<6 m) backreefs, reef flats, and forereefs along the length of the Upper, Middle, and Lower Florida Keys.

Twenty-eight georectified images were subjected to atmospheric and water column corrections, then calibrated to remote sensing reflectance ($R_{rs}$) for change detection analyses. Published values for production were applied additively to estimate overall changes in production. A decline in cover of coral habitat of >50% is observed both *in situ* and by satellite between 1996-2002, and is reflected in changes in production estimates. Similar approaches could be applied over other areas with good temporal availability of remote sensing imagery validated by *in situ* observations. Using remote sensing as a tool for scaling-up *in situ* measurements of production has potential applications for monitoring synoptic scale environmental impacts, such as the broad reaching effects from ocean acidification.

## 3-20

**Comparative Microarray Analysis During Onset Of Calcification In The Phylogenetic Distinct Scleractinian Coral Species Acropora Millepora And Montastraea Faveolata.**

**Alejandro REYES*[1,2]**, Chris VOOLSTRA[1], Lauretta GRASSO[3], David HAYWARD[3], Eldon BALL[3], Alina SZMANT[4], Roberto IGLESIAS[5], David MILLER[2], Monica MEDINA[1]

[1]Natural Sciences, UC Merced, Merced, CA, [2]Molecular Sciences, James Cook University, Townsville, Australia, [3]Research Shool of BIological Sciences, Australian National University, Camberra, Australia, [4]Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC, [5]Instituto de Ciencias del Mar y Limnologia, Universidad Autónoma Nacional de México, PuertoMorelos, Mexico

In reef building corals, cells from the calicoblastic ectoderm secret and mature an organic matrix. In this matrix, calcium ions are concentrated and calcium carbonate crystals incorporated into the massive exoskeleton. These calcareous structures not only provide protection for coral polyps, they also constitute the framework of the reef ecosystem. Current concerns, that rising atmospheric CO2 may inhibit the biological deposition of calcium carbonate in the marine environment, have directed attention to the way in which coral reefs will respond to climate change.

Although it is likely that conserved molecular mechanisms regulate skeleton deposition in scleractinian corals, there is evidence suggesting that differential organic matrix composition and physiological plasticity might be responsible for species-specific responses to environmental perturbations. To test this idea we are comparing gene expression microarray data from two phylogenetic distant hermatypic coral species: Acropora millepora (Complex clade), and Montastrea faveolata (Robust clade).

Microarray analysis for each species included non-calcifying aposymbiotic planulae, calcifying aposymbiotic primary polyps as well as adult symbiotic calcifying samples. In both cases a number of extracellular membrane matrix proteins, carbonic anhydrase, carbohydrates transporters and cytoskeleton regulators were differentially expressed in calcifying stages when compared to non-calcifiyng samples. The identification of species-specific gene expression patterns might help understand calcification related processes that are either conserved or coral clade-specific.

## 4-1

**Coralline P/Ca: Evidence For A New Seawater $PO_4$ Proxy**

**Michèle LAVIGNE*[1]**, Robert M. SHERRELL[2], M. Paul FIELD[1], Eleni ANAGNOSTOU[1], Kim COBB[3], Andréa G. GROTTOLI[4], Braddock LINSLEY[5], Gerard M. WELLINGTON[6]

[1]Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, [2]Institute of Marine and Coastal Sciences and Department of Earth and Planetary Sciences, Rutgers University, New Brunswick, NJ, [3]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, [4]School of Earth Sciences, The Ohio State University, Columbus, OH, [5]Department of Earth and Atmospheric Sciences, University at Albany, State University of New York, Albany, NY, [6]Biology and Biochemistry, University of Houston, Houston, TX

A proxy for surface water nutrient concentrations, recorded in coral skeleton, would provide novel records of sub-seasonal to centennial variations in nutrient dynamics and primary production in the past. Records of tropical euphotic zone nutrient supply and uptake could link decadal-centennial scale climate oscillations to low latitude carbon fixation more directly than can be achieved using available paleo-SST/upwelling proxies alone. A coral proxy for seawater phosphate would complement records from established but quantitatively uncertain surface water upwelling proxies in coral such as Cd/Ca and Ba/Ca. Using solution phase and laser ablation HR-ICP-MS methods, we have found that average skeletal P/Ca in surface corals growing in regions with distinct nutrient regimes (Gulf of Panamá (*Pavona gigantea*), Martinique (*Montastrea faveolata*), Pacific Line Islands and Rarotonga (*Porites lutea*)) are positively correlated with mean local surface phosphate concentrations. Further, a 4-year record along the growth axis of the *Pavona gigantea* coral growing under seasonally varying nutrient levels in the upwelling regime of the Gulf of Panamá shows repeated annual cycles of P/Ca (~75 -230 µmol/mol), with maxima occurring during cool upwelling periods, following the ~3 fold seasonal variations of surface water phosphate (LaVigne et al., in review). Based on rigorous solution cleaning and soluble reactive phosphate analyses of drilled powders, we hypothesize that the P/Ca signal measured by ICP-MS reflects a combination of inorganic and organic intracrystalline phases, incorporated in proportion to ambient seawater phosphate. We plan to further investigate the skeletal P incorporation mechanism and test the validity of this new proxy in corals of different ages and nutrient environments. Modern cores from the Pacific Line Islands (~160ºW, 2-4ºN) will be used to evaluate coralline P/Ca (preliminary range ~30-60 µmol/mol) for reconstructing tropical Pacific nutrient availability in relation to past ENSO-driven changes in equatorial upwelling.

## 4-2

**U/ca As A Possible Proxy Of Carbonate System in Coral Reef**

**Alrum ARMID*[1]**, Yuki TAKAESU[1], Tanri FAHMIATI[1], Hiroyuki FUJIMURA[1], Tomihiko HIGUCHI[1], Eiko TAIRA[2], Tamotsu OOMORI[1]

[1]Department of Chemistry, University of the Ryukyus, Japan, Nishihara, Japan, [2]Aqua Culture Okinawa, Japan, Nishihara, Japan

Increasing carbon dioxide in the atmosphere and absorption into the ocean will modify the carbonate chemistry of the surface ocean. The atmospheric $CO_2$ level has already increased from the concentration of 280 ppm in the pre-industrial age to 380 ppm in 2007, and it is predicted to reach 560 ppm before the end of the 21st century. Ocean acidification influences calcium carbonate ($CaCO_3$) equilibrium of the ocean due to the decrease in carbonate ($CO_3^{2-}$) ion concentration. During calcification process of marine carbonates (such as coral), some trace elements can be incorporated into carbonate skeleton. Since the elevated atmospheric $CO_2$ reduces the oceanic pH, and the alteration of oceanic pH governs both the ocean carbonate chemistry and the speciation of elements, the mechanism of trace elements incorporated into coral skeleton will be also affected.

In seawater, $UO_2^{2+}$ forms complex ions such as $UO_2CO_3^0$, $UO_2(CO_3)_2^{2-}$, and/or $UO_2(CO_3)_3^{4-}$. Uranium is thought to be incorporated into carbonate as uranyl ($UO_2^{2+}$) ion. However, the mechanism of their incorporation into coral skeleton based on the pH changes is poorly understood. Therefore, study of such complex uranyl ions incorporated into coral skeleton is significantly needed to establish basic concept of uranium uptake by coral.

Incorporation of uranium into coral skeleton was investigated in the labotatory incubation under the controlled $pCO_2$ at 27°C. Distribution coefficient, $\lambda UO_2$, between coral skeleton and seawater was measured, which varies from 2.6 to 0.6 with the change in $CO_3^{2-}$ ion activity in seawater.

## 4-3

**A Rayleigh-Based Approach To Coral Thermometry: Seeing Through The "Vital Effect"**

**Glenn GAETANI*[1]**, Anne COHEN[1], Zhengrong WANG[1,2]

[1]Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]Yale University, New Haven

Paleotemperature proxy records are typically derived from coral skeleton using empirical relationships between elemental ratios and water temperature. While this approach has produced significant advances in our understanding of Earth's climate system, its accuracy is limited by the impact of physiological processes ("vital effects") on compositional variability within the skeleton. Several recent studies have identified the importance of Rayleigh fractionation in producing "vital effects" in coral skeleton, providing the basis for a new approach to coral paleothermometry. In contrast with conventional paleothermometry, this approach does not rely on calibrations involving living corals, and no prior knowledge of water temperature is required. By combining analyses of multiple elemental ratios (Mg/Ca, Sr/Ca and Ba/Ca) from a given coral skeleton with experimentally determined partition coefficients for abiogenic aragonite, a mathematically overconstrained system of Rayleigh equations can be constructed that describe element fractionations during coral biomineralization. While these equations cannot be solved explicitly for temperature, global minimization techniques can be used to derive ocean temperatures. The accuracy and precision of this approach was tested on aragonite skeletons from two coral species grown in significantly different environments: (1) *Acropora* sp., a symbiont-bearing tropical coral grown at 21 to 29°C by Reynaud et al. (2007, Geochim Cosmochim Acta,71:354-362) and (2) *Lophelia pertusa*, an asymbiotic, cold-water coral collected from a depth of 129 m on the Tisler Reef, NE Skagerrak, where water temperature ranges from ~5 to ~9°C. Results from these corals show that our approach is yields ocean temperatures that are both accurate and precise to within a few tenths of a degree, and that it is applicable both across species and to corals growing in vastly different environments.

## 4-4

**Identification And Calibration Of Proxies For Thermal And Disease Stress From Lipid Biomarkers**

**Jessie KNEELAND*[1]**, Konrad HUGHEN[1], James CERVINO[2,3], Erich BARTELS[4]

[1]Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]Pace University, New York, NY, [3]Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, [4]Mote Marine Laboratory, Summerland Key, FL

New lipid biomarkers indicative of thermal and disease stress on corals are important for assessing coral health, and lipids also have the potential for preservation in coral aragonite. To identify such stress biomarkers, we cultured *Symbiodinium* zooxanthellae clade subtypes A, B, C1 and D1 at one-degree temperature increments (24-32 degrees C), with and without introduction of *Vibrio* pathogens, for 1 to 5 weeks. We also performed analagous incubations of whole coral samples of *Montastraea faveolata* from Summerland Key, Florida. Lipids were extracted from the cells using a Bligh and Dyer protocol, and were analyzed by gas chromatography and mass spectrometry. Triplicate cultures under each set of conditions were analyzed up to three times each to ensure a reproducible signal. Resulting indices are calculated as ratios of lipids, providing a robust measure that is not sensitive to total lipid abundance and non-constant sample size. The ratios of fatty acid to sterols, and unsaturation ratios in the fatty acids respond strongly to both increasing temperatures and length of exposure. Comparisons between cultured *Symbiodinium* lipids and coral tissue, and comparisons between diseased and non-diseased samples, demonstrate the potential for biomarkers as thermal and disease stress proxies.

## 4-5

**Coral Record of Ba/Ca from the Southern Gulf of Mexico and its Relationship to Fluvial Discharge**

**Guillermo HORTA-PUGA*[1]**, José D. CARRIQUIRY[2]

[1]Facultad de Estudios Superiores Iztacala, UBIPRO, Universidad Nacional Autónoma de México, Tlalnepantla, México, Mexico, [2]Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Ensenada, Baja California, Mexico

The Ba/Ca ratio in the annual growth bands of Montastraea faveolata from the Veracruz Reef System was used to record long-term environmental change associated to anthropogenic activity in the Southern Gulf of Mexico (SGM). Annual samples, from cores of two colonies collected at Anegada de Adentro and Isla Verde reefs, were cleaned to quantify both the total and the Ca-sustitutive Ba/Ca ratios by ICP-OES. The total and the Ca-sustitutive Ba/Ca records from the Anegada de Adentro reef were similar for the period 1835-2002, ranging from 5.9 to 10.2 µmol/mol with averages of 7.8 µmol/mol. As no significant statistical differences were found between records, it is concluded that almost all Ba is incorporated in the Ca-sustitutive fraction. The Ba/Ca ratio average increased from 7.4 µmol/mol in the 1835-1920 period to 8.2 µmol/mol in the 1920-2002 period. As the human population in the SGM increased >600% in the last period, it is probable that the sediment load of river waters also increased due to higher erosion rates enhanced by human activities, which also caused and increase of about 10% in the concentration of Ba in the seawater of the SGM. The 62-yr record of Ba/Ca from Isla Verde reef (1941-2002), showed a significant correlation with the Jamapa River total annual discharge for the periods 1957-1974 ($r=0.78$, $p<0.05$) and 1988-1996 ($r=0.54$, $p<0.05$). Thus, most of the coral Ba content derives from suspended sediments delivered to the SGM by the river. The periods when correlation (with the river's discharge) decreased abruptly are coincident with peaks of high barite production in the USA, in 1975-1985 and 1995-2002. This suggests that barite, a component of drilling-muds used in oil industry in the northern Gulf of Mexico, could be transported by surface ocean currents, becoming and additional source of Ba in the SGM.

## 4-6

**Mg Isotope Fractionation in Corals: Developing A Promising Paleothermometer**

**Zhengrong WANG*[1]**, Anne COHEN[2], Glenn GAETANI[2], Rinat GABITOV[3], Stanley HART[2]

[1]Geology and Geophysics, Yale University, New Haven, CT, [2]Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA, [3]Division of Geological and Planetary Sciences, Caltech, Pasadena, CA

We report a systematic study of Mg isotope fractionation that reveals temperature-correlated annual δ26Mg cycles in coral skeletons. δ26Mg ratios were measured in the skeleton of the massive reef corals and in experimental abiogenic aragonites precipitated from seawater. Clear annual cycles in δ26Mg were observed in two *Montastrea* and one *Porites* coral colonies that experienced seasonal SST changes of 4 oC and 7 oC, respectively. We tested for "vital effects" by comparing δ26Mg along 'bumps' and 'valleys' of the same *Montastrea* coral. δ26Mg values were consistent between 'bumps' and 'valleys', whereas Sr/Ca ratios showed significant differences. We empirically calibrated the temperature-dependence of Mg isotope fractionation between corals and seawater. This fractionation factor has a linear relationship to inverse absolute temperature, corresponding to a temperature sensitivity of about 0.10 per mil/oC for both corals, which is slightly larger than the measurement precision of our improved analytical technique to resolve degree-level sea surface temperature variation (c.a. 0.09 per mil for ~ 1 mg sample). Moreover, the Mg isotope fractionation between abiogenic aragonite slowly precipitated in the experiment and seawater at 25oC falls along *Montastrea* coral calibration curve. All of these results suggest the possible lack of 'vital effects' on Mg isotope fractionation between seawater and coral skeletons, and indicate the temperature dependent Mg isotope fractionation could be developed as a potential paleothermometer.

## 4-7

**Records Of Past Thermal And Disease Stress From Lipid Biomarkers in Coral Aragonite**

**Konrad HUGHEN*[1]**, Jessie KNEELAND[1], James CERVINO[1,2], Jessica CARILLI[3]

[1]Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]Pace University, New York, [3]Scripps Institution of Oceanography, La Jolla, CA

Coral reefs are being threatened by combinations of stressors including global climate change and local environmental degradation. In order to predict the future response of corals to on-going environmental stress, we need accurate data quantifying the response of corals to a wide range of adverse conditions. A rich source of such information can be found in past records of coral bleaching and disease outbreaks, and the environmental conditions that preceded them. However, although numerous proxies exist for quantifying environmental parameters, there are currently no quantitative proxies for coral stress, such as caused by elevated temperatures or disease. Here we report new records of past coral stress constructed from lipid biomarkers in coral aragonite. Experiments with Symbiodinium zooxanthellae and Montastrea faveolata corals grown in culture were used to develop new proxies for thermal and disease stress. Samples exposed to elevated temperatures for periods up to 5 weeks, and those inoculated with Vibrio bacterial pathogens, showed distinct changes in lipid biomarker concentration and distribution. Lipids responding to thermal stress changed as a function of both temperature and duration of exposure. The same lipid biomarkers used to develop stress indices in cultured samples are found in adequate abundance for quantification in intracrystalline coral aragonite. Coral drill cores up to 1.2m long were obtained from four locations in the Mesoamerican Reef – Turneffe Atoll, Sapodilla Cayes, Utila Island and Cayos Cochinos Islands. Yearly density bands were identified from x-rayed slabs, and samples were cut and cleaned for analysis at annual resolution to construct records of coral stress over the past 100-150 years. Locations in the southern Mesoamerican Reef have a well-documented history of recent mass bleaching events, providing a verification period to test the accuracy of these new biomarker stress proxies.

## 4-8

**Foraminifera As Bio-Indicators? The History Of Foram Communities From The Wet Tropical Inshore Reefs, Great Barrier Reef**

**Claire REYMOND*[1]**, John PANDOLFI[1]

[1]ARC Centre of Excellence in Coral Reef Studies, Centre for Marine Studies, University of Queensland, Brisbane, Australia

As a result of land based activities there is an increasing need to develop marine bio-indicators for effective monitoring programs within coastal marine regions. Benthic foraminifera are prolific unicellular marine organisms, which are regarded as powerful indicators of environmental perturbation. Reef coral and foraminiferal assemblages are found in close association and exhibit distinctive local and regional patterns. We present a historical reconstruction of foraminiferal communities from the Great Barrier Reef (GBR) inshore wet tropical region based on ten 5-meter cores collected from the back reef habitats of Pandora Reef and Havannah Island. Community similarity is up to 75% for over 1,500 years. Fourteen key species differentiate two community types within the core. There is a positive correlation in the abundance of *Quinqueloculina philippinensis* and *Elphidium craticulatum*, and a negative correlation in the abundance of *Calcarina mayori* and *Peneroplis pertusus*, both endosymbiont-bearing species. It is clearly not the most abundant or the rare species that are differentiate these communities down core, more so it is the species with intermediate abundances. Highly abundant species are commonly distributed throughout the core. Understanding the nature of foraminiferal biology and sensitivity to environmental change is important when comparing modern day assemblages with assemblages from the last millennium.

## 4-9

**Long-Term Caribbean Nutrient Perturbations Recorded by Gorgonian Corals**

**David BAKER*[1]**, Kirby WEBSTER[2], Eduardos VALAITIS[3], Kiho KIM[2]

[1]Department of Ecology & Evolutionary Biology, Cornell University, Ithaca, NY, [2]Department of Biology, American University, Washington, DC, [3]Department of Mathematics & Statistics, American University, Washington, DC

Over the last century the Wider Caribbean has experienced dramatic changes from human activities. Widespread land-use change to agriculture, the concomitant removal of coastal mangrove forests, and recently accelerated population growth has led to perturbation of aquatic ecosystems. Of particular concern is increasing amounts of anthropogenic nutrients, and their effect on coastal marine habitats. Coral reefs are particularly sensitive to nutrification, and there is an abundance of reports on the deleterious effects of nitrogen (N) on these systems. However, the paucity of historical nutrient pollution data inhibits our understanding of the full scope of the problem. Fertilizer and sewage-derived N represent opposing end-members across the natural range of $\delta^{15}N$ from near zero to > 20 ‰, respectively. The relative proportion of N from these and natural sources dictates the resulting $\delta^{15}N$ of any mixture. Thus, in the absence of information about the relative contributions of fertilizer and sewage derived N, interpretation of $\delta^{15}N$ values is problematic. In this study, we use fertilizer use and human population data in a cointegration model to tease apart their respective contributions to long-term changes in N inputs to the Wider Caribbean. We analyzed four species of gorgonians collected from 10 regions within the past 155 years as an integrator of N sources. We show that $\delta^{15}N$ values of gorgonian corals are positively correlated with population, and negatively correlated with fertilizer consumption. Trends in gorgonian $\delta^{15}N$ since 1851 indicate a minimum inflection value in the 1970's, after which $\delta^{15}N$ increases. We conclude that widespread land-use change to agriculture has historically perturbed N dynamics in coastal Caribbean environments however, recent population growth has offset fertilizer isotope signals in corals, and suggests that the interplay between fertilizer and sewage derived N on coral $\delta^{15}N$ may lead to underestimation of their respective contributions.

## 4-10

**Identification Of Bleaching Events In Coral Skeletal Records Using High-Resolution Stable Isotope And Trace Element Records**

**Abbey CHRYSTAL*[1]**, Andrea GROTTOLI[1], Lisa RODRIGUES[2]

[1]School of Earth Sciences, The Ohio State University, Columbus, OH, [2]Department of Geography and the Environment, Villanova University, Villanova, PA

Coral skeletal stable oxygen isotopes (δ18O) reflect changing seawater temperature and salinity, while stable carbon isotopes (δ13C) reflect metabolic and kinetic fractionation. These isotopic changes may provide a record of past bleaching events. The effects of bleaching and subsequent recovery on skeletal isotopes in the mounding coral *Porites lobata* were experimentally investigated by inducing bleaching in outdoor tanks via increased water temperature (30°C). Control fragments from the same parent colonies were separately maintained at ambient seawater temperature (27°C). After one month all were returned to the reef for 20 months of recovery. Alizarin red staining was used to mark specific dates throughout the 21 months. Isotopes were measured by Kiel-SIR-MS at 0.1 mm increments along the major axis of growth for one bleached and one control fragment. Skeletal δ18O did not differ between the bleached and control fragments during the month of elevated temperatures, nor during recovery under natural reef temperature variations. However, δ13C decreased dramatically relative to the control several weeks into recovery, recovered to control levels after 4 months, and showed a negative departure again the following summer. The initial lag in δ13C depletion suggests that while *P. lobata* is fairly resistant to initial physiological effects of bleaching, it continues to be affected by the stress event during the first few weeks of recovery. Lower $\delta^{13}C$ values the second summer suggest that the bleached fragment was more susceptible to thermal-stress from a second moderate warming. Overall, high-resolution skeletal $\delta^{13}C$ has potential as a proxy for past bleaching events in this species independent of $\delta^{18}O$ variability. Skeletal trace element analyses in both bleached and control fragments are underway and will also be presented.

## 4-11

**Coral Growth Records From Southeast Florida: A History Of Anthropogenic Influence**

**Kevin P HELMLE*[1]**, Richard E DODGE[1], Peter K SWART[2], J Harold HUDSON[3]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [3]Florida Keys National Marine Sanctuary (ret.), National Oceanic and Atmospheric Administration, Key Largo, FL

Coral skeletal growth records of extension, density, and calcification from Southeast Florida reveal a three-decade period of stress spanning ca. 1940 to 1970. The period is characterized by dramatically decreased annual extension rate and increased skeletal bulk density. No similar periods of growth departures of this intensity or duration are present in locally collected corals dating back to 1694. Coral growth from a total of 80 corals exhibits strong correlation with master chronologies indicating a common growth response to one or a combination of environmental limiting factors. Near-shore shallow-water corals in Southeast Florida are affected by a number of stresses including freshwater drainage and coastal runoff. The 30-year period of high skeletal densities and low extension rates matches with a 30-year period of increased freshwater discharge, at times, an order of magnitude greater than normal. Construction of the four major South Florida canal systems diverted waters from Lake Okeechobee in the 40s, 50s, and 60s to the ocean. Comparison of temporal patterns in coral extension with environmental variables reveals a positive correlation between extension rate and salinity (represented by sea water density). The direct cause may be linked to influences from freshwater discharge such as high turbidity and decreased light penetration, salinity, or deleterious water quality. Further analysis of skeletal chemistry will help to identify specific limitations on the growth potential of these corals. Since the early 1970's, growth rates have generally increased relative to the historical average; however, the frequency of single-year stress bands has also risen. Increased growth rates coincide with warmer temperatures and stress bands likely resulting from partial bleaching when temperature thresholds are exceeded. This research has applications to better understanding coral stress and recovery with particular regard to watershed management.

## 4-12

**The Significance Of Geochemical Proxies in Corals, Does Size (Age) Matter?**

**Tim OURBAK*[1,2]**, Kristine DELONG[1], Thierry CORRÈGE[3], Bruno MALAIZÉ[3], Halimeda KILBOURNE[4,5], Sandrine CAQUINEAU[2], David HOLLANDER[6]

[1]College of Marine Science, St Peterbsurg, FL, [2]Institut de Recherche pour le Developpement, Bondy, France, [3]UMR 5805 EPOC, Universite Bordeaux 1, Talence cedex, France, [4]Earth Systems Research Laboratory Physical Sciences Division, NOAA, Boulder, CO, [5]College of Marine Science, St Peterbsurg, [6]College of Marine Science, St Petersburg, FL

Massive corals contain a myriad of geochemical tracers that have lead to numerous paleoenvironmental studies (sea surface temperature reconstructions for example). Most of the time, coring is achieved on a coral head, which is then sampled to produce geochemical analyses, used as proxies to estimate paleoclimate variability.

The present work deals with the impact of the age (and the size) of the coral head on geochemical results.

We analyzed three pristine coral heads using a multiproxy approach (Sr/Ca, Mg/Ca, $\delta^{18}O$ , $\delta^{13}C$). The first one is a 7m high core from New Caledonia where the modern period (top of the core) is compared to the settlement period (bottom of the core, when the coral was still at a juvenile stage).

The geochemical signatures of two coral heads (small vs. large) that have grown in a similar environment (Vanuatu) are also compared.

Large geochemical differences observed (between juvenile vs. mature and, to a less extent, between small vs. large coral heads) could not be explained only because of environmental variability.

We will develop the potential causes of such differences in term of variability of the tracers (kinetic effects, reproductive patterns etc).

The implications of this work are that paleonvironmental work based on coral archives should clearly state the length of the core retrieved. For example, if the SST range is well captured by Sr/Ca ratio, independently of the size/stage of growth of the coral head, applying directly calibration equation to reconstruct absolute SST bias the result and only relative SST values should be compared and interpreted.

## 4-13

**Coral Records Of Late 20th Century Warming And Freshening in The Central Tropical Pacific**

**Intan NURHATI*[1]**, Kim COBB[1], Chris CHARLES[2]

[1]Georgia Tech, Atlanta, GA, [2]Scripps Inst. of Oceanography, UCSD, La Jolla, CA

Corals have been widely used to reconstruct past climate due to high fidelity in capturing climate variability. Modern corals from the central tropical Pacific (CTP) have provided monthly climate records that show trends toward depleted coral d18O values in the late 20th century. These trends might infer warming and/or seawater freshening in the region. It is important to understand the mechanism behind these trends, to better predict low-frequency changes in tropical Pacific climate that may be associated with anthropogenic warming. One mechanism involves weakened tropical Pacific zonal SST gradient that would warm the CTP by reducing upwelling and enhance precipitation. Alternatively, warming might have occurred without changes in upwelling, and the lower salinities may signal changes in the location and/or strength of the ITCZ. Here we reconstruct late 20th century SST and salinity using coral d18O and Sr/Ca from Palmyra, Fanning and Christmas Islands (2-6ºN,157-162ºW). Palmyra at the northern end, is heavily influenced by the North Equatorial Counter Current (NECC) and the ITCZ; while Christmas at the southern end, is heavily influenced by the South Equatorial Current and equatorial upwelling. We measure Sr/Ca (SST proxy) and coral d18O values with analytical errors of ±0.3% or ±0.4ºC(1s), and ±0.05‰(1s), respectively. We derive d18O of seawater (salinity proxy) by removing the Sr/Ca-derived SST contribution from coral d18O values. Sr/Ca-based SST reconstructions show warming of 0.22, 0.25 and 0.5ºC/decade from Palmyra to Christmas, which may suggest a decrease in equatorial upwelling. d18Osw-based salinity reconstructions show seawater freshening of 0.31, 0.1 and 0.12psu/decade from Palmyra to Christmas, which may suggest an enhanced and/or southward migration of the ITCZ as well as changes in the salinity of waters advected by the NECC. Simultaneous warming and freshening in CTP corals may indicate a weakening of the tropical Pacific zonal SST gradient in the late 20th century.

## 4-14

**Reconstructing Sea Surface Temperature Variability in The Southwest Pacific: A Replication Study Using Multiple Coral Sr/ca Records From New Caledonia**

**Kristine DELONG*[1]**, Terrence QUINN[2,3], Frederick TAYLOR[2]

[1]College of Marine Science, University of South Florida, St. Petersburg, FL, [2]Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, [3]Dept. of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, Austin

Coral Sr/Ca reproducibility was investigated using three intracolony and three intercolony coral records from the reefs offshore of Amédée Island, New Caledonia. By convention, coral colonies are sampled along the vertical growth axis. This convention was tested by comparing vertical and horizontal paths on a small *Porites* colony from Vanuatu and a larger colony from New Caledonia. No significant difference in Sr/Ca variations was observed when the corallite growth direction was parallel to the sampling path and the sampling path followed the top of the lobe. Different sampling resolutions were examined in coral Sr/Ca (fortnightly and monthly) and δ18O (fortnightly, monthly, and seasonally) as well as similar scale subsampling of the daily in situ sea surface temperature (SST) record. The mean coral Sr/Ca, δ18O, and SST values do not change as a function of sampling resolution. The coral Sr/Ca signal is highly reproducible; the average absolute offset between coeval monthly Sr/Ca determinations between any two coral time series is 0.035 ± 0.026 mmol/mol (1σ) (~0.65ºC), which is less than twice the analytical precision of the coral Sr/Ca measurements. The stack average of the monthly coral Sr/Ca variations and monthly anomalies are significantly correlated with monthly in situ SST (1967–1992; $r = –0.96$ and –0.64, respectively; $p < 0.05$; and $n = 302$) and 1º grid monthly SST data product (1900–1999; $r = –0.95$, and –0.56, respectively; $p < 0.05$, $n = 1198$). The coral Sr/Ca–SST reconstruction exhibits interannual and decadal-scale fluctuations that exceed those observed in the gridded SST record, which may reflect true differences between SST at a shallow reef site and those averaged over a 1º grid box or inadequacies in the methodology used to create the gridded SST product when few observations are available.

## 4-15

**Stable Isotope Records From Western Pacific Shallow-Water Soft Coral And Black Coral**

**Branwen WILLIAMS*[1]**, Andrea GROTTOLI[2]

[1]School of Earth Sciences, Ohio State University, Columbus, [2]School of Earth Sciences, Ohio State University, columbus, OH

In some genera of soft corals and black corals, the $\delta^{13}C$ and $\delta^{15}N$ composition of the concentrically banded organic skeleton is controlled by the $\delta^{13}C$ and $\delta^{15}N$ composition of the particulate organic matter (POM) consumed by the coral colony. To test if these organisms record differences in the geochemistry of POM across depth, a sub-surface black coral (5m) and a deeper soft coral (85m) were collected live in 2006 from Palau (western tropical Pacific). High resolution (100 micron increments) $\delta^{13}C$ and $\delta^{15}N$ values were measured across a radial transect of the base of the organic skeleton in both colonies. The sub-surface black coral record showed an overall depletion of organic skeletal $\delta^{13}C$ values at a rate comparable to that measured over the past few decades in atmospheric $CO_2$-$\delta^{13}C$ (i.e., Suess effect). The 85m soft coral record showed a depletion of $\delta^{13}C$ values consistent with the past century of the Suess effect suggesting that this specimen was over one hundred years old. Overall, these initial data suggest the 85m colony had a slower growth rate typical of deep-water taxa, and that POM is the main source of carbon for skeletogenesis in these organisms. The ages of the two colonies will be more accurately constrained using radiocarbon measurements. A statistical comparison of the skeletal records with a seven year in-situ temperature record will be run to test for correlations between temperature (i.e., a proxy for water mass such that colder temperatures represents water below the mixed layer), and stable isotopes in the skeletal records. Together, soft corals and black corals in the western Pacific may provide paleoceanographic information on decadal to centennial timescales across the entire ocean depth range.

## 4-16

**523 Years Of Interannual (Enso-Like) To Multidecadal (Pdo-Like) Climatic Signals Continuously Recorded in New Caledonia By Sr/ca And $\delta^{18}o$ in A Giant Massive Porites**

**Tim OURBAK*[1,2]**, Thierry CORRÈGE[2], Bruno MALAIZÉ[2], Florence LE CORNEC[3], Boris DEWITTE[4]

[1]College of Marine Science, St Peterbsurg, FL, [2]UMR 5805 EPOC, Universite Bordeaux 1, Talence cedex, France, [3]Institut de Recherche pour le Developpement, Bondy, France, [4]Observatoire Midi Pyrénées., Toulouse, France

The southwest Pacific is a critical region concerning interannual to interdecadal climatic phenomena, such as El Niño Southern Oscillation (ENSO) or the Pacific Decadal Oscillation (PDO). Unfortunately, the length of meteorological data critically limits the understanding and analyses of such climatic variability. Trace elements and stable isotopes have been investigated in a 7m long coral core which records more than 500 years of environmental variability from Ile des Pins, south of New Caledonia (22°S, 167°E). This multiproxy approach allows reconstruction of sea surface temperature (SST) and sea surface salinity (SSS). SST variations, estimated from Sr/Ca, reveal a long-term warming over the period 1475 to 1998, modulated by interdecadal cycles. By removing SST component from the $\delta^{18}O$ signal, we have estimated the paleosalinity variability. The SSS reconstruction presents mean saltier conditions at the beginning of the record, and a slow decrease in SSS throughout the whole record punctuated with freshening events, such as the one coinciding with a strong warming trend observed since ~1890. We argue that changes in wind intensity (via evaporation/precipitation), together with advection processes, have changed over the last centuries in New Caledonia. Moreover, this very long core has recorded very intense ENSO phenomena during the end of the 16th century and the beginning of the 17th century consistent with numerous proxies circum-Pacific.

## 4-17

**Water Quality in Nearshore Areas Of The Great Barrier Reef: A Large Scale Monitoring Program And An Assessment Of The Use Of Benthic Foarminifera As Water Quality Indicators**

**Sven UTHICKE*[1]**, Schaffelke BRITTA[1], Angus THOMPSON[1], Damian THOMSON[1]

[1]Water Quality, Australian Institute of Marine Science, Townsville MC, Australia

As for most Coral Reefs, a potential decline in water quality (WQ) is a concern for reef health of Great Barrier Reef (GBR) inshore reefs. A large scale (32 reefs, 4 regions) GBR inshore monitoring program was initiated in 2005, encompassing annual coral community analysis, and half-yearly WQ measurements. We additionally investigated the benthic foraminifera at these monitoring sites to evaluate their utility as WQ indicators in the GBR. WQ measurements confirmed that most parameters (e.g. chlorophyll a, suspended solids) are higher in inshore areas of the GBR when compared to offshore reefs. Higher concentrations of most parameters were measured during the wet season, but regional differences in WQ were more distinct in the dry season.

Regional differences in coral cover and community composition are pronounced. A substantial proportion of the variation in coral community composition is explained by differences in the hydrodynamic conditions, with several genera resilient to sedimentation attaining consistently higher relative abundance in areas where fine sediments predominate. Coral cover estimates mostly reflect recent disturbance history rather than WQ conditions. Along a distinct WQ gradient, the FORAM index (FI), as previously developed and applied in the Caribbean, showed a high correlation with WQ. Foraminiferan communities also showed distinct regional differences. While the FI did not predict coral cover, one symbiont-bearing species (Calcarina mayori) was positively correlated with high algal/low coral cover. Because of the vulnerability of corals to other disturbances it appears that foraminifera are more specific indicators for WQ. Combined analysis of the WQ, coral- and foraminiferan community data from this monitoring program provides important insights into the value of WQ indicators based on individual species' density or a combined FORAM index. We consider the future application of this index in the GBR as beneficial, after refinements in the weighting of individual species.

## 4-18

**Linkages Between Coral Assemblages And Coral-Based Proxies Of Terrestrial Exposure Along A Cross-Shelf Gradient Of The Great Barrier Reef**

**Stacy JUPITER*[1,2]**, Guy MARION[3], George ROFF[3], Meegan HENDERSON[3], Verena SCHRAMEYER[3], Malcolm MCCULLOCH[1], Ove HOEGH-GULDBERG[3]

[1]Research School of Earth Science, ARC Centre of Excellence for Coral Reef Studies, Canberra, Australia, [2]Australian Institute of Marine Science, Townsville, Australia, [3]Centre for Marine Studies, ARC Centre of Excellence for Coral Reef Studies, Brisbane, Australia

We present a novel approach to assess cross-shelf differences in coral community structure by linking present day coral assemblages with disturbance histories from sites within varying proximity to the agricultural region of Mackay (Queensland, Australia). In March 2006, transects were scored for benthic cover composition at sites along a gradient of distance offshore from the Pioneer River mouth. We additionally measured multiple proxies from massive *Porites* corals (luminescence lines, Ba/Ca, δ15N) collected along the same transect to assess the frequency and intensity of exposure to terrestrial discharge and fertilizer-derived nitrogen. High, significant cross-shelf variability in live hard coral cover was observed. The sites closest to the mainland (Round Top, Keswick, St. Bees) were characterized by low hard coral cover (≤10%), with no significant differences among sites. Corals at Round Top Island (5 km offshore) occurred as isolated colonies or thin veneers. Distinct annual luminescence lines and elevated baseline Ba/Ca (mean = 5.0 μmol/mol) in the core records indicated chronic (sub-annual) exposure to freshwater and resuspended terrestrial sediment that may have historically prevented reef formation. By contrast, reef assemblages at Keswick and St. Bees Islands (~33 km offshore) were categorically different due to the dominance of large stands of macroalgae overgrowing dead reef matrix. Cores from Keswick Island indicated high exposure to Pioneer River discharge during extreme flood events (1974, 1991), with bright luminescent lines and significantly enriched δ15N (12-14‰) reflecting an isotopically distinct lower Pioneer catchment source (~9‰) combined with further fractionation by phytoplankton blooms. Scawfell Island (50 km offshore) had high hard coral (22%) and soft coral (35%) cover, and coral core records indicated little exposure to Pioneer catchment influence. These results suggest that nearshore reefs adjacent to highly modified catchments may be particularly vulnerable to phase shifts if they are episodically disturbed by pulses of nutrient-rich terrestrial runoff.

## 4-19

**Unable To Retrieve Title from Database**

**Tsuyoshi WATANABE*[1]**, Atsushi SUZUKI[2], Tatsunori KAWASHIMA[1], Shoshiro MINOBE[1], Yolanda AGUILAR[3], Koji KAMEO[4], Kayo MINOSHIMA[2], Ryoji WANI[5], Hodaka KAWAHATA[6], Tomoki KASE[7]

[1]Natural history Sciences, Hokkaido University, Sapporo, Japan, [2]National institution of Advanced Industrial Science and Techlology, Tsukuba, Japan, [3]Bureau of Mine and Geosciences, Philippine, Manila, Philippines, [4]Chiba Univercity, Chiba, Japan, [5]Yokohama National University, Yokohama, Japan, [6]University of Tokyo, Tokyo, Japan, [7]National Science Museum, Tokyo, Japan

Global mean temperature and atmospheric CO2 concentration during the early Pliocene warm period (PWP; 5-3 Ma) were substantially high as much as those predicted for the future climatic system in 100 years future. The oceanic and atmospheric conditions can be studied in the context of future global warmth. However, the role of El Nino-Southern Oscillation (ENSO) in this greenhouse warming remains controversial mainly because of the lack of the information about seasonal to inter-annual variability in sea surface water in low latitude regions. We found two well-preserved fossil corals in muddy sand layers of the northern part of Philippians including this warm period (3.5-3.8Ma). Here, we demonstrate two 35 years coral oxygen isotopic profiles with monthly resolution in order to investigate seasonal and interannual characteristics of Pliocene ENSO. In the present day, the anomalies of sea surface temperature and precipitation were significantly evident in Philippine during El Nino occurring. Significant attenuations of seasonal amplitude were found in 18O/16O ratios of both two PWP coral records, which were also detected in the recent corals during modern El Nino events.

## 4-20

**High-precision U-series and 14C Dating Of The Deep-Sea Coral *Enallopsammia rostrata***

**Fanny HOULBREQUE*[1,2]**, Brendan ROARK[1], Robert DUNBAR[1], Tom GUILDERSON[3], Malcolm MCCULLOCH[4], Anders MEIBOM[5]

[1]Geological & Environmental Sciences, Stanford University, Stanford, CA, [2]Marine Environment Laboratory, International Atomic Energy Agency, Monaco, Monaco, [3]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA, [4]Research School of Earth Sciences, Australian National University, Canberra, Australia, [5]Laboratoire d'Etude de la Matiere Extraterrestre, Museum National d'Histoire Naturelle, Paris, France

We utilize deep-sea corals in a systematic approach to reconstruct past ocean conditions over centennial to millennial timescales. As part of this endeavor we present new results on *Enallopsammia rostrata*, a pan-oceanic scleractinian species. Here we show that *E. rostrata* collected live using the Pisces submersibles from water depths between 480-790 m at three locations in the Line Islands (~160°W, central Equatorial Pacific) has the potential to act as a recorder of changes in deep-sea environments over centennial time scales. To improve the utility of this scleractinian species as a monitor of interior ocean variability, we have applied a high-precision, low blank technique to measure 230Th and 238U-234U in small amounts (80 ± 10 mg) of modern and near modern calcareous skeletons using MC-ICPMS (Multicollector Inductively Coupled Plasma Mass Spectrometry). Absolute dated specimens exhibit radial growth rates from 23-114 μm/yr and vertical extension rates from 0.57 to 1.87 mm/yr. Colony life spans ranged from 108 ± 5 yrs to 607 ± 6 yrs. The growth rates reported here are similar to those of other deep-sea scleractinian corals, but with a 2 to 3-fold greater life span for the oldest samples. Slow growth rates and great longevity make this species especially vulnerable to disturbances and impacts from climate change and anthropogenic activities. Paired U-series and 14C dating measurements along radial sampling tracks of different colonies of *E. rostrata*, allow us to estimate 14C-ventilation rates of the water masses that the corals experienced on centennial timescales. Our initial results document a centennial periodicity in the 14C ventilation ages in this region of the Pacific Basin.

## 4-21

**The P/ca, Ba/ca, And B/ca Proxies in The Solitary Deep Sea Coral *d.dianthus*: Mapping And Sources Of Contamination**

**Eleni ANAGNOSTOU*[1]**, Robert SHERRELL[2], Michele LAVIGNE[1], Jess ADKINS[3], Alex GAGNON[4]

[1]Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, [2]Institute of Marine and Coastal Sciences/ Department of Earth and Planetary Sciences, Rutgers University, New Brunswick, NJ, [3]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, [4]Division of Chemistry, California Institute of Technology, Pasadena, CA

We present skeletal proxies for nutrient and carbonate system seawater properties by measuring elemental ratios in globally distributed modern samples of *D. Dianthus*. Mean P/Ca, Ba/Ca, and B/Ca ratios for each coral, integrating multiple years of growth, are obtained for lines along the exterior surfaces of septa using 193nm laser ablation HR-ICP-MS, and are regressed against hydrographic data from nearby stations. P/Ca is strongly correlated with seawater phosphate ($D_{PO4}$~0.7, where D=element/Ca in coral divided by element/Ca in seawater; $R^2$~0.85), and Ba/Ca with seawater dissolved barium ($D_{Ba}$~1.8, $R^2$~0.96), while B/Ca is positively correlated with seawater pH. Additionally, we present 2-D maps of P/Ca, Ba/Ca, and B/Ca across different skeletal features including centers of calcification and surrounding aragonite, to identify possible non-environmental factors influencing skeletal elemental ratios. We also examine patterns of appearance of contaminant iron/manganese phases enriched in phosphorus that are incorporated into the skeletal structure. Finally, we summarize the above results to present possible mechanisms of incorporation of phosphorus, barium, and into the coral aragonite to explore the potential and feasibility of applying these deep sea coral proxies for reconstruction of past nutrient and carbonate system distributions.

## 4-22

**Stable Isotopes And Sr/ca Ratios Indicate Records Of Groundwater Influence On Florida Reefs**

**Peter SWART*[1]**, Sarah BELLMUND[2], Richard DODGE[3], Kevin HELMLE[4], Rene PRICE[5], Jeremy STALKER[5]

[1]MGG, University of Miami, Miami, FL, [2]NPS, Miami, FL, [3]Oceanographic Center, Nova Southeastern University, Dania, FL, [4]Oceanographic Center, Nova Southeastern University, Dania, FL, [5]Geology, Florida International University, Miami, FL

The waters off Elliot Key, within Biscayne National Park (BNP) in the United States, contain some of the longest lived specimens of *Montastraea faveolata* in the Caribbean. Previously we have noticed an inconsistency between measured water temperatures and temperatures estimated using the Sr/Ca and the □18O of the coral skeletons. This inconsistency is a result of the fact that the reefs are influenced by evaporated water emanating from Biscayne Bay as well as groundwater from the adjacent mainland. The water from Biscayne Bay is elevated in 18O, which influences the reefs to a greater extent during the summer thereby depressing the □18O amplitude of the skeleton. At the same time the ground and surface waters are highly elevated in calcium, resulting in lower than expected Sr/Ca ratios. This enhances the range of Sr/Ca in the corals. By combining these two proxies with measured SST data, it is possible to use the corals as proxies of the amount of freshwater discharge from the adjacent mainland. It is possible to distinguish surface water from ground water using the Ba/Ca ratio. Surface waters have elevated Ba/Ca ratios compared to ground water, and therefore distinctions between surface discharge and groundwater discharge can be assessed using this ratio in the coral skeletons. In this presentation we present (i) high resolution reconstructions (>40 samples per year) over the past 50 years from three sites in Biscayne National Park, and (ii) a lower resolution record extending back to ~1750.

## 4-23

**Historical Land Use Patterns Recorded By Coral Chemistry From Moloka'i, Hawaii**

**Nancy GRUMET PROUTY*[1]**, Michael FIELD[1]

[1]Coastal and Marine Geology, U.S.G.S., Santa Cruz, CA

Land-use practices, such as clearing and agriculture, can degrade river catchments and increase the amount of sediment flowing in rivers to the coastal ocean. An increase in erosion on the island of Moloka'i, Hawaii has been linked to intensification of farming, clearing of native vegetation, and introduction of both feral and domesticated grazing animals. The fringing reef of Moloka'i's southern coast has been the focus of several studies to understand the dynamics of sediment transport and its impact on coral reef health. These results have documented chronic turbidity in coastal waters that results from both flood discharge following heavy rains from a Kona storm and daily suspension of terrigenous sediment by trade-wind waves. The belt of suspended sediment extends across the reef flat and beyond.

It is difficult, however, to decisively demonstrate a clear link between land use patterns and changes in coral condition based on surveys alone. Geochemical proxy records from corals offer a technique for recording environmental changes. Because suspended sediment in river water contains minor levels of barium, as the river water enters the ocean, barium is carried to the ocean where corals incorporate it into their skeletons. Thus, coral Ba/Ca records provide in-situ baselines of past seawater quality. We collected a suite of coral cores from *P. lobata* heads from the fringing reef off south Moloka'i to investigate the link between sedimentation and coral reef ecosystem health due to chronic exposure to sedimentation; we also investigated the effects of infrequent, large scale events and perturbations due to modification of the coastline. Our results were compared to historical information from adjacent watersheds to compare present day conditions with those of the past several decades.

## 4-24

**Geochemical Analyses From Florida's 'Monster Coral': Reconstructing Environmental Changes From The Port Everglades Area Over The Last 100 Years**

**Amanda WAITE*[1]**, Kevin HELMLE[2], Richard DODGE[2], Peter SWART[1], J. Harold HUDSON[3]

[1]Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania, FL, [3]FKNMS (retired), NOAA, Miami, FL

In 2005, a 300+ year old colony of the star coral, *Montastraea faveolata*, was cored in 20 feet of water approximately 2 miles south of Port Everglades, Florida USA. Given the coral's latitude and proximity to the activity and impact of a large urban population and a large shipping and cruise port, it is considered exceptional for both its age and size. The specimen therefore may provide insight into the effects of South Florida's development on corals over time. Stable isotopic analysis of this coral's skeleton reveals δ18O values between -4.1 and -2.6‰, and δ13C values between -3.5 and +0.4‰. Both the oxygen and carbon isotopes demonstrate regular seasonal cyclicity. Minor element concentrations were also measured. Ratios of Sr/Ca, Mg/Ca, and Ba/Ca vary between ~9.1 and 9.6 mM/M, 5 and 13 mM/M, and 4.5 to 6.5 mM/M respectively, and depict annual fluctuations in concentration. X-radiography of slabs from this coral's skeleton reveals a 300 year chronology of seasonal density banding along with a period of anomalously high density from 1940 to 1970 which suggests that some sort of stress was acting on the coral. Re-evaluating the geochemical data in light of this density anomaly reveals, with few exceptions, little difference between the typical modern growth and the relatively high density period between 1940 and 1970. The exception to this is in the amplitude of stable isotopic variation, which does appear to be slightly suppressed where density was anomalously high in the coral with δ18O from -3.8 and -2.6 ‰ and δ13C between -2.5 and +0.4‰.

## 4-26

**Biologic Influence On Proxies Of Scleractinian Coral Skeleton**

**Anne JUILLET-LECLERC*[1]**, Stéphanie REYNAUD[2]

[1]LSCE, CNRS, Gif sur Yvette, France, [2]CSM, Monaco, France

The coral skeleton d18O is the most commonly used SST proxy essentially depending on external factors such as SST and water d18O.

Acropora cultured under variable light (equivalent to seasonal light variation) show systematic d18O fractionation. But, temperature and light lead to opposite responses with a lower effect due to light. This effect is associated to metabolic processes underlining the strong relationship between metabolism of symbiotic algae and skeleton formation. However, isotopic fractionation obeys to physical rules. Weber and Woodhead (1972) provided annual mean isotope values, statistically significant, partly rejecting vital effect. By using these data and introducing seawater d18O, we derived from these data Acropora calibration similar to ones of Epstein.

The question arises if this effect is specific to cultured Acropora? In order to estimate the influence of seasonality, we compared data measured on Porites colonies that developed close to each other in a well-constrained environment. Although deposited under identical conditions we obtain highly variable SST calibrations for different species, different colonies and even different sampling on a single head. This can be only explained by additional seasonal biologic effects. Light and temperature being the main seasonal changes, we conclude that both temperature and light, in addition to the physical SST influence, affect d18O through metabolism.

Based on these evidences we developed a new method using multi-proxies, which revealed that corals are likely a better archive than a simple isotopic thermometer.

## 4-27

**High-Resolution Acropora Cervicornis $\delta^{18}$o: Implications For Early Holocene Caribbean Temperatures And Position Of The Intertropical Convergence Zone**

**Lida TENEVA*[1]**, Lisa GREER[2], William PATTERSON[3]

[1]Earth and Environmental Sciences, Columbia University, Palisades, NY, [2]Geology, Washington and Lee University, Lexington, VA, [3]Geological Sciences, University of Saskachewan, Saskatoon, SK, Canada

High-resolution coral □18O data, coupled with precise dating techniques, have the potential to provide critical information on paleoclimate variability and tropical ocean-atmosphere interactions through time. Here we present paleotemperature data from well-dated pristine early Holocene (~9360-8900 years BP) *Acropora cervicornis* of the Enriquillo Valley, Dominican Republic. A new paleotemperature reconstruction equation based on previous *Acropora* coral culture studies (Reynaud et al. 2007) was used to calculate Holocene temperature variability. Taking into account deglacial changes in seawater □18O (Δ□18O) in the early Holocene, our data reveal lower temperatures than previously estimated using equations based on molluskan calcite (Epstein et al. 1953, O'Neil et al. 1969) and molluskan aragonite (Grossman and Ku 1986). Our calculations show the early Holocene in the Dominican Republic was ~4oC cooler than today's average (26.5-29.5oC). We consider this temperature difference unrealistic, and propose Dominican Holocene coral □18O data can be attributed to combined temperature and salinity effects. The latter refers to a precipitation effect associated with a northward incursion of the Intertropical Convergence Zone (ITCZ) in the early Holocene. Using the culture-based temperature equation, the modern annual temperature range of 3oC for the Dominican Republic would correspond to half the □18O amplitude observed in our study. Thus, precipitation changes likely played an important role in □18O signal variability since the deglacial Δ□18O contribution peaked at ~0.46‰. On first order, oxygen isotope records from this study show covariability in time with tropical ice cap $\square^{18}$O data from Huascaran, Peru and Sajama, Bolivia. This may imply that at least in the early Holocene, the northern Caribbean and northern South America may have derived their moisture from the same source at the same time (i.e. enhanced ITCZ precipitation).

## 4-28

**Eighty Years Long Oxygen And Carbon Isotopic Data Series From A Southwestern Atlantic Coral**

**Ruy KIKUCHI*[1]**, Henning KUHNERT[2], Jürgen PÄTZOLD[3], Zelinda LEAO[1], Alexandre COSTA[4], Ricardo DOMINGUES[5], Marília OLIVEIRA[1], Carlos LENTINI[4]

[1]Geophysics and Geology Research Center, Universidade Federal da Bahia, Salvador, Brazil, [2]RCOM Research Centre for Ocean Margins, Universitaet Bremen, Bremen, Germany, [3]Universitaet Bremen, Bremen, Germany, [4]Institute of Physics, Universidade Federal da Bahia, Salvador, Brazil, [5]Institute of Geosciences, Universidade Federal da Bahia, Salvador, Brazil

The oldest sea surface temperature instrumental records available in Brazilian Navy records date from 1973, and climate proxy indicators in the Southwestern Atlantic are scarce, if not absent. Our project aim to evaluate the quality and reconstruct the longer possible time series of temperature record based on isotopic proxies in the endemic coral Mussismilia braziliensis skeleton. This species is the main reef builder in Abrolhos Reef Complex. Seasonal temperature amplitude in the region is about 4-5oC varying from about 23.5oC to 28.5oC. Turbidity and cloudiness are greater during winter when southern polar fronts tend to reach Brazilian Eastern Coast as far as 12oS. Among 15 cores taken in the region, one 70 cm long coral core (from 17o47,173'S, 39o02,935'W) was cut as a slab of 1,5 cm thick, X-rayed and sampled along a growth axis from top to bottom every 0,5 mm with a 0,8 mm wide drill. The analyses were made in a Finnigan MAT mass spectrometer coupled with an automated sampler. Both d18O and d13C exhibited a cyclical pattern that, in general, conforms to the density banding. Oxygen and carbon curves have inverse behavior relative do each other. d18O varies from -3.42 to -3.70‰ (VPDB) and d13C from 2.04 to -2.46‰ (VPDB). The seasonality in d18O, in the order of 0.4‰ is low compared to the expected seasonality 0.8‰-1.0‰, but is explained by the depletion in 16O that occurs during the summer in seawater (ca. 0.5‰). The 80 years represented by the isotopic data exhibit a decadal (ca. 12 years) variability and milder temperatures before the 70's. Highest temperature signal occur in the end of the 70's and beginning of the 80's and in 2001-2003.

## 4-29

**Corals As Recorders Of Land-Ocean Carbon Transport in Puerto Rico Using $\delta^{13}$c And Ba/ca**

**Ryan MOYER*[1]**, Andrea GROTTOLI[1]

[1]School of Earth Science, The Ohio State University, Columbus, OH

Rivers link terrestrial and marine ecosystems and influence the abundance, composition, and timing of carbon delivered to the coastal ocean. During periods of sustained high river discharge, the stable carbon isotope (δ13C) signature of coastal seawater DIC is likely influenced by the δ13C of the organic and inorganic carbon of the adjacent catchment. In coastal areas where coral reefs occur in close proximity to the mouths of rivers, coral skeletal δ13C should record deviations in seawater DI- δ13C during periods of high river discharge. Additionally, Ba in coral skeletons acts as a conservative tracer of freshwater pulses in coastal marine systems, and can be used to identify past flood events in coral cores. To further establish this connection and extend the record of river discharge, coral skeletal δ13C and Ba/Ca were measured in a *Montastraea faveolata* coral core collected approximately 400 m from the mouth of the Fajardo River (Puerto Rico). Cross-spectral analysis of coral skeletal Ba/Ca and river discharge yields significant bi-weekly coherence for the portion of the record where instrumental river discharge records are available (1979 - 2004). Coral $\delta^{13}$C and river discharge are annually coherent over this same time interval, with $\delta^{13}$C decreasing as discharge increases. Coral Ba/Ca and $\delta^{13}$C are also annually coherent over the entire 56-year record. These data suggest that such a multi-proxy approach is extremely valuable in elucidating periods of heavy river discharge where coral $\delta^{13}$C is likely affected by terrestrial carbon transport. In combination with previous work, the data also suggest that skeletal $\delta^{13}$C in corals growing near the mouths of small tropical rivers provide a record of terrestrial carbon delivery to the coastal ocean and coral reefs, as well as the land-use history of the river catchment.

## 4-30

**Corals At The Flower Garden Banks: Monitors Of Environmental Change And North American Climate Variability**

**Amy WAGNER*[1]**, Niall SLOWEY[1,2]

[1]Oceanography, Texas A&M University, College Station, TX, [2]Oceanography, Texas A&M University, College Station

The Pacific/North American (PNA) pattern is a dominant atmospheric pattern of climate variability in the extratropical Northern Hemisphere and strongly influences the winter climate of the southeast United States. The instrumental record used to characterize the PNA pattern does not exist prior to the mid-1940s. However, information about past variability in the PNA pattern is preserved in the skeletons of long-lived corals at the reefs of the Flower Garden Banks National Marine Sanctuary (NMS). The Flower Garden Banks NMS is located approximately 180 km south of the Texas/Louisiana border in the Gulf of Mexico and is the northernmost hermatypic reef on the United States continental shelf. It has previously been shown that linear coral extension rates at the Flower Garden Banks are highly correlated with winter air and sea surface temperatures. In addition, average winter temperatures in the southeastern United States are negatively correlated with the phase of the PNA pattern. During a positive phase of the PNA pattern, the southeast US experiences stronger and more frequent winter storms while a negative phase of the PNA pattern brings milder winters to the region. Thus, past coral extension rates at the Flower Garden Banks provide a means to reconstruct the history of temporal variations in the PNA pattern. We have collected several long cores of skeletal material from long-lived Montastrea faveolata and Siderastrea siderea coral heads from the Flower Garden Banks NMS. Annual extension rates have been determined based on X- radiographic analysis of high/low density growth bands and are used to characterize interdecadal variability associated with changes in the PNA pattern. In addition, the presence of winter stress bands due to below average water temperatures indicate winters with more severe and/or frequent storms. Analysis of these results will contribute directly to our understanding of the temporal character of interannual and interdecadal variations of North American winter climate.

## 5-2

**The Transition From Autotrophy To Heterotrophy in The Coral Montastraea Cavernosa Over A Depth Range Of 3 M To 91 M**

**Michael LESSER*[1]**

[1]Department of Microbiology, University of New Hampshire, Durham, NH

Most studies on coral reefs have focused on shallow reef (<30 m) systems. This is not surprising given the technical limitations of conducting scientific diving deeper than 30 m. Recently the technical limitations of deep reef research have been overcome by the introduction of mixed gas technical diving (both open circuit SCUBA and closed circuit rebreathers) to the scientific diving community. Our lack of knowledge about deep reef environments, and in particular coral populations, has slowed our broader understanding of the ecology, connectivity, and biodiversity of coral reef communities. We know that the light environment is an important component of the productivity, physiology, and ecology of corals and restricts the distribution of most species of coral to depths of 60 m or less. In the Bahamas one of the deepest occurring corals is Montastraea cavernosa and it is found at depths exceeding 90 m. Using a range of optical, physiological, and biochemical approaches the relative dependence on autotrophy versus heterotrophy was assed for this coral from 3 m to 91 m. It was observed that the quantum yield of PSII fluorescence for this species increases significantly with depth while gross primary productivity decreases with depth. While morphological and physiological photoacclimatization is evident down to 91 m, stable isotope data of the tissues, symbionts, and skeleton show a marked decrease in overall metabolism and a sharp transition to heterotrophy between 45 and 61 m that is consistent with previous studies and models despite the fact that the 1% light level in this system occurs at 80 m. Food and light limitation below these depths appear to induce severe energy conservation in these corals, and the deep "Twilight Zone" appears to support significantly fewer, slower growing, individuals of M. cavernosa.

## 5-3

**Effect Of Light And Feeding On The Fatty Acid And Sterol Composition in *Turbinaria Reniformis***

Treignier CLAIRE[1], Grover RENAUD[1], Tolosa IMMA[2], **Ferrier-Pagès CHRISTINE*[1]**

[1]CSM, Monaco, Monaco, [2]IAEA, Monaco, Monaco

We investigated the effect of light and feeding on the composition and □13C signature of the fatty acids (FA) and sterols of the scleractinian coral *Turbinaria reniformis*. Other parameters (calcification, photosynthesis, chlorophyll concentrations) were also measured. Nubbins were maintained during six weeks under two light (100 and 300 µmoles photons m-2 s-1) and feeding (starved and fed) levels in a factorial experiment. In all conditions, polyunsaturated fatty acids (PUFA) such as C18:4 n-3, C20:5 n-3, C22:6 n-3 were in higher concentrations in the zooxanthellae than in the host, suggesting that they were synthesized by the algae and transferred to the host. This lipid transfer was confirmed by a similarity in the □13C-lipid signatures between the host and the symbiont. High light increased rates of photosynthesis and growth in fed corals. Total concentrations of FA and sterols were also increased for corals maintained under high light, with significantly higher □13C values, compared to those exposed to low light. This supports the widespread theory of enhanced 13C fixation with increasing irradiance and photosynthesis. Feeding affected differently the coral metabolism depending on the light level. Under low light, feeding enabled corals to slightly increase their growth rates and accumulate greater concentrations of storage lipids (SAFA) and membrane constituents (PUFA and sterols). Conversely, under high light, energy provided by feeding increased calcification, chlorophyll and protein contents whereas. no change was noticed in lipid concentrations. Feeding enriched some FA (C14, C16, C18 and C22:4n-6) of the host tissue and of the zooxanthellae (composite C18:3n-6+C18:4n-3 and C22:6n-3) in 13C. Isotopic results also indicated that the animal did not assimilate directly the zooplankton FA, but he likely synthesised them from the selective assimilation of carbohydrates or amino acids contained in the food.

## 5-4

**Impacts Of Nitrogen On Great Barrier Reef Coral**

**Annamieke VAN DEN HEUVEL*[1]**, William LEGGAT[2], David YELLOWLEES[2], Sophie DOVE[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]School of Pharmacy and Molecular Sciences, James Cook University, Townsville, Australia

Elevated levels of inorganic nitrogen can have severe impacts on coral health. Key to understanding why corals respond detrimentally to elevated inorganic nitrogen is to fully comprehend the pathways involved in nitrogen uptake and assimilation for both the symbiont and host. This study examined the effects of elevated nitrogen on the coral-algae symbiosis. Coral fragments of Acropora aspera were collected from the reef flat of Heron Island, Australia and exposed to high concentrations of ammonium and nitrate in separate treatments. Fragments were sampled throughout the day for changes in the expression profile of ammonium transporters, nitrate transporters and glutamate synthase. Real Time PCR revealed that changes in the concentration of both ammonium and nitrate affected the expression profile of these genes. In addition, characterization of ammonium transporters from Symbiodinium sp. symbiotic with A. aspera, show high sequence conservation. Sequence analysis shows Symbiodinium transporters come from two distinct ammonium transporter families, the eukaryotic like AMT1 family and the prokaryotic like AMT2 family. This is the first time that ammonium transporters have been characterised in dinoflagellates and that members of the AMT2 family have been identified outside of bacteria and higher plants.

## 5-5

**Symbiotic Intertidal Temperate Sea Anemones (Anthopleura Spp.): Their Contribution To Our Understanding Of Cnidarian-Algal Symbioses.**

**Gisele MULLER-PARKER*[1]**

[1]Biology, Western Washington University, Anacortes, WA

The first evidence for direct transfer of photosynthetic carbon from zooxanthellae to the host was obtained for the temperate anemone *Anthopleura elegantissima* by L. Muscatine in 1958. Since then, researchers have concentrated on the relationship between zooxanthellae and tropical corals and anemones, major contributors to coral reef primary productivity. This effort has assumed increased urgency with the need to understand the mechanisms of coral bleaching and to predict how symbioses will continue to respond to climate change. Symbiotic associations in temperate regions offer relevant comparisons in both environmental conditions and the physiological responses of zooxanthellae. Anemones in the temperate intertidal zone are of particular interest, as they are exposed to pronounced fluctuations in air and seawater temperature on time scales ranging from hourly to decadal, and they host multiple symbionts with different tolerances to temperature. Our work with *Anthopleura elegantissima* has revealed exceptionally broad thermal tolerance (~15oC) for growth and photosynthesis of zooxanthellae. The distribution patterns of two zooxanthellae and a green algal symbiont within the host are strongly correlated with physiological tolerances of the algae to temperature, suggesting environmental control of algal complements. However, anemones in the Pacific Northwest with mixtures of symbionts predominantly contain algae of one type; 50:50 mixtures are extremely rare and probably inherently unstable and suggestive of host control. Also in contrast with tropical cnidarians, *A. elegantissima* hosts constant population densities of algal symbionts year-round, despite 7-fold reductions in light during winter. This is probably accomplished through a reduction in growth and expulsion of algae, coupled with algal heterotrophy. These results, and future studies with temperate associations, are important in the development of general models to help predict the effects of climate change on algal-cnidarian symbioses.

## 5-6

**Acquisition And Allocation Of Carbon in Bleached Hawaiian Corals**

**Andrea GROTTOLI*[1]**, Adam HUGHES[2,3], Tamara PEASE[2]

[1]School of Earth Sciences, The Ohio State University, Columbus, OH, [2]Department of Marine Science, The University of Texas at Austin, Port Aransas, TX, [3]School of Earth Sciences, The Ohio State University, Columbus

Photosynthesis and growth are dramatically reduced in bleached corals. *Montipora capitata* corals compensate by dramatically increasing heterotrophy, while *Porites compressa* corals sustain themselves by utilizing their stored energy reserves when bleached. Here, we further assessed how photosynthetically and heterotrophically acquired carbon is acquired, allocated, and utilized among the host tissue, zooxanthellae, and skeleton in bleached and non-bleached *P. compressa* and *M. capitata* corals using 13C-labeled bicarbonate in seawater and 13C-labeled rotifer pulse chase labeling techniques. Photosynthetically acquired carbon was taken up from bicarbonate by the zooxanthellae, transferred to the host tissue, respired, and taken up by the skeleton at dramatically lower rates in bleached corals relative to controls. In both bleached and non-bleached corals, the photosynthetically derived carbon appeared to be the primary source of carbon for calcification but was not incorporated into either the zooxanthellae or host tissue for long-term storage. In contrast, heterotrophically-derived carbon (i.e., rotifers) was rapidly translocated between the zooxanthellae and host tissues in bleached and non-bleached *M. capitata* and non-bleached *P. compressa* (but not bleached *P. compressa*), was not a source of carbon for calcification, and appears to be the primary source of carbon for long-term tissue growth and carbon storage. Thus, long-term recovery from bleaching will depend on a coral's ability to acquire fixed carbon via heterotrophy to support its tissues while bleached, and to regain photosynthesis in order to stimulate calcification.

## 5-7

**When Is Not Bleaching "Unhealthy" For Corals And/Or Coral Reefs?**

**Sophie DOVE*[1]**, George ROFF[1], Simon DUNN[1]

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

"Thermal tolerance" and "bleaching tolerance" are used interchangeably in the coral literature. Furthermore the subject who is "tolerant" is often very vague with unexplained transitions from symbiont to host and/or coral reef ecosystems. Any of these levels are viewed as "healthy", as long as they are not bleached. Mass coral bleaching events where entire coral reef ecosystems turn white, accompanied by the sulfurous smells of death are obviously unhealthy; but how universally applicable is this label to colonial corals that tend to reduced symbiont densities in actively growing regions and on a seasonal basis, or to symbionts that have the ability to increase or maintain productivity by reducing the chlorophyll concentration of their light harvesting antennae? Conversely, as observed by Len Muscatine, symbiont densities are linked to quantity of carbon-skeletons leaked to the host. A more parasitic symbiont may fail to bleach simply because it passes on any losses in productivity to the host by reducing the quantity of fixed carbon translocated. In this way, a greater pool of energy is retained by the symbiont to repair photosystems and maintain symbiont populations at the expense of host metabolic activity or health. Data will be presented demonstrating that (i) corals can be 80% bleached, supporting remnant symbionts with 3 fold greater Pnet max cell-1 than adjacent non-bleached corals; (ii) that symbiont cultures can be at least 60% bleached yet growing at 2.5 times the rate of unbleached cultures. The results from 14C experiments on whole colonies from a variety of host-symbiont associations exposed to temperature x CO2 treatments, and starved at tips or bases will also be presented to monitor effect of treatment on carbon translocation not only between symbiont and host, but also between polyps.

## 5-8

**The Importance Of Zooplankton To The Total Energy Budget Of Healthy And Bleached Corals At Two Depths**

**James PALARDY*[1]**, Lisa RODRIGUES[2], Andrea GROTTOLI[3]

[1]Department of Ecology & Evolutionary Biology, Brown University, Providence, RI, [2]Department of Geography and the Environment, Villanova University, Villanova, PA, [3]School of Earth Sciences, Ohio State University, Columbus, OH

Bleached and non-bleached fragments of three species of Hawaiian corals were exposed to enhanced and ambient concentrations of zooplankton at 1 and 6 m depth to determine the contribution of zooplankton to the coral's total energy budget. The size and taxonomic grouping were recorded for every zooplankton captured and the relative input of zooplankton of different size classes determined. The contribution of heterotrophic carbon to animal respiration (CHAR) was calculated using an improved calculation method that included the proportionate contribution of zooplankton from all size classes. The results show that feeding rates followed the same pattern in both ambient and enhanced zooplankton concentrations. Corals captured the same size and assemblage of zooplankton under all evaluated conditions, and preferentially captured plankters smaller than 400μm. Feeding rates increased with depth in non-bleached corals, but not in bleached corals. Relative to non-bleached fragments at the same depth, feeding rates of bleached Montipora capitata increased, Porites compressa decreased and Porites lobata remained unchanged at both 1 and 6 m depth. Therefore, the response of corals to the same disturbance may vary considerably. The calculated CHAR values show that heterotrophic carbon from zooplankton plays a much larger role in the total energy budget of corals than was previously estimated, and may account for over 65% of some coral species' daily metabolic energy requirements when healthy and over 200% when bleached. Our results show that heterotrophically acquired carbon makes a significant contribution to the total carbon budget of corals under all conditions and depths, and suggests that nutrient acquisition via zooplankton feeding may play a significant role in coral-algal symbiosis balance.

## 5-9

**Unravelling Coral Photoacclimation: *symbiodinium* Strategy And Host Modification**

**Sebastian HENNIGE*[1]**, David SMITH[1], Kathleen MCDOUGALL[2], Mark WARNER[3], David SUGGETT[1]

[1]Coral Reef Research Unit, University of Essex, Colchester, United Kingdom, [2]Environmental Research Institute, North Highland College, Caithness, United Kingdom, [3]College of Marine Studies, University of Delaware, Lewes, DE

Light is often the most abundant resource within the nutrient poor waters surrounding coral reefs. Consequently, zooxanthellae (*Symbiodinium spp.*) must continually photoacclimate to optimise productivity and ensure coral success. To accurately assess *Symbiodinium* photoacclimation *in situ*, differences in acclimation strategies and bio-optical signatures need to be characterised between genetic types of *Symbiodinium.* Using a systematic series of laboratory experiments, eight types of *Symbiodinium* were cultured and examined using techniques such as active (FIRe) fluorescence, Photosystem I (PSI) and II counts, spectrophotometry and high performance liquid chromatography. Two key 'strategies' of photoacclimation are known to exist amongst microalgae: a preferential modification of the light harvesting antennae (□-based) or of the reaction centre bed (n-based) for PSII and/or PSI. Our measurements demonstrated that acclimation strategies employed by *Symbiodinium* were highly varied between algal type but despite this variability, many optical signatures were conserved. Also, when absorption was considered per photosystem, a 1:1 balance was observed between PSI and PSII. Acclimation strategies of intact *Acropora formosa* and *Seriatopora caliendrum* at two light levels were further examined using fluorescence and optical signatures to determine host contribution to acclimation. Overall, our results demonstrated that (1) biophysical (active fluorescence, photosystem-specific) but not bio-optical signatures were highly variable between algal types; consequently, bio-physical signatures that are altered by an adaptation of the algal community structure may be misinterpreted as photoacclimation and (2) host acclimation and modification of the light environment plays a key role in *Symbiodinium* photoacclimation.

## 5-10

**Combining O2 Microsensors And Fiber-Optic Technology To Measure Photo-Physiological Responses Of Symbiodinium**

**Karin ULSTRUP*[1,2]**, Michael KÜHL[1], Peter RALPH[2], Madeleine VAN OPPEN[3], David BOURNE[3]

[1]Department of Biology, Marinbiological Laboratory, University of Copenhagen, Helsingør, Denmark, [2]Department of Environmental Science, University of Technology, Sydney, Sydney, Australia, [3]Australian Institute of Marine Science, Townsville, Australia

Corals associate with a diverse microbial assemblage of which endosymbiotic and phototrophic microalgae, i.e. dinoflagellates belonging to the genetically diverse genus Symbiodinium, are best known. Traditional techniques to estimate photosynthesis activity such as oxygen exchange and 14C-incorporation of Symbiodinium are confounded by processes due to the coral host. In three case studies we employed a novel approach using two technologies that enable differentiation of the photosynthesis activity of Symbiodinium, pulse-amplitude-modulation (PAM) and O2 microsensors. The case studies included i) monotypic Symbiodinium associating with a coral (Pocillopora damicornis), ii) a ciliate forming a brown band on the coral Acropora muricata, and iii) a genotypically diverse Symbiodinium association with Acropora valida. In all instances, the combination of fibre-optic technology and an O2 microelectrode enabled parallel measurements of gross photosynthesis rate and photosystem II quantum yield at the coral surface under steady-state conditions as a function of increasing irradiances. The studies showed large plasticity in photo-physiological acclimation of Symbiodinium linked to light microclimate as well as motility (in the case of the ciliate) and Symbiodinium genotype (in the case of A. valida). In case i) and iii) there was non-linearity between relative electron transport rate (rETR) and gross photosynthesis measurements at moderate to high irradiances possibly due to vertical heterogeneity of the symbionts in the tissue and/or the operation of an alternative electron pathway such as cyclic electron flow around PSII. Case ii) demonstrated that Symbiodinium ingested by ciliates are photosynthetically competent and do not become compromised during the progression of the brown band zone. In contrast to case i) and iii) the symbionts produced relatively high gross photosynthesis rate and rETR at moderate to high irradiance due to greater efficiency of light absorption caused by a higher density of symbionts in the ciliate.

## 5-11

**Coral Holobionts Over Large Depth Ranges: Investigating The Roles Of Host Species, Colour Morphs And Functional Diversity Of Algal Symbionts**

**Pedro R FRADE*[1,2]**, Rolf PM BAK[1,2]

[1]Marine Ecology and Evolution, Netherlands Institute for Sea Research, Den Burg, Netherlands, [2]Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, Netherlands

We investigate the roles of host and symbiont on the *in situ* physiological response of coral genus *Madracis* holobionts towards light. Across a large depth gradient (5-40 m) and for four *Madracis* species, we studied the *Symbiodinium* identity as defined by rDNA ITS2 sequence variation and assessed a large set of functional variables by measuring chlorophyll *a* fluorescence, photosynthetic pigment composition and symbiont population descriptors. The same approach was applied on three colour morphs of the species *Madracis pharensis*. Overall, three symbiont types were identified, whose distributions are strong evidence for niche partitioning by depth, host species and colour morphs, as shown by logistic regression models. Multivariate analyses on the functional variables indicated most of the holobiont variation to be explained by few main photobiological components, which are ranging from environmentally flexible to more genetically constrained. Thus, photochemical or photosynthetic efficiencies are highly variable with external environment; symbiont cell densities and sizes strongly depend on genetic identity; and xanthophyll-cycle photoprotective pigments are regulated by both host and environment. This interaction between host and environment highlights the role of host properties in adjusting the internal environment available for the endosymbionts. The functioning of symbiont types plays a significant role in coral adaptation along reef slopes. Furthermore, different holobiont strategies are recognized, which vary in their optimization of light harvesting or protective mechanisms and which relate to host species or colour morph distribution and dominance over the reef slope.

## 5-12

**Phototropic growth and molecular basis for axial polyp differentiation in the branching coral Acropora aspera**

**Paulina KANIEWSKA*[1]**, Paul CAMPBELL[2], Maoz FINE[3], Ove HOEGH-GULDBERG[1]

[1]University of Queensland, Brisbane, Australia, [2]Department of Primary Industries and Fisheries, Brisbane, Australia, [3]Bar-Ilan University, Eilat, Israel

Reef building corals have high morphological variation across coral families, with many species also displaying phenotypic plasticity across environmental gradients. In particular, the colony geometry of branching corals is altered by the frequency, location and direction of branch initiation and growth. The environmental cues and molecular signaling pathways involved in axial polyp differentiation, the basis for new branch formation, are currently unknown. This study demonstrates that for the branching species *Acropora aspera*, light plays a key role in axial polyp differentiation. *A. aspera* branches exhibited a directional growth response, where axial polyp structures only developed when light was available, and towards the incident light. Field experimentation revealed that there was a light intensity threshold of 45 µmol photon m-2 s-1, below which axial polyp structures would not develop and this response was blue light (400 nm to 500 nm) dependent. There was a fourfold increase in axial polyp structure growth above this light intensity threshold. These features of coral branch growth are highly reminiscent of phototropic branch growth in terrestrial plants, which is directed by the blue light component of sunlight. To understand molecular signals involved in axial polyp differentiation, experiments investigating differential expression of genes in axial and radial polyps were conducted. This study is the first to present genes involved in axial polyp differentiation and therefore branch initiation. Here we indicate that a negative feedback may be involved. These results present a new avenue for discovering molecular processes involved in colony integration, an area which should become increasingly more important if we are to understand the complex responses of corals at a colony level to environmental change.

## 5-13

**The Role Of Photorespiration in The Symbiotic Association Between Dinoflagellates And Scleractinian Corals**

**Alicia CRAWLEY*[1]**, Ken ANTHONY[1], Sophie DOVE[1]

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

Rising $CO_2$ levels in the sea threaten to break-down the important relationship between reef-building corals and their symbiotic dinoflagellates. Photorespiration plays a significant role in maintaining dinoflagellate well-being by offering an alternative photochemical-quenching pathway and potentially triggering the Carbon-Concentrating Mechanism. As photorespiration is dependant on the ratio of $CO_2$ to $O_2$, rising $CO_2$ may ultimately lead to reduced capacity for photoprotection and increased occurrence of coral bleaching. Here we present data from a microcosm experiment with controlled levels of $CO_2$ and $O_2$. Physiological data has been derived from classical respiration measurements to produce Photosynthesis-Irradiance (P-E) curves. The P-E curves showed a decline in symbiont production at the highest $CO_2$ level (1100 ppm, pH 7.6). Excitation pressure, measured with a pulse amplitude modulation fluorometer, increased significantly with increasing $CO_2$ and decreasing $O_2$. However, these relationships were dependant on the proximity of growth light to saturating light intensities. We observed calcification at pH 7.8 but decalcification at pH 7.6 using the total alkalinity technique. These findings were closely linked to the gene expression of a key enzyme in the photorespiratory pathway, phosphoglycolate phosphatase (PGPase). mRNA of PGPase declined significantly by 54% at 560 ppm $CO_2$ (pH 7.8) and by 70% at 1100 ppm $CO_2$ (pH 7.6). This decline in photorespiration at high $CO_2$ provides a key insight towards the mechanism of $CO_2$-induced bleaching.

## 5-14

**Directed Pocilloporin Expression And Amino Acid Translocation in Response To Physical Injury in Scleractinian Coral Colonies**

**Jeffry DECKENBACK*[1]**, Sophie DOVE[1]

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

This research focused upon the potential for coral colonies to collect dissolved organic materials from external sources in response to physical injury and to translocate these materials in a specific manner in order to aide in regrowth and/or increased pocilloporin production. Within healthy coral tissues, myriad biochemical pathways exist both to harvest solar energy and prevent photo-inhibition by blocking or channelling excess energy that would otherwise damage the photosystems. Calcium carbonate skeleton exposed by injury may increase the path length of incident visible wavelength photons, reflecting them into the already disturbed tissues that border the sites of injury. By pooling and reallocating biochemical resources as appropriate, Scleractinian coral colonies can decrease the cost of regrowth to polyps at the site of injury by spreading this cost throughout the whole colony. Observations identified bands of bright pigment, likely a pocilloporin variant, surround sites of injury within 48 hours of initial injury. 14C-labelled amino acids were injected into selected artificially injured colonies of tan morph *Montipora sp.* and allowed to incubate. Upon appearance of pigment bands at injury sites, samples were collected to quantify host pigment content, mRNA signal expression, amino acid content, and total radioactivity. Injured corals expressed a strong response to physical injury, collecting available amino acids and allocating these within the colony as required to start the regrowth processes while also up-regulating pocilloporin mRNA signal expression within polyps closest to the site of injury. At the site of injury, regrowth was observed within two days, creating a region distinct from both the healthy tissue and exposed skeleton. Within this region, chlorophyll-specific absorbance was significantly lower than within healthy tissues, but pocilloporin-specific absorbance was unchanged relative to healthy tissues. In all, the coral colonies demonstrated very active and directed healing and recovery responses in response to physical injuries.

## 5-15

**The Effect Of Fluctuating Light On *symbiodinium* Photosynthetic Gene Expression**

**Lynda BOLDT*[1]**, David YELLOWLEES[2], Sophie DOVE[3], Bill LEGGAT[2]

[1]School of Pharmacy and Molecular Sciences, James Cook University, Townsville, QLD, Australia, [2]School of Pharmacy and Molecular Sciences, James Cook University, Townsville, Australia, [3]Centre for Marine Studies, University of Queensland, Brisbane, Australia

This study examined the membrane bound light harvesting proteins of *Symbiodinium*, an endosymbiotic dinoflagellate of reef building corals as well as other marine invertebrates. We investigated whether genes involved in photosynthesis are differentially expressed on a diurnal basis and if known physiological responses can be linked with differential gene expression. Putative membrane bound light harvesting proteins of *Symbiodinium* isolated from *Acropora aspera* collected from the reef flat surrounding Heron Island were characterized with several indicating homology with red algae while the major homology was with other dinoflagellate light harvesting proteins. To further elucidate the relationship between light and *Symbiodinium* photosynthesis, *Symbiodinium* isolated from *Acropora formosa* collected from Orpheus Island, part of the Palm Island group on The Great Barrier Reef, were analysed and photosynthetic gene expression compared with samples exposed to no light over a 24 hour period. While there were no significant physiological differences or variation in photosystem II functionality between coral branches exposed to no light and those exposed to diurnal light fluctuations, the response of various genes involved in photosynthetic processes did vary diurnally. This work is the first to examine the putative membrane bound light harvesting proteins of *Symbiodinium* and confirm that photosynthetic genes of *Symbiodinium* isolated from a reef building coral are differentially expressed on a diurnal basis and that the removal of light results in the down regulation of key light dependent photosynthetic genes.

## 5-16

**Light Energy Transformation Processes By Fluorescent Pigments Of Corals**

**Anya SALIH*[1]**, Yuri ZAVOROTNY[2]

[1]Confocal Bio-Imaging Facility, University of Western Sydney, Penrith, Australia, [2]Advanced Laser Technologies Department, Institute of Laser and Information Technologies RAS, Moscow, Russian Federation

Tissues of reef building corals are pigmented by multi-colored and fluorescent proteins belonging to a family of GFPs (Green Fluorescent Proteins). Experimental evidence indicates that one of the major biological functions of these pigments is in light regulation and photoprotection by light absorption, scattering and energy transformation via fluorescence. Here we examine the different modes of energy transformation by GFP-type proteins in tissues of shaded, light-acclimated and bleached Great Barrier Reef (Australia) corals using steady state fluorescence spectroscopy and Fluorescence Life-Time Imaging (FLIM) confocal microscopy. We show that corals can dynamically regulate energy transformation properties of their tissues in response to light as it passes through pigments. In low light corals, Förster resonance energy transfer (FRET) capacity of tissues was reduced compared to high light corals and both non-radiative FRET and radiative energy channelling capacity were increased in the latter. Cellular fluorescence lifetimes were highest in several acroporiid bleached species examined, indicating that GFP-type proteins increased cellular capacity to dissipate excessive incident light. Since light energy transfer processes among chlorophyll molecules determine the photosynthetic efficiency of coral's symbiotic microalgae, FLIM of symbionts in live tissues was also used to provide a rapid and efficient means to access their health. At high irradiances, chlorophyll lifetimes of GFP-pigmented tissues were shorter than of less pigmented ones, indicative of less photo-stressed microalgae. Our study showed that confocal micro-spectral imaging in combination with FLIM provides a rapid and an accurate method to visualise and analyse cellular and optical properties of the coral host and to quantitatively determine the photosynthetic capacity of the symbionts. The study provides important information about the physiological responses of the host to light, the cellular mechanisms it uses to counteract photo-stress and to reduce the susceptibility to bleaching.

## 5-17

**Roles And Origins Of Superoxide Dismutases in A Symbiotic Cnidarian**

**Paola FURLA*[1]**, Sophie RICHIER[2], Pierre-Laurent MERLE[1], Ginette GARELLO[1], Amandine PLANTIVAUX[3], Didier FORCIOLI[1], Denis ALLEMAND[4]

[1]EA ECOMERS, Nice-Sophia Antipolis University, Nice cedex 02, France, [2]UMR 7093, Villefranche-sur-mer oceanological observatory, Villefranche-sur-Mer Cedex, France, [3]NUI Galway, Galway, Ireland, [4]Scientific Center of Monaco, Monaco, Monaco

Cnidarians living in symbiosis with photosynthetic dinoflagellates daily experience hyperoxia state due to the photosynthetic activity of the symbiont. Studies on the symbiotic sea anemone, Anemonia viridis, showed an increase of three-fold normoxic value within the coelenteric cavity after 20 minutes of light exposure. However, no accompanying oxidative damage was observed suggesting the presence of efficient antioxidant defenses. Among them, superoxide dismutases (SOD) constitute the first line of antioxidant defense. A detailed analysis of this enzyme family in both host tissues and symbionts showed several particularities in 'symbiotic cnidarians' such as high isoform diversity and presence of extracellular SOD and common isoforms between the two partners. Eight SOD isoforms have been identified belonging to four SOD classes : 4 Manganese SOD (MnSOD), 1 intracellular copper-zinc SOD (CuZnSOD), 1 extracellular copper-zinc SOD (ECSOD) and 2 iron SOD (FeSOD). Although both intracellular and extracellular CuZnSOD were localized exclusively to the cnidarian host tissues MnSOD and FeSOD isoforms are shared between the two partners. Investigation of the genetic origin of these shared SODs unveiled high degree of co-evolution between the two organisms inferring mechanism of protein translocation and events of horizontal gene transfert.

## 5-18

**Morphological Dependence Of The Variation in The Light Amplification Capacity Of Coral Skeleton**

**Susana ENRÍQUEZ*[1]**, Eugenio MÉNDEZ[2], Ove HOEGH-GULDBERG[3], Roberto IGLESIAS-PRIETO[1]

[1]Unidad Académica Puerto Morelos, Universidad Nacional Autonoma de Mexico, Cancun, Mexico, [2]Departamento de Óptica, CICESE, Ensenada, Mexico, [3]Center for Marine Studies, University of Queensland, Brisbane, Australia

Multiple scattering produced by the highly reflective aragonite coral skeleton, has been associated with a strong increment in the light absorption capacity of the symbiotic algae. For a Caribbean scleractinian coral used as a model organism, it has been quantified that algal pigments in the intact tissues are between 2 and 5 times more efficient for absorbing light than freshly isolated cell suspension containing similar amount of pigments. Theoretical calculations based on a flat lambertian surface indicate amplification factor up to three. More complex structures or concave surfaces are expected to have much higher values, although are theoretically intractable. Here, we analyzed the variability in the light amplification capacity of naked coral skeletons associated with the variation in skeleton morphology. We quantified the capacity of light amplification of 76 Indo-Pacific coral species belonging to 9 different families. Among them, 49 species belonged to the Faviide family. We found large variation among coral skeleton morphologies, in their light amplification capacity, from a minimum of 3 shown by the species *Caulastrea curvata* to a maximum of 10 shown by *Echinopora lamellose*. These results confirm the importance of coral skeleton morphology for understanding algal light environment and the magnitude of pigment packaging within coral tissue. We will discuss the patterns found in this comparison and their evolutionary implications.

## 5-19

**Characterization Of Optical Properties Of Reef-Building Coral Skeletons**

Vadim BACKMAN[1], Margaret SIPLE[2,3], Erin DALY[2], Andrew FANG[2], Mark WESTNEAT[4], Vladimir TURZHITSKY[1], Jeremy ROGERS[1], **Luisa MARCELINO*[2,3]**

[1]Biomedical Engineering Department, Northwestern University, Evanston, IL, [2]Civil and Environmental Engineering, Northwestern University, Evanston, IL, [3]Zoology, Field Museum of Natural History, Chicago, [4]Zoology, Field Museum of Natural History, Chicago, IL

A successful symbiotic algae-coral partnership is largely determined by the efficiency with which reef-building corals absorb light. This is achieved in two major ways: by controlling symbionts/pigment concentration and by multiple light-scattering in the skeleton resulting in homogenization of the light available to the coral tissue. Here we propose that light redistribution needs vary among corals with different growth forms. We characterized the optical properties of coral skeletons using a novel technique, low-coherence enhanced-backscattering (LEBS). We measured light mean free-path length (ls) in coral skeletons grouped into three growth forms: Branching, Massive and Laminar. We found that ls is significantly longer in Branching compared with Massive and Laminar corals. Longer ls results in a better redistribution and delivery of light to the shaded parts of a coral colony and increases the amplification of light availability to the entire colony. We tested if skeleton density determines these observed optical properties. Branching and Laminar corals had significantly higher densities then Massive corals. This agrees with previous studies: greater density is required by Branching and Laminar corals to support their mechanical stability. However, increased skeletal density typically results in shorter ls. To reconcile these observations, we measured the micro-architecture of coral skeletons using LEBS. We found that the length-scale of nanoscale density variation (i.e. granularity) is lower in Branching corals than in Massive or Laminar. According to light-scattering theory, this finer granularity results in longer ls. Thus, the nanoarchitecture of Branching corals ensures long distances of light transport necessary for light delivery to coral tissue without sacrificing their mechanical stability. Because light transport in coral is responsible for the amplification of light availability to coral tissue and Branching corals show higher bleaching-related mortality, this finding may have implications for differential bleaching resistance in different corals.

## 5-20

**In Hospite Operation Of The Photosystem Ii Repair Cycle in Symbiotic Dinoflagellates**

**Xavier HERNANDEZ-PECH*[1]**, Roberto IGLESIAS-PRIETO[1]

[1]Unidad Academica Puerto Morelos ICMyL UNAM, Puerto Morelos, Mexico

Photosynthesis by symbiotic microalgae is a fundamental process in coral reefs. Algal photosynthesis can provide more than 100% of the metabolic requirements of the intact symbiotic association. The maintenance of optimal photosynthetic rates in nature is achieved by balancing the rates of light-induced damage of photosystem II (PSII) with the *de novo* synthesis of PSII. The intracellular environment in which symbiotic dinoflagellates flourish experiences dramatic diurnal oscillations in O2 concentrations. During the daylight hours, *p*O2 can be as high as 300% saturation, whereas during the nighttime, *p*O2 may reach values as low as 5%. These conditions may modify the rates of damage and repair of PSII in hospite. To understand the factors that control the regulation of photosynthesis in hospite, we inhibited protein synthesis with chloramphenicol (50mg/L) and Licomycine (50 µg/L) on *Porites astreoides* nubbins exposed to half of the surface irradiance in external aquariums. Synthesis was inhibited during one hour at different times of the day. A continuous inhibition treatment from 6 am to 2 pm, and a control treatment without inhibition were maintained. PSII charge separation efficiency (ΔF/Fm`) was monitored every hour during the experiment. Our data showed significant reduction on ΔF/Fm` proportional to the time of exposure and light intensity at which synthesis was inhibited. In the experimental treatments, ΔF/Fm` fail to recover at dusk. These losses were proportional to the light intensity and time of inhibition. Our analyses revealed average lifetimes for PSII of 3.1 hours, suggesting that this process consume large amounts of energy that could not be translocated to the coral host.

## 5-21

**Asymbiotic Coral Larvae Preferentially Acquire Free-Living Symbiodinium From The Sediment Rather Than From The Water Column**

**Lisa ADAMS*[1]**, Vivian CUMBO[2], Misaki TAKABAYASHI[1]

[1]Marine Science Department, University of Hawaii at Hilo, Hilo, HI, [2]James Cook University, Townsville, Australia

Primary or secondary acquisition of free-living Symbiodinium could influence recovery, resilience, and long-term adaptation of many species of symbiotic marine invertebrates. Previous studies have identified environmental populations of free-living Symbiodinium in the water column and sediments of coral reefs. The diversity, abundance, and distribution patterns of these free-living Symbiodinium that are acquired by animal hosts are not well characterized to date. We conducted tank experiments to test whether asymbiotic coral larvae of Acropora monticulosa acquired free-living Symbiodinium from the water column or sediment. Treatments included natural sediment and filtered (0.22um) seawater (FSW), natural sediment with unfiltered seawater (SW), no sediment with FSW, and no sediment with SW. In treatments containing natural sediment, 40 +/- 8.2 % of larvae had acquired Symbiodinium after 3 days of exposure, and 80-90 +/- 7.85 % by 6 days of exposure. The Symbiodinium densities within the larvae were highly variable at all time points. In treatments without natural sediment, acquisition of Symbiodinium was not evident until day 6, and only up to 20 +/- 10 % of the larvae were infected throughout the 12-day experiment. Furthermore, Symbiodinium densities in larvae of seawater treatments were consistently low, averaging 1-2 cells per larva. Results from this experiment indicate that infaunal population of Symbiodinium is more accessible for asymbiotic larvae of A. moticulosa either because the infaunal population of Symbiodinium is higher than in water column, the infaunal Symbiodinium is more viable than their counterpart in water column, due to larval behavior that puts them more in contact with sediment than water column, or a combination of these factors. Moreover, preliminary DNA analysis suggests that larvae are acquiring different strains Symbiodinium from sediment to those from the water column.

## 5-22

**Dynamic Establishment Of Coral-Dinoflagellate Symbioses in Heat Stressed Coral Juveniles**

**David ABREGO*[1]**, Bette WILLIS[1], Madeleine VANOPPEN[2]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

Very little is known about how environmental conditions affect the capacity of newly settled coral juveniles to acquire symbionts and establish the initial symbiosis. Here we examine the uptake of *Symbiodinium* dinoflagellates by newly settled *Acropora* corals kept at three different temperatures and two light levels including treatments typically considered environmentally stressful. Visual scoring and cell counts of the corals revealed a significant delay in the uptake and establishment of symbionts in high temperatures (31 °C) and/or high light, even though the relative survival of juveniles in these treatments was similar to those in the control temperature (28 °C) and low light. Using real-time quantitative PCR we measured the proportion of symbionts taken up from a pool of two phylotypes offered. In *A. millepora* juveniles type D *Symbiodinium* was detected in higher proportions than type C1 in juveniles at high temperatures and high light. These results suggest that type D is more competitive under environmentally stressful conditions. By comparing the uptake patterns in *A. tenuis* juveniles we will discuss the role of the host in regulating the initial establishment of the symbioses and the generality of type D as a stress-tolerant symbiont.

## 5-23

**Initiation Of Coral/algal Symbioses: The Role Of Cell Surface Lectin/glycan Interactions in Recognition And Specificity**

**Elisha WOOD-CHARLSON*[1]**, Virginia WEIS[1,2]

[1]Zoology, Oregon State University, Corvallis, OR, [2]Zoology, Oregon State University, Corvallis

The majority of corals rely on horizontal transmission of the dinoflagellate symbionts *Symbiodinium* spp. to perpetuate their symbiotic condition from one generation to the next, and most coral hosts are only found in association with a specific clade of symbiont. How do larval corals and their symbiotic algae discriminate between their preferred partner and other hosts or microbes during the onset of symbiosis? We hypothesized that cell surface lectin/glycan interactions act as one mechanism of recognition and specificity during initial contact between the partners. To determine the role of these interactions during infection, we modified the glycans on the cell surface of algal symbionts (C1f and C31, found in nature in adult *Fungia scutaria* and *Montipora capitata*, respectively), introduced the modified symbionts to *F. scutaria* larvae, and then looked for changes in infection success. After cell surface modification, infection rates of native C1f algae decreased. In contrast, cell surface modification of non-native C31 algae resulted in higher infection rates compared to unmodified, control algae. These data suggest that the symbiont cell surface plays a role in specificity between *F. scutaria* larvae and C1f symbionts. To explore the source of this specificity, we investigated the variability of glycans present on the cell surface of several clade C symbionts. We found that cell surface glycan profiles were different for each symbiont, and we hypothesize that a specific glycan profile serves to identify the symbiont to its host coral. Finally, we described a complex array of C-type lectins, a type of glycan receptor, in the anemone *Nematostella vectensis* genome. The diversity of glycan profiles on symbiont cell surfaces and C-type lectins in cnidarians suggests that these interactions serve as a signal for recognition and specificity between symbiotic partners.

## 5-24

**Variability In Cell Surface Glycan Profiles Across A Range Of *Symbiodinium* Dinoflagellate Types.**

**Daniel LOGAN*[1]**, Anne LAFLAMME[1], Virginia WEIS[2], Simon DAVY[1]

[1]Victoria University of Wellington, Wellington, New Zealand, [2]Oregon State University, Corvallis, OR

*Symbiodinium* sp. dinoflagellates are the symbiotic partner in many cnidarian hosted mutualistic relationships. These *Symbiodinium* show a degree of specificity for particular hosts with a limited range of symbiont types being found in association with a given host. This specificity may be partially determined through cell surface glycan-lectin interactions during the initiation of the symbiosis. The diversity of glycans present on the *Symbiodinium* cell surface was investigated through the use of sugar-specific fluorescently labeled lectin probes and flow cytometry. The four lectin probes utilized exhibited differential levels of binding to the cell surfaces of the initial four *Symbiodinium* types examined, suggesting variation in cell surface glycan diversity and concentration between *Symbiodinium* types. It appears that variation in glycan profiles may be lowest between *Symbiodinium* types originally isolated from similar hosts. This work is ongoing with an expanded range of *Symbiodinium* types and lectin probes. Once a wider range of glycan profiles have been compiled, these data will be analyzed to elucidate whether any correlations between glycan variation, phylogenetic distance and host-symbiont specificity exist.

## 5-25

**Identification and Expression Analysis of Symbiotically Enhanced Coral mRNAs**

**Ikuko YUYAMA*[1]**, Toshiki WATANABE[1]

[1]Department of Marine Bioscience, Ocean Rsearch Institute, The University of Tokyo, Tokyo, Japan

Hermatypic corals live in obligatory mutualistic symbiosis with the dinoflagellates Symbiodinium spp. The molecular mechanisms by which corals establish and maintain symbiosis, however, remain unknown. With the purpose of identifying coral mRNAs that play pivotal roles in symbiosis, the mRNA expression profiles were compared between juvenile polyps of Acropora tenuis in the following two states: (i) aposymbiotic, and (ii) inhabited by Symbiodinium cells strain PL-TS-1 (clade A3) or CCMP2467 (A1). Using suppression subtractive hybridization and HiCEP (a cDNA AFLP-based expression profiling technique), eight cDNA fragments were isolated including those which encode sulfate transporter, syndecan, lipase, and protein kinase. Sequence analysis of the sulfate transporter cDNA suggested that the encoded protein, an integral membrane protein with eleven trans-membrane domains, is a cnidarian member of the SLC26A11 sulfate/anion exchanger family. The expression level of the mRNA was increased by the presence of both Symbiodinium strains PL-TS-1 and CCMP2467. An immunohistochemical study showed that the sulfate transporter protein is expressed in a cell-specific manner. Notable expression of the protein was observed in the following cells: (i) endodermal cells in the tissue between the coelenteron and skeleton in the peritheca, (ii) mucus cells, and (iii) cells of unidenfied types in the mesenterial filament. These results may suggest that in the above cells the uptake of SO42- is augmented and synthesis of sulfated macromolecules (such as glycosaminoglycans) is thereby enhanced by the presence of Symbiodinium cells. Such sulfated molecules are presumably used for the formation of the mucus and organic matrix of the calcified skeleton.

## 5-26

**Suicide Is Painless, It Brings On Many Changes: Apoptosis And Autophagy in Cnidarian-Dinoflagellate Symbiosis.**

**Simon DUNN*[1]**, Sophie DOVE[1]

[1]Center for Marine Studies, University of Queensland, St Lucia, Brisbane, Australia

The underlying cellular pathways that control the onset, maintenance and breakdown of cnidarian–dinoflagellate symbiosis are just beginning to be described. The pathways that have been shown to operate during these processes are highly conserved from yeast to complex metazoans, including higher vertebrates. Two examples of these pathways are apoptosis and autophagy, which are crucial to development, tissue homeostasis and immunity. Apoptosis and autophagy leading to the suicide of specific cells has been shown to be active when the cnidarian-dinoflagellate symbiosis is under stress. Key molecular components of these signal transduction pathways have been identified in cnidarians. However, the triggers activating the initiation of these pathways in this symbiosis remain unresolved and are now under investigation. This study focuses on the role of mitochondria in these cellular processes.

## 5-27

**Potential Parental Effects On Establishment And Maintenance Of Cnidarian-Algal Symbioses**

**Daniel POLAND*[1]**, Andrew HANNES[1], Mary Alice COFFROTH[2]

[1]Department of Biological Sciences, SUNY at Buffalo, Buffalo, NY, [2]Department of Geology, SUNY at Buffalo, Buffalo, NY

During early stages of cnidarian-algal symbioses coral recruits acquire a diverse array of symbiotic dinoflagellate algae (genus *Symbiodinium*). Yet over time *Symbiodinium* diversity within the host is reduced as the adult host-*Symbiodinium* specificity is established. The factors controlling this are unclear. Here, we investigated the establishment of symbioses between a Caribbean octocoral, *Briareum asbestinum*, and its *Symbiodinium* partners. Adult *B. asbestinum* harbor *Symbiodinium* of two lineages within clade B (B178 and B184), which are distinguished by sequence variability in the chloroplast large subunit (23S) ribosomal DNA. *B. asbestinum* harbored *Symbiodinium* B178 in most Caribbean and Florida Keys populations sampled. However, in the Florida Keys, a few *B. asbestinum* populations harbored mostly B184 or B178+B184 *Symbiodinium*. To investigate the progression of the symbiosis from newly settled polyps (recruits) to established colonies, asymbiotic larvae were collected from parents with B184 or B178 *Symbiodinium*. Larvae from B178 adults were placed in several habitats and larvae from B184 adults were raised at a site where only B178 adults were found. Regardless of the *Symbiodinium* populations in adults, recruits initially harbored *Symbiodinium* assemblages dominated by B184, although other algal symbionts were also present. After 24 months, 98% of recruits originating from parents with B184 *Symbiodinium* harbored only B184, despite the predominance of B178 in the local host population. Recruits originating from parents with B178 *Symbiodinium* showed an increased frequency of B178 with 10% and 40% of the recruits harboring B178 and B178+184, respectively, and 50% maintaining only B184 *Symbiodinium*. These results suggest that establishment of symbiotic relationships in cnidarians may remain dynamic for many years following settlement and initial *Symbiodinium* acquisition.

## 5-28

**Cell-Cycle Regulation in The Dinoflagellate-Cnidarian Symbiosis**

**Santiago PEREZ*[1]**, John PRINGLE[1], Carlo CARUSO[1]

[1]Genetics, Stanford, Stanford, CA

Studies of cnidarian-algal symbiosis have described many aspects of their anatomy and physiology. However, to date, the molecular and cellular underpinnings of these ecologically important symbioses remain grossly understudied. For example, several studies of the hydrozoan species *Hydra viridis* concluded that its symbiotic green-algal cells coordinate their cell cycles with those of the host cells and that light, inorganic nutrients, and host feeding are important regulators of this process. Yet, we do not know the mechanisms either of host-symbiont coordination or of the environmental influences on the process, nor is it clear whether the controls that appear to operate in *Hydra* are also found in other systems such as coral-dinoflagellate symbioses. We are one of several laboratories attempting to develop the small tropical sea anemone *Aiptasia* spp. as a tractable laboratory model system for study of the molecular and cell biology of cnidarian-dinoflagellate symbioses. *Aiptasia,* like the scleractinian corals, is symbiotic with dinoflagellates of the genus *Symbiodinium,* so it is likely that our results will be widely applicable. We will describe our progress in developing methods for the study of and in elucidating the coordination between the host and symbiont cellular reproduction during the initial establishment of the symbiosis, its steady-state maintenance, and the stress conditions that lead to the breakdown of the symbiois.

## 5-29

**Functional Diversity in The Symbiotic Interactions Between Coral And *symbiodinium***

**Michael STAT*[1]**, Emily MORRIS[1], Ruth GATES[1]

[1]HIMB, University of Hawaii, Kaneohe, HI

The symbiotic continuum ranges between mutualism and parasitism. In coral-dinoflagellate symbiosis, the interaction has been defined as mutualistic via the exchange of organic and inorganic nutrients that in turn allows for the growth and formation of coral reefs. The symbiotic dinoflagellate genus *Symbiodinium* is genetically diverse containing eight broad lineages (clades A-H). Corals predominantly associate with clade C *Symbiodinium*, and less commonly with clades A, B, D, F, and G. Variation in the function and interactive physiology of different coral-dinoflagellate assemblages is virtually unexplored but important to our understanding of factors that contribute to coral reef resilience. In this study, we evaluated the symbiotic interaction between coral and *Symbiodinium* belonging to two clades, A and C. We approached this using ecological, phylogenetic, and biochemical analyses. Our data shows 1) that there is a significant correlation between the presence of *Symbiodinium* clade A and health compromised corals; 2) that phylogenetic and genetic distance analyses place clade A as more closely related to free-living dinoflagellates than the other *Symbiodinium* lineages; and 3) that *Symbiodinium* clade A fixes and releases significantly lower amounts of carbon in the presence of a coral synthetic host factor than clade C. Collectively these data demonstrate that the interaction between coral and *Symbiodinium* clade A is not the same as the relationship between clade C and coral and that along the symbiotic continuum the interaction between clade A and coral is closer to parasitic than mutualistic in nature.

## 5-30

**Introduction Of Foreign Genes in *symbiodinium*: A Strategy To Study The Function Of The Cytoskeleton And Other Proteins**

**Marco VILLANUEVA*[1]**, Tania ISLAS-FLORES[2], Claudia MORERA[1], Roberto IGLESIAS-PRIETO[1], Patricia THOMÉ-ORTIZ[1], Frantisek BALUSKA[3], Diedrik MENZEL[3], Boris VOIGT[3]

[1]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología-UNAM, Puerto Morelos, Mexico, [2]Plant Molecular Biology, Instituto de Biotecnología-UNAM, Cuernavaca, Mexico, [3]Institute of Cellular and Molecular Botany, University of Bonn, Bonn, Germany

Two proteins were visualized through the use of their corresponding fusions to the reporter green fluorescent protein (GFP). First, the actin microfilaments in *Symbiodinium* cells in culture were visualized through the introduction of an actin-binding domain of fimbrin (ABD2) fused to GFP. In addition, the constitutively expressed distribution of a receptor for activated protein kinase C (RACK1) from the plant *Arabidopsis thaliana* also fused to GFP was assessed in *Symbiodinium kawagutii* cells. In both cases, the plasmid vectors containing the 35S constitutive promoter and the corresponding fusions, also contained resistance genes for selection of the transformed cells. The ABD2-GFP construct was located in a pCAMBIA 1390 vector with a resistance gene to hygromycin, and the GFP-RACK1 construct was in pCB302 with a resistance gene to the herbicide Basta™. The plasmid constructs were introduced by a brief treatment of the cells with a bead beater in the presence of polyethylene glycol and glass beads. The cells were grown in ASP-8A with the corresponding selection agent. The selected cells were analyzed at the initial stages and after prolonged cell culture with normal light and epifluorescence under a Zeiss Axiostar Plus FL microscope and a Zeiss confocal microscope. In the case of the GFP-RACK1 expression, the fluorescence of the GFP was evident and reflected the expression of the protein introduced in the construction, which was throughout the cell in the cytoplasmic matrix. In the case of ABD2-GFP, the fluorescence was evident in the cytoskeletal matrix. This strategy will be useful for the study of the cytoskeleton and other proteins relevant in various biological processes in *Symbiodinium*.

## 5-31

**Redistribution Of Endosymbiotic Dinoflagellates Between Different Tissue Layers in Coral Larvae**

**Hui-Ju HUANG*[1]**, Li-Hsueh WANG[1,2], Hui-Jun KANG[1], Lee-Shing FANG[3], Chii-Shiarng CHEN[1,2]

[1]Coral Research Center, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [2]Institute of Marine Biotechnology, National Dong Hwa University, Pingtung, Taiwan, [3]Cheng Shiu University, Kaohsiung, Taiwan

In adult cnidarians, symbiotic dinoflagellate *Symbiodinium* is usually located in the gastrodermis. However, during early development, they have also been observed in oocytes or the epidermis of the planula larva. It indicates that the cellular site of the cnidaria-dinoflagellate endosymbiosis may be regulated developmentally, highlighting a dynamic and complicated interaction between the host cell differentiation and the symbiont. This study first examined the distribution of the *Symbiodinium* population in tissue layers of planula larvae in the stony coral *Euphyllia glabrescens*. Here, *Symbiodinium* were redistributed from the epidermis to the gastrodermis, at a rate that was fastest during early planulation and then decreased prior to metamorphosis. Based on the whole embryo analysis and the transmission electron microscopic examination, the redistribution of symbionts is attributed to a direct translocation of the *Symbiodinium* sp. from the epidermis to the gastrodermis. The translocation can be inhibited by treatments with nocodazole and DCMU (3-(3, 4-Dichlorophenyl)-1, 1-dimethylurea), leading to the retardation of larval settlement and metamorphosis. This suggested the involvement of host cytoskeleton and photosynthesis of the symbiont in regulating the translocation. Finally, using MALDI imaging mass spectrometry and synchrotron radiation-based infrared microspectroscopy, the timing of *Symbiodinium* translocation was shown to be correlated with changes of spatial distribution and composition of lipid bodies (LB) in the host cell. The result indicates that the *Symbiodinium* translocation is regulated by the host tissue.

## 5-32

**Juvenile Corals Acquire More Carbon From High-Performance Algal Symbionts**

**Neal CANTIN*[1,2]**, Madeleine VAN OPPEN[2], Bette WILLIS[1], Jos MIEOG[3], Andrew NEGRI[2]

[1]James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia, [3]University of Groningen, Haren, Netherlands

Algal endosymbionts of the genus *Symbiodinium* play a key role in the nutrition of reef building corals and strongly affect the thermal tolerance and growth rate of the animal host. We used 9 month old *Acropora millepora* juveniles that had a common parentage and had been experimentally infected with either *Symbiodinium* C1 or D immediately following metamorphosis to test the influence of genetically distinct symbionts on the physiological performance of reef-building corals. Here we report that the capacity of photosystem II (rETRMAX) is 87% greater in *Symbiodinium* C1 than in *Symbiodinium* D *in hospite*, and that 14C photosynthate incorporation (carbon based energy) into juvenile tissues of the coral, *A. millepora*, is doubled in C1 corals. Greater carbon delivery from *Symbiodinium* C1 provides juveniles with a competitive advantage since rapid early development typically limits mortality. *Symbiodinium* C1 corals, however, lose this competitive advantage under stressful conditions that limit electron transport. These findings significantly advance our current understanding of symbiotic relationships between plants and animals and describe a photophysiological mechanism that may enhance the growth and resilience of corals facing an uncertain future climate.

## 5-33

**Determinant Of Histoincompatibility Reactions in Corals**

**Michio HIDAKA*[1]**, Diah PERMATA[2]

[1]Department of Chemistry, Biology and Marine Science, University of the Ryukyus, Nishihara, Okinawa, 903-0213, Japan, [2]Diponegoro Univeristy, Semarang, Indonesia

In colonial corals, two allogeneic colonies display various contact reactions such as rejection, non-fusion, overgrowth, and fusion, while clonemates invariably fuse with each other. It has been suggested that historecognition system is not fully developed in early stages of development in some corals. The objective of this study was to investigate whether outcomes of allogeneic contact are determined by the genetic relatedness of the pairs or influenced by developmental stages. We observed the interface of allogeneic pairs of primary polyps and adult colonies of *Pocillopora damicornis* under light and electron microscopes. We found that pairs of primary polyps derived from different colonies of *P. damicornis* showed either fusion, non-fusion, or incompatible fusion response. In incompatible fusion, tissues were continuous but a white zone with few zooxanthellae was formed at the interface and polyps at the interface zone were sometimes absorbed. The skeleton at the interface was also continuous but irregular in shape. Shrunk nuclei and large extracellular spaces suggest that cell death via apoptosis occurred at the interface region. Incompatibly fused pairs transformed to non-fusion after several months, though the speed of this shift differed among pairs. Shrunk nuclei and extracellular spaces were also observed in non-fused pairs of adult branches. Even in non-fused pairs, tissues of the paired branches touched each other at the growing edge and competition occurred at a cellular level. When two allogeneic tissues contact with each other, some pairs show stable fusion resulting in chimeric colonies, while others transform from temporary fusion to incompatible fusion response, which later transform into non-fusion response. The speed of this shift of contact reaction might be determined by the genetic relatedness of the pairs rather than developmental stages of the pairs.

## 5-34

**Developmental Mechanisms And The Onset Of Symbiosis in Scleractinian Coral Embryos**

**Heather Q. MARLOW*[1]**, Mark Q. MARTINDALE[1]

[1]Kewalo Marine Laboratory, University of Hawaii, Honolulu, HI

Advances in understanding symbiosis, bleaching, eco-toxicology and mineralization are being made in adult corals, but fewer studies into the early embryonic and larval stages of the coral life cycle have been conducted. Events critical to the survival of the coral polyp occur in these early stages such as the development of tissue layers, acquisition of symbionts, and formation of the nervous system. Embryonic coral development provides the opportunity to examine ecologically relevant questions such as the onset of symbiosis as well as questions surrounding the evolution of developmental mechanisms in corals. Practically, embryonic material from scleractinian corals provides an excellent opportunity to study the cell biology of the onset of symbiosis without the difficulties associated with adult skeleton and contaminating commensal organisms. To examine the onset of symbiosis, we have utilized cell lineage tracing experiments as well as high resolution microscopy to examine symbiodinium uptake and localization in *Fungia scutaria* and *Pocillopora meandrina*. Our findings suggest that an ancient anthozoan mechanism that allows early embryos to localize yolk stores has been co-opted to facilitate symbiodinium localization in the embryo. As a next step in more carefully examining these events as well as those surrounding developmental mechanisms such as neurogenesis and body axis specification we are utilizing genomic and molecular techniques developed for the model anthozoan *Nematostella vectensis*. We have cloned genes necessary for axis specification, gut formation, and neurogenesis and have performed in situ hybridization experiments to localize these transcripts in embryonic corals. These studies allow us to understand common themes in anthozoan development and determine how these mechanisms affect the early life history and survival of coral embryos.

## 5-35

**A Computational Model For Gene Regulation Of Early Development in The Sea Anemone *nematostella Vectensis* And The Coral *acropora Millepora***

**Jaap KAANDORP*[1]**, Konstantin KOZLOV[2], Vitaly GURSKY[3], Yves FOMEKONG NANFACK[1], Maksat ASHYRALIYEV[4], Marten POSTMA[1], Maria SAMSONOVA[2], Alexander SAMSONOV[3], David MILLER[5], Joke BLOM[4]

[1]Section Computational Science, University of Amsterdam, Amsterdam, Netherlands, [2]St. Petersburg State Polytechnical University, St Petersburg, Russian Federation, [3]Theoretical Department, The Ioffe Institute of the Russian Academy of Sciences, St Petersburg, Russian Federation, [4]Center for Mathematics and Computer Science (CWI), Amsterdam, Netherlands, [5]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland, Australia

Recently significant progress has been made towards understanding the genetic regulation of early development of the cnidarians *Nematostella vectensis* and *Acropora millepora*. Both organisms are members of the basal cnidarian Class Anthozoa, with relatively simple body plans. Whereas in many organisms early embryogenesis involves complex sequences of unequal cell divisions, the fact that cell division up to gastrulation occurs equally and the expectation of relatively simple gene regulation, make *Nematostella vectensis* and *Acropora millepora* excellent case studies for developing a cell-based computational model of gene regulation of early development. Despite some major morphological differences, the body of molecular data indicates that the underlying developmental biology of both organisms is similar in many ways, The most obvious physiological difference is that *N. vectensis* is a non-calcifying sea anemone, while *A. millepora* secretes an extensive aragonite skeleton after settlement. Based on in situ hybridizations available for different developmental stages of both organisms we have developed a spatio-temporal model of gene regulation of early embryogenesis which can be applied to both organisms (the ``AcroNema'' model). The model is based on a set of coupled partial differential equations. The AcroNema model is generic for the early development of both organisms and can produce an 8-folded radial symmetry which is characteristic for the bodyplan of *Nematostella vectensis* and a 6-folded symmetry which is found in the body plan in *Acropora millepora*. In this generic model we propose that the gene *dpp* (*decapentaplegic*), which is responsible for bilateral symmetrical body plans in animals, plays a fundamental role in setting up the basic radial symmetric pattern in the developing polyp and where the initial expression pattern of *dpp* determines the number of mesenteries in a developing polyp.

## 5-36

**Circadian Clock Genes in The Coral Stylophora Pistillata, Red Sea**

**Eli SHEMESH*[1]**, Oren LEVY[1]

[1]Bar Ilan University, Ramat Gan, Israel

Life on Earth has evolved under rhythmic day to night cycles of light and temperature, which are caused by our planet's rotation. Most organisms, including prokaryotes and eukaryotes, have evolved endogenous clocks in response to these predictable changes, allowing them to anticipate daily and seasonal environmental cycles, and to adjust their biochemical, physiological, and behavioral processes accordingly. The molecular mechanism of the circadian clock contains autoregulatory feedback loops comprised of positive and negative elements that generate 24-hour circuits. This work will present for the first time the presence of two circadian core genes known as Clock (Clk) and Bmal, found in the coral host Stylophora pistillata, by using degenerate primers homolog to Clock and Bmal form higher organisms. The expression patterns of both genes was investigated under ambient light dark cycles, continuous darkness and continuous light intensity, in order to test whether the S. pistillata clock genes act as circadian clock genes or not. Nubbins from four mother colonies were sampled at intervals of four hours and served for RNA extractions. The pattern of expression was tested by using QPCR and in situ hybridizations. The results show clearly that both genes oscillate as circadian clock genes found in higher organisms. The results presented here add important aspects into the origin of clock genes found in the base of animalia, the cnidarians.

## 5-37

**Physiology of Calcification and Light-Enhanced Calcification : the Scleractinian Coral Stylophora pistillata as a Model**

**Sylvie TAMBUTTÉ*[1]**, Eric TAMBUTTÉ[1], Didier ZOCCOLA[1], Aurélie MOYA[1,2], Denis ALLEMAND[1]

[1]Centre Scientifique de Monaco, Monaco, Monaco, [2]UMR 1112 INRA-UNSA, University of Nice-Sophia-Antipolis, Nice, France

The mechanism of calcification in corals still remains enigmatic but increasing data are available especially for the hermatypic scleractinian coral Stylophora pistillata which can be cultivated in laboratory under controlled conditions and is thus considered as a good model to study calcification. Since coral calcification is a case of biomineralization it involves several components: the interface between the tissue and the skeleton, the synthesis of an organic matrix, the transport of ions and the nucleation/growth and inhibition of crystal formation. I will pass under review what we actually know/don't know on the control of the organism on these components. As an introduction, I will present an up-to-date review of the anatomy, histology and characteristics of the interface tissue-skeleton to understand how the animal and its skeleton are linked. I will then summarize the data obtained by physiogical and molecular approaches on the transport of ions in Stylophora pistillata. Then I will present the current status of knowledge on the organic fraction, from its synthesis by the tissues to its incorporation in the skeleton. I will also highlight what are the consequences of a biological control of calcification on the effect of environmental parameters. I will end with a presentation of the numerous interconnected hypotheses proposed to explain light-enhanced calcification, and I will discuss some of them in the light of the last data that we have obtained both at the physiological, biochemical, cellular and molecular levels. I will insist on the available data but also on the missing data necessary for a better understanding of coral calcification.

## 5-38

**Differential Expression Of Genes Between Light And Dark Calcification**

**Aurélie MOYA*[1,2]**, Sylvie TAMBUTTÉ[1], Guillaume BÉRANGER[3,4], Béatrice GAUME[1], Jean-Claude SCIMECA[3], Séverine LOTTO[1], Denis ALLEMAND[1], Didier ZOCCOLA[1]

[1]Centre Scientifique de Monaco, Monaco, Monaco, [2], University of Nice-Sophia Antipolis, UMR 1112 INRA-UNSA, NICE Cedex 2, France, [3]Faculté de Médecine, GéPITOS, K 2943, CNRS, NICE Cedex 02, France, [4]- Research Institute of Molecular Pathology, Vienna, Austria

Most scleractinian corals establish a symbiotic relationship with phototrophic dinoflagellates. This symbiosis is responsible for the "light-enhanced calcification" (LEC) phenomenon in corals. Despite numerous researches on this phenomenon, the mechanisms by which photosynthetic symbionts enhance calcification still remain enigmatic. In order to characterize the LEC in corals we tested the hypothesis that coral genes are differentially expressed between light and dark calcification. As a preliminary approach, the differential expression of three genes involved in calcium and bicarbonate supply for calcification (Ca channel, Ca ATPase, and carbonic anhydrase) was tested between light and dark conditions in the coral Stylophora pistillata, using the real-time Polymerase Chain Reaction as a technique.

For this purpose, we first cloned and sequenced a housekeeping gene, 36B4 gene from the coral Stylophora pistillata. We then validated 36B4 and ß-actin as housekeeping genes and two photosynthetic genes (Rubisco and D1 protein of the photosystem II) as positive control genes between light and dark conditions.

Finally, we determined that the two genes encoding proteins involved in calcium transport for coral calcification (a calcium ATPase and a calcium channel) do not show differential expression between light and dark conditions, while the gene encoding a carbonic anhydrase is two-fold more expressed in the dark than in the light. We suggest that up-regulation of the gene encoding a carbonic anhydrase in the dark allows to cope with night acidosis of tissues.

## 5-39

**Photoacclimation, Photoadaptation And Coral Bleaching**

**Roberto IGLESIAS-PRIETO*[1]**

[1]Instituto de Ciencias del Mar y Limnología, Unidad Académica Puerto Morelos, Universidad Nacional Autónoma de México, Cancún, Mexico

During the last 200 million years scleractinian corals in symbioses with photosynthetic dinoflagellates have been responsible for the formation and maintenance of coral reefs. In these organisms, algal photosynthesis can provide more that a 100% of the basal metabolic requirements. The nutritional advantages that symbiotic invertebrates obtain from the translocation and consumption of algal photosynthates can explain why symbiotic corals possess significantly larger calcification rates relative to non-symbiotic invertebrates. In this context, algal photosynthesis is a key element in the formation of modern coral reefs. Considering the importance of algal photosynthesis for the well being of symbiotic corals, the study of the photobiology of these organisms has attracted significant attention. Symbiotic corals inhabit the entire photic zone and are subject to extraordinary variations in light intensity. I will review the physiological mechanisms employed by corals and their symbiotic algae to successfully harvest and utilize the available solar radiation. Based on comparative analyses of the differential responses of individual algal species to variations in growth irradiance in culture, or intact associations in nature, it has been postulated that the differential utilization of solar radiation is an important axis for niche diversification among reef-building corals. Recent analyses of the optical properties of intact coral surfaces using transmittance determinations indicate that due to the multiple scattering on the highly reflective aragonite skeleton, the specific absorption coefficients of the symbiotic algae are much higher that those obtained from freshly isolated algae, making symbiotic scleractinians one of the most efficient solar collector in nature. The role of the animal skeleton in modulating the absorption properties of the symbiotic algae has profound implications for our understanding of the evolution of these organisms. Finally, I will discuss the role of multiple scattering of coral skeletons in the propagation of thermal stress, leading to coral bleaching.

## 5-40

**Thermal Stress Stimulates The Production Of Nitric Oxide in *symbiodinium Microadriaticum* : Is Nitric Oxide A Key Molecule in The Coral Bleaching Phenomenon?**

**Josée Nina BOUCHARD*[1]**, Hideo YAMASAKI[1]

[1]University of the Ryukyus, Nishihara, Japan

In a recent study, nitric oxide (NO) has been suggested to be implicated in the mechanism leading to the expulsion of symbiotic algae from the coral host during a thermal stress event. In this previous study, the production of NO was attributed exclusively to the coral host and not to its algal symbionts. Recently, the production of NO has been shown to occur in diverse species of marine microalgae and to act as a signal molecule of stress response and/or as an indicator of growth status. These findings prompted us to determine whether coral symbiotic microalgae also produce NO both under normal growth and thermal stress conditions. Our results showed that *Symbiodinium microadriaticum* grown under laboratory conditions can produce NO when supplemented with either sodium nitrite or L-arginine as a substrate. The production of NO was confirmed by electrochemical and fluorimetric techniques. Microscopic observations of cells marked with the NO fluorescent dye DAF-2 DA also confirmed that NO was truly produced inside the microalgal cells. Ultimately, when *S. microadriaticum* were exposed to an acute heat stress (from 27 to 41 °C) the production of NO increased along with the increasing temperature. This increase in temperature was also associated with a decline in the physiological state of the cells as observed by a decline in the $F_v/F_m$ values. Results from the present study are the first to unambiguously report that zooxanthellae can synthesize NO even when they are not in a symbiotic association with a coral host. The increase in NO production upon heat stress suggests that NO can be synthesized upon exposure of the microalgae to stressful environmental conditions. The possible implications of such findings are discussed in the light of the coral bleaching phenomenon which is associated with global warming.

## 5-41

**Induced Bleaching Of Stylophora Pistillata By Darkness Stress And Its Subsequent Recovery**

**Zvy DUBINSKY*[1]**, Shachar KOREN[1], Osnat CHOMSKY[2]

[1]Life Sciences, Bar Ilan University, Ramat Gan, Israel, [2]Biology, National Institute of Oceanography IOLR, Haifa, Israel

Bleaching, the visible effect of losing zooxanthellae by corals, has been observed with increasing frequency in most of the world's reefs. Since it usually leads to coral colony death and whole reef destruction, it has been the subject of several studies in recent years. In the present article we describe a method to causing complete, but reversible, bleaching in the common Red Sea coral, *Stylophora pistillata* by darkness stress. That treatment affects the coral by reducing the density of the zooxanthellae, the endosymbiotic algae living within the coral's cells, causing the animal tissue to lose pigmentation. After 8 days in the dark the coral begins to show visible bleaching, which a week later progressed to 70%, and by the 44th day we obtained complete bleaching. At that time no zooxanthellae or chlorophyll were detected in the coral tissue. Following the transferal of the corals to darkness, at first the algal cells exhibit a photoacclimative response, accumulating chlorophyll up to 10 fold of the initial values. Fragments that were 70% bleached showed full recovery 30 days after having been returned to light. In the course of recovery, cellular chlorophyll gradually decreased to control – and initial concentrations

## 5-42

**Cellular Defense in Corals: Characterisation And Functional Analysis Of A Multi-Xenobiotic Resistance (P-Glycoprotein) Gene Homolog in The Reef-Building Coral *montastraea Franksi***

**Alexander VENN*[1]**, Jennifer QUINN[1], Ross JONES[1], Andrea BODNAR[1]

[1]Bermuda Institute of Ocean Sciences, St Georges, Bermuda

Multi-xenobiotic resistance (MXR) in marine organisms is on the front line of cellular defense against natural toxins and anthropogenic contaminants, and is a phenomenon analogous to multidrug resistance in mammalian tumour cells tolerant of anti-cancer drugs. Transmembrane P-glycoproteins (P-gp) play a key role in multidrug resistance mechanisms by actively transporting a wide variety of structurally and functionally diverse compounds out of cells. The purpose of this study was to identify the presence of a P-gp encoding gene in a reef building coral and investigate its function. Consensus-degenerate hybrid oligonucleotide primers (CODEHOPs) were designed in conserved regions of P-gp sequences from other organisms, and used to isolate a fragment of P-gp from *Montastraea franksi* mRNA by reverse transcription PCR. Rapid amplification of cDNA ends (RACE) PCR and sequencing revealed that the deduced amino acid sequence has strong structural similarities to known P-glycoproteins in well characterised vertebrate systems including humans. Expression analysis of this gene by Taqman real-time PCR confirmed that it was responsive to the classic inducer of P-gp, the chemotherapeutic drug vinblastine. Further experiments were conducted on coral fragments in specially constructed all-Teflon dosing chambers to test the response of this gene to environmentally important contaminants such as copper and oil-dispersant. These findings provide important insight into how corals defend themselves against pollution and will be integrated into initiatives to develop molecular biomarkers of stress in reef-building corals.

## 5-43

**Comparative Analysis Of The Gastrodermal Proteome Of Scleractinian Coral (Euphyllia Glabrescens) in Heat Stressed And Subsequently Bleached State**

**Shao-En PENG*[1,2]**, I-Te LEE[1], L.H. WANG[1,2], H.J. HUANG[2], Lee-Shing FANG[3], Chii-Shiarng CHEN[1,2]

[1]Institute of Marine Biotechnology, National Dong-Hwa University, Pingtung, Taiwan, [2]Department of Planning and Research, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [3]Department of Kinesiology, Health and Leisure Studies, Cheng Shiu University, Kaohsiung, Taiwan

Endosymbiosis between coral and its photosynthetic dinoflagellate symbiont Symbiodinium spp, (also called zooxanthellae) is a crucial relationship to sustain the coral reef ecosystem. This endosymbiosis occurs inside specifc host gastrodermal cells, and its molecular mechanism still remains unclear notwithstanding decades of research. In this study, we developed a new method to isolate and extract the gastrodermal and epidermal protein of scleractinian coral (Euphyllia glabrescens) and then subjected to proteomic analysis. It revealed that the stress response related proteins were up-regulated in the gastrodermal tissue of stressed coral and the proteins that involved in nitrogen metabolism, cytoskeleton, de novo purine synthesis, protein degradation and protein folding were subsequently down-regulated in bleached (aposymbiotic) state. The comparative analysis of epidermal and gastrodermal proteome demonstrated that the endosymbiosis related proteins (e.g. the key protein involved in nutrition metabolism) were differently regulated in epidermal and gastrodermal tissue of coral during the high temperature stress and bleaching event. This is also the first report to demonstrate the protein expression profiles in the gastrodermal tissue of coral that endosymbiosis occurs inside.

## 5-44

**The Effect Of Temperature On Integrin-Mediated Adhesion in The Sea Anemone, *Aiptasia Pulchella***

**Sara SAWYER*[1]**, Gina PAULAUSKIS[2]

[1]Biological Sciences, Southern Illinois University Edwardsville, Edwardsville, IL, [2]Southern Illinois University Edwardsville, Edwardsville, IL

Temperature-induced coral bleaching results from the loss of the symbiotic dinoflagellate algae from the coral host. One potential mechanism underlying temperature-induced coral bleaching is loss of the host cell containing the endosymbiotic algae. This loss of host cells could be the result of apoptosis, or could induce apoptosis. We have been investigating how temperature affects integrin mediated cell adhesion in the tropical symbiotic sea anemone, *Aiptasia pulchella*. A β-integrin has been sequenced from Cnidarians, but the function has not been investigated in these animals. Using both commercially available anti-β1-integrin antibodies and an antibody made again a conserved extracellular domain of the Cnidarian integrin (CNβ1) we have identified a protein of the correct molecular weight for an integrin (approximately 120 kDa) from tissue extracts from the sea anemone, *A. pulchella.* In addition, we have identified by immunoprecipitation a putative focal adhesion kinase (FAK) protein of approximately 125 kDa protein using an anti-FAK antibody in tissue extracts from *A. pulchella*. Using immunohistochemistry, we have investigated the tissue localization of integrins using the CNβ1 antibody. Integrin staining is the strongest where the cells of the endoderm attach to the acelllular mesoglea. To investigate how temperature affects the tissue distribution of these integrins, anemones were heat shocked for 12, 24 and 48 hours at 30°C and then processed for immunohistochemistry. Temperature shock disrupts the strong integrin staining at the base of the endodermal cells suggesting that integrin adhesion is disrupted by temperature shock. Further studies will investigate how temperature affects integrin signaling and as well as the timing of the temperature effect on integrin distribution.

## 5-45

**Long-Term Changes in The Chlorophyll Fluorescence Of Bleached And Recovering Corals From Hawaii**

**Lisa RODRIGUES*[1]**, Andrea GROTTOLI[2], Michael LESSER[3]

[1]Geography & the Environment, Villanova University, Villanova, PA, [2]Ohio State University, Columbus, OH, [3]University of New Hampshire, Durham, NH

Chlorophyll fluorescence has been used to predict and monitor coral bleaching over short timescales (hours to days), while long-term changes during recovery remain largely unknown. To evaluate changes in fluorescence during long-term bleaching and recovery, *Porites compressa* and *Montipora capitata* corals were experimentally bleached in tanks at 30°C for one month, while control fragments were maintained at 27°C. A pulse amplitude modulated (PAM) fluorometer measured the quantum yield of photosystem II fluorescence (Fv/Fm) of the zooxanthellae each week during bleaching, and after 0, 1.5, 4, and 8 months recovery. *M. capitata* appeared bleached 6 days sooner than *P. compressa*, yet their fluorescence profiles during bleaching did not significantly differ. Changes in minimum (Fo), maximum (Fm), and variable (Fv) fluorescence throughout bleaching and recovery indicated periods of initial photoprotection followed by mostly photodamage in *P. compressa* and chronic photoinhibition in *M. capitata*. Fv/Fm fully recovered 6.5 months earlier in *P. compressa* than *M. capitata*, suggesting that the zooxanthellae type of *P. compressa* was more resilient to bleaching stress. Other host-related physiological (energy reserves, photosynthesis and respiration) and biogeochemical (stable carbon isotopes) evidence indicates that the host of *M. capitata* recovers faster than that of *P. compressa.* Altogether then, these two corals utilized different strategies for recovery from coral bleaching.

## 5-46

**Mechanisms Of Coral Bleaching And Cell Death Under Thermal Stress**

**Badrun NESA*[1]**, Michio HIDAKA[2]

[1]Department of Marine and Environmental Science, Graduate School of Engeneering and Science, University of The Ryukyus, Nishihara, Okinawa 903-0213, Japan, Nishihara, Japan, [2]Chemistry, Biology and Marine Science, Faculty of Science, University of the Ryukyus, Nishihara, Okinawa 903-0213, Japan, Nishihara, Japan

We have established an experimental system to study the response of coral cells to stress treatment using coral cell aggregates (tissue balls). Dissociated coral cells aggregate to form spherical bodies, which rotate by ciliary movement. These spherical bodies (tissue balls) stop their rotation and become disintegrated when exposed to stress. The objective of this study was to test the hypothesis that zooxanthellae become a burden for coral hosts under stressful conditions and to study cell death mechanisms using tissue balls as experimental system. Tissue balls prepared from dissociated cells of *Pavona divaricata* and *Fungia* sp. were exposed to elevated ($31^0$C) and control temperature ($25^0$C) under normal light (35 µmol $m^{-2}s^{-1}$). The relationship between the survival time and zooxanthella density of tissue balls were recorded. Cell death mechanisms were investigated using a Comet Assay (single cell gel electrophoresis), which can detect DNA damage in individual target cells. There was a negative correlation between the survival time and zooxanthella density of tissue balls at $31^o$C, while no significant correlation between these parameters was found at $25^o$C. The present results support the hypothesis that zooxanthellae become a burden for host corals under high temperature stress and suggest that zooxanthellae produce harmful substances under stress condition. Antioxidants extended the survival time of tissue balls at high temperature in some cases. This suggests that zooxanthellae produced active oxygen species under the stress condition. Apoptotic death of coral cells was detected in tissue balls exposed to high temperature stress using comet assay. This study also showed that tissue balls provide us a good experimental system to study the effect of stress and various chemical reagents on corals cells.

Key words: Coral, apoptosis, comet assay, bleaching

## 5-47

**Characterizing Bleaching Responses in Corals Exposed To Dcmu, Copper, And Elevated Temperature Using Pam Fluorimetry And Gene Expression Profiling.**

**Amy ANDERSON*[1]**, Alexander VENN[2], Ross JONES[2], Michael MORGAN[1]

[1]Berry College, Mount Berry, GA, [2]Bermuda Institute of Ocean Sciences, Ferry Reach, St George's, Bermuda

The photosynthetic inhibitor DCMU, the heavy metal copper, and heat stress, are all individually capable of inducing bleaching (the dissociation of the coral-algal symbiosis) in hard corals. Whether this is by the same or different cellular or physiological mechanism is presently unknown. In this study, small branches of the hard coral *Madracis mirabilis* were exposed to various concentrations (0, 10, 30, 100, 300 ppb) of DCMU, or copper, or to different temperatures (28°C or 32°C) for 72 h. Pulse Amplitude Modulated (PAM) chlorophyll fluorimetry was used to characterize effect of these treatments on the photosynthetic capacity of the symbiotic dinoflaglleates in the tissues (*in hospite*). These analyses were combined with Representational Difference Analysis (RDA) to amplify differentially expressed genes associated with each treatment. Sixty-six genes were isolated from corals exposed to 300 ppb DCMU and a subset of these genes appears to differentially expressed. Genomic and Proteomic database searches reveal many of the RDA products have significant homology to proteins of functional relevance. Expression profiles for each putatively differentially expressed gene were established by probing for targeted transcripts within RNA samples from each stressor treatment. A number of genes showed up-regulation at different concentration of DCMU. Copper exposures also produced varied expression profiles for the genes investigated. In contrast, most of the genes exhibited decreased expression as temperature increased. The specificity of responses varied between genes as well as between concentrations used for an individual stressor exposure. The expression profiles generated in this study represent a new and informative way to characterize of how corals respond to different environmentally relevant stressors as well as being a useful tool for examining the molecular mechanism associated with coral bleaching.

## 5-48

**Differential Stability Of The Photosynthetic Membrane Of Symbiotic Dinoflagellates in Response To Elevated Temperature**

Erika M. DÍAZ-ALMEYDA[1], Roberto IGLESIAS-PRIETO[2], **Patricia E. THOMÉ*[2]**

[1]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Cancún, Quintana Roo, Mexico, [2]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Puerto Morelos, Quintana Roo, Mexico

Coral bleaching has been correlated with small increments of sea surface temperature of local summer averages. This phenomenon is initiated with the uncoupling of light harvesting and photosynthesis and may result in expulsion or death of the symbiont and eventually death of the host. Not all coral species are equally susceptible to elevated temperature. Using charge separation efficiency of photosystem II (Fv/Fm) after brief exposures (5 minutes) to high temperatures, we assessed the fluidity of the photosynthetic membrane of cultured and freshly isolated symbiotic dinoflagellates. The melting temperatures of the thylakoid membrane in 5 cultures grown at 24°C, show differences of 4.5°C between the most temperature-sensitive *Symbiodinium microadriaticum* and the temperature resistant *Symbiodinium sp.* (clade D1a) suggesting a strong genetic component. To explore temperature acclimation responses, these two symbionts were grown at 31°C. Results indicate changes in melting temperatures as well as changes in lipid composition of the photosynthetic membrane, suggesting limited acclimation to high temperature.

The photosynthetic membrane from freshly isolated dinoflagellates of the *Madracis auretenra* were found to be more temperature resistant than those isolated from *Montastrea faveolata*, suggesting that the stability of the photosynthetic membrane is an important component in determining susceptibility to coral bleaching.

## 5-49

**The Role of Oxidative DNA Damage and Repair in Cnidarian-Dinoflagellate Symbiosis Breakdown**

**Joshua MEISEL*[1]**, Ruth REEF[2], Mauricio RODRIGUEZ-LANETTY[2], Sophie DOVE[2], Ove HOEGH-GULDBERG[2]

[1]Centre for Marine Studies, University of Queensland, Highgate Hill, Australia, [2]Centre for Marine Studies, University of Queensland, St. Lucia, Australia

In an effort to further understand the cellular and molecular processes underlying cnidarian-dinoflagellate symbiosis breakdown, this study investigates the role of oxidative DNA damage and repair in coral bleaching. In the presence of high light and heat, compromised dinoflagellate photosystems can generate reactive oxygen species (ROS) that damage both host and symbiont cellular components and may ultimately initiate a bleaching response. This study focuses on the oxidative damage ROS inflict on the genomes of the Scleractinian coral *Acropora aspera* and its endosymbiont *Symbiodinum sp.* and what mechanisms exist to combat this damage. *Acropora* branches collected from the Heron Island reef flat were mounted into racks and subjected to a gradual 20-day heating regime, peaking at 32 degrees, and symbiosis breakdown was quantified through dinoflagellate counts and dark-adapted photosynthetic yields. DNA was extracted from both host and symbiont at 8 time points throughout the bleaching course and probed for the oxidative DNA base lesion 8-hydroxyguanine using a competitive ELISA assay. To further understand the role of oxidative stress in this process, experiments were repeated in the presence of DCMU (a photosynthesis-inhibitor that generates ROS), catalase (an anti-oxidant enzyme that neutralizes hydrogen peroxide), 3-amino-1,2,4-triazole (a catalase-inhibitor), and hydrogen peroxide. To investigate pathways that may operate in repairing this damage, the OGG1 protein (which excises 8-hydroxyguanine lesions) was cloned from *Acropora* and will be used in qPCR studies to monitor oxidative DNA repair. This is the first study to quantify oxidative DNA damage in the cnidarian-dinoflagellate system and may provide insight into how oxidative stress, DNA damage, and genomic instability initiate symbiosis breakdown and coral bleaching.

## 5-50

**Cell-Death Pathways Associated With Vibrio Infection And Inhibition Of Heat Shock Proteins And Apoptosis "Cell Death Signals"in Clade Subtypes A,b,c,d**

**James CERVINO*[1,2]**, Nancy KRUCHER[1], Konrad HUGHEN[3]

[1]Biological Sciences, Pace University, NY, NY, [2]Geochemistry, Woods Hole Oceanographic Inst., Woods Hole, [3]Geochemistry, Woods Hole Oceanographic Inst., Woods Hole, MA

The biochemical impairment mechanisms associated with infection of *Symbiodinium spp.* results in a reduction of protein synthesis within 4 hr of treatment *in vitro*. Heat shock proteins (HSPs) are a family of highly conserved proteins found in cells that are induced due to cell stress. We have found an HSP70-related protein in *Symbiodinium* (sub-type C1) with an apparent molecular weight of 120-140kd using HSP70 specific antibodies. This putative HSP70-related protein is expressed highly in CLADE C, at low levels in CLADE A, but was not found in CLADES B and D, which is consistent with the observed patterns of CLADE D and A sub-type thermal tolerance. Interestingly, inoculation of *Vibrio* pathogens reverse the induction of the HSP70-related protein in heat stressed (33oC) *Symbiodinium* CLADE C1. These data are also consistent with cell-cycle mitotic index impairment analysis. All *Symbiodinium* CLADE subtypes show a decline in cell division following 48 hr treatment with *Vibrio* pathogens together with thermal stress. HSP and cell-cycle inhibition are also consistant with Apoptosis markers using Annexin *V* flouresence staining. Improperly regulated apoptosis is implicated during the *Vibrio* induced disease states at higher temperatures. Thermally stressed cells are detected by annexin *V* binding to externalized phosphatidylserine, however with thermal stress together with *Vibrio* infection, the presence of phosphatidylserine is not evident. These data support the recent findings and hypothesis that coral disease cell death mechanisms follow a different cell-death process compared to thermal bleaching mechanisms. Using *Symbiodinium* CLADE subtypes as in vitro models can also give researchers and better understanding into cancer cell research that are associated with bacterial infections.

## 6-2

**The Coral Transcriptome – A Beginner's Guide**

**David MILLER*[1,2]**, Eldon BALL[2]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]ARC Centre for the Molecular Genetics of Development, Australian National University, Canberra, Australia

Although corals are amongst the simplest true animals at the morphological level, in terms of the total number and types of genes they are comparable with the most complex of animals – the vertebrates. The coral genome contains a large number of genes once thought of as vertebrate-specific, including clear homologs of many key components of the vertebrate innate immune repertoire; considerable effort is presently being directed into exploring the roles of these in combating coral disease. The genomes of anthozoan cnidarians such as corals also contain a significant number of "non-metazoan" genes – genes only previously known from members of the other kingdoms of life. These are not the products of recent lateral gene transfers, but long-term residents of cnidarian genomes that potentially increase the biochemical complexity of the organism. The unexpected complexity and heterogeneity of the coral transcriptome represents a major challenge in understanding the functional biology of corals; essentially, one cannot predict how corals will respond based on what is known about other animals.

Whole genome sequences are now available for two cnidarians – the sea anemone Nematostella vectensis and the freshwater Hydra magnipapillata – and comparisons between the coral Acropora and these organisms have the potential to provide insights into nominally coral-specific processes such as calcification and symbiosis. Moreover, comparisons between the Indo-Pacific coral Acropora millepora and the Caribbean species Acropora palmata permit the identification of genes under positive selection that are candidates for roles in allorecognition, gamete interactions and other coral-specific traits. Future progress in coral functional biology will increasingly rely on microarray and genomic approaches based on high-throughput DNA sequencing, coupled with use of biological 'models' for coral traits.

## 6-3

**Gene Expression in Symbiodinium Under Stress**

Bill LEGGAT[1,2], David YELLOWLEES[2], Sophie DOVE[3,4], **Ove HOEGH-GULDBERG*[3,4]**

[1]Biochemistry and Molecular Science, James Cook University, Townsville, Australia, [2]ARC CoE for Coral Reef Studies, James Cook University, Townsville, Australia, [3]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [4]ARC CoE for Coral Reef Studies, Brisbane, Australia

It is now well documented that the dinoflagellate Symbiodinium (zooxanthellae) are a weak link in the coral symbiosis. An obvious example of this is the fact that small increases in temperature lead to damage to the Symbiodinium photosynthetic apparatus and their eventual expulsion from their coral host (coral bleaching). However we know very little about how Symbiodinium copes with stress. Characterisation of a Symbiodinium stress transcriptome, which is made up of over 5000 contigs, has found that a large number of genes that are expressed when under temperature, nutrient or CO2 stress are novel and do not match any sequences in the available databases (approximately 55%). In fact the function of the most highly expressed gene, which makes up to 3% of the transcriptome, is also unknown. In addition to these unknown genes Symbiodinium contains a variety of typical "stress" response genes (e.g. heat shock proteins, catalase, super-oxide dismutase etc). However even these are sometimes often not what would be expected a typical alga; for example the Symbiodinium catalase is most closely related to that found in bacteria and fungi rather than a traditional eukaryote catalase. This unique genetic make up means that how the genes that are up- or down-regulated in response to stress in Symbiodinium may differ from what is seen in other photoautrophs. The use of a newly developed Symbiodinium microaray is now allowing us to examine how these ecologically key dinoflagellates respond to stress at the gene expression level. We are examining how changes in temperature, CO2 and nutrients affect the Symbiodinium transcriptome and the phenotype of the alga.

## 6-4

**Integrating Genomics With Coral Reef Biology And Management**

**Cheryl WOODLEY*[1]**, Craig DOWNS[2]

[1]NOAA National Ocean Service, Charleston, SC, [2]Haereticus Environmental Laboratory, Clifford, VA

Genomics is a methodology for studying genomes (the chromosomes and their genes). The original purpose was to sequence the genomes of organisms, identify and map genes to the genome, categorizing (annotate) new genes based on similarities with previously identified genes of known function, and document which genes are activated under various conditions. The initial focus for these efforts was aimed at improving human health. One of the most successful outcomes of genomic efforts has been identifying genes responsible for heritable diseases involving only a few genes. Diagnostic tests were quickly developed and drug development began targeting specific steps in disease pathways. Genomics uncovered disease variations that allow more discriminating diagnosis such as subtyping tumors (e.g., breast cancers) and individualized treatments. Sequencing genomes quickly spread to model organisms, domestic animals and crops, and more recently to commercially valuable marine organisms (e.g., salmon, shrimp, oysters). The rationale varied for each genome but included understanding development, comparative studies for altered physiological or environmental conditions, pathology, population genetics, breeding, crop improvement or drug development. Coral reef biologists have recently turned to genomics in hopes of answering questions in toxicology, symbiosis, pathology, development, evolutionary and ecological processes and environmental monitoring. Genomics alone, however, will fail in trying to address these questions. It is a tool that can provide unprecedented amounts of data, but more data does not mean more knowledge. Not until we view genomics as a tool to be used in the context of a scientific research plan or resource management strategy with other methods and disciplines (e.g., genetics, physiology, biochemistry and cell biology) for conducting hypothesis driven experiments, will our understanding coral reef biology and health move forward.

## 6-5

**Differential Gene Expression During The Initial Onset Of Coral/algal Symbiosis Using A Cdna Microarray**

**Christine SCHNITZLER*[1]**, Virginia WEIS[1]

[1]Department of Zoology, Oregon State University, Corvallis, OR

Very little is known about the molecular and cellular mechanisms controlling the successful establishment of a stable relationship in the early stages of coral/algal symbiosis. The planula larva of the solitary Hawaiian scleractinian coral *Fungia scutaria* and its dinoflagellate symbiont *Symbiodinium* sp. type C1f represents an ideal model for studying the onset of coral/algal symbiosis due to the predictable availability of gametes, and the ability to raise non-symbiotic larvae and establish the symbiosis experimentally. The goal of this study was to identify genes differentially expressed in *F. scutaria* larvae during the initiation of symbiosis with its algal symbiont using a high-throughput technique. We predicted that our discovery-based approach would identify expression differences in host genes involved in cellular processes critical to the establishment of coral/algal symbiosis, such as cell signaling, proliferation, metabolism and immunity. Symbiotic larvae were compared to non-symbiotic larvae using a custom cDNA microarray. The 5,184-feature array was constructed with cDNA libraries from newly symbiotic and non-symbiotic larvae, including 3,072 features (60%) that were enriched for either state by subtracted hybridization. The array was hybridized with cDNA from newly symbiotic and non-symbiotic *F. scutaria* larvae using a multiple dye swap design and six biological replicates. Following normalization to control features, transcripts differentially expressed (up- or down-regulated) as a function of the symbiotic state were sequenced and used to identify homologs, and differential expression was quantified using real time PCR. Specific primers were constructed for use in PCR with host-only and algae-only genomic DNA to confirm the source of genes expressed from the symbiotic larval cDNA library. Future studies will focus on functional and biochemical assays in an attempt to further characterize individual target genes.

## 6-6

**Coral Reef Genomics: A Genome Wide Approach To Study Establishment And Maintenance Of Coral-Zooxanthellae Symbioses**

**Christian VOOLSTRA*[1]**, Jodi SCHWARZ[2], Mary Alice COFFROTH[3], Alina M. SZMANT[4], Mónica MEDINA[5]

[1]School of Natural Sciences, University of California, Merced, Merced, CA, [2]Vassar College, Poughkeepsie, NY, [3]State University of New York at Buffalo, Buffalo, NY, [4]UNCW-Center for Marine Science, Wilmington, NC, [5]University of California, Merced, Merced, CA

Symbioses between scleractinian corals and their photosynthetic unicellular symbionts (dinoflagellates or zooxanthellae) form the basis of coral reef ecosystems. While the importance of this mutualistic relationship is well documented, surprisingly little is known about the cellular processes involved in the establishment and maintenance of this partnership.

We use large scale gene expression profiling (microarrays) to study the transcriptomic changes in two Caribbean reef building coral species (*Montastraea faveolata* and *Acropora palmata*) in response to infection with different strains of zooxanthellae. A high number of genes change expression upon infection; and genes involved in signal transduction, cytoskeletal activity, metabolism and energy production, and stress are modified. In contrast, only a few differences exist upon infection with different zooxanthella strains.

These data indicate that although there is a profound change in coral physiology upon establishment of symbiosis, an evolutionarily conserved mechanism of establishment of symbiosis exists.

## 6-7

**Differential Gene Expression During Thermal Stress And Bleaching in The Caribbean Coral *montastraea Faveolata***

**Michael DESALVO*[1]**, Christian VOOLSTRA[1], Shinichi SUNAGAWA[1], Jodi SCHWARZ[2], Mary Alice COFFROTH[3], Alina SZMANT[4], Mónica MEDINA[1]

[1]School of Natural Sciences, University of California, Merced, Merced, CA, [2]Department of Biology, Vassar College, Poughkeepsie, NY, [3]Graduate Program in Evolution, Ecology, and Behavior, State University of New York at Buffalo, Buffalo, NY, [4]Center for Marine Science, University of North Carolina, Wilmington, Wilmington, NC

The declining health of coral reefs worldwide is likely to intensify in response to continued anthropogenic disturbance from coastal development, pollution, and climate change. Reef-building corals respond to stress by bleaching, in which their symbiosis with zooxanthellae collapses. Mass coral bleaching in response to elevated water temperature can devastate coral reefs on a huge geographic scale. In order to understand the molecular and cellular basis of thermal bleaching in corals, we have taken a transcriptomic approach. cDNA microarrays, containing features representing 1,310 genes of the Caribbean coral *Montastraea faveolata*, were utilized to measure gene expression changes associated with thermal stress and bleaching. Thermal stress experiments were conducted in temperature-controlled aquaria, and bleaching was elicited by increasing the temperature by 3oC above normal. Differentially expressed genes were identified in two separate experiments: the first experiment compared gene expression between control fragments and partially bleached fragments; and the second experiment compared control fragments to heat stressed fragments along a time course ending at partial bleaching. Our findings suggest that thermal stress and bleaching in *M. faveolata* results in: heat shock protein expression, oxidative stress, re-organization of the cytoskeleton, disruption of Ca2+ homeostasis, decreased calcification, metabolism, and protein synthesis, increased activity of transposons and defensin-like peptides, and the initiation of cell death. We believe that oxidative stress in heat-stressed corals results in a disruption of cellular Ca2+ homeostasis, which leads to cytoskeletal and cell adhesion changes, decreased calcification, and the initiation of cell death via apoptosis and necrosis.

## 6-8

**An Ecological Microarray Study Of Coral Bleaching**

Francois SENECA[1,2], **Francois SENECA*[1,2]**, Sylvain FORET[3], Nicolas GOFFARD[4], Carolyn SMITH[2], Lauretta GRASSO[3], David HAYWARD[3], Robert SAINT[3], Madeleine VAN OPPEN[2], Eldon BALL[3], David MILLER[1,3]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville 4811, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville 4810, Townsville, Australia, [3]ARC Centre for the Molecular Genetics of Development, Australian National University, Canberra 2601, Canberra, Australia, [4]Louis Malardé Institute, Papeete 98713, Papeete, French Polynesia

Reef building corals live close to their upper thermal tolerance limit and prolonged exposure to temperatures exceeding 31°C induces coral bleaching – the expulsion of *Symbiodinium sp.* which is often the first step toward mass mortality. Current projections suggest that average tropical ocean temperatures could warm by 1-3°C by the end of this century, so unless corals have the capacity for adaptation to anthropogenically induced climate change, those species that survive are likely to undergo dramatic shifts in distribution patterns. To investigate coral stress responses at a fundamental level we used microarrays of approximately 17,000 expressed sequence tags (ESTs) from the hermatypic coral *Acropora millepora* to attempt to identify genes responsible for individual fitness and the capacity to survive.

Bleaching responses have traditionally been investigated largely by subjecting corals to acute thermal stress in vitro. Our approach has focussed on several coral colonies growing in a single bay that have been sampled in situ through a natural bleaching episode and the subsequent recovery period. During the sampling period, water temperature was continuously monitored (at 15 min intervals) and symbiont density recorded at monthly intervals as a measure of bleaching status.

Individual colonies differed dramatically in their overall responses to similar environmental conditions – the extent of reduction of symbiont density varied considerably and, whereas some colonies recovered after the summer period, others died. Microarray experiments on a subset of colonies, which showed similar patterns of symbiont loss, identified a large number of genes with expression significantly correlated to decreases in symbiont density. The implications of these experiments in terms of understanding the mechanisms by which corals respond during bleaching episodes will be discussed.

## 6-9

**Bacterial Community And Gene Expression Profiling Using 16srrna Gene And Cdna Microarrays: Introduction Of A Dual High-Throughput Approach To The Study Of Coral Disease And Bleaching**

**Shinichi SUNAGAWA*[1]**, Paul FISHER[2], Michael DESALVO[1], Christian VOOLSTRA[1], Ernesto WEIL[3], Gary ANDERSEN[4], Roberto IGLESIAS-PRIETO[2], Mónica MEDINA[1]

[1]School of Natural Sciences, University of California Merced, Merced, CA, [2]Unidad Académica de Sistemas Arrecifales ICML-UNAM, Universidad Nacional Autónoma de México, Puerto Morelos, Mexico, [3]Department of Marine Science, University of Puerto Rico, Mayagüez, Puerto Rico, [4]Center for Environmental Biotechnology, Lawrence Berkeley National Laboratory, Berkeley, CA

Increasing evidence highlights the fact that bacteria play a crucial role within coral holobiont, i.e. the coral host and its associated microbial communities. Current approaches to describe the bacterial diversity in corals involve the universal amplification of bacterial 16SrRNA gene via the polymerase chain reaction (PCR) with subsequent analysis by terminal-restriction fragment length polymorphism (t-RLFP), temperature/denaturing gradient gel electrophoresis (T/DGGE), or sequencing of recombinant 16SrDNA clone libraries. Analyzing the expression of one or a few genes in coral samples may be accomplished through quantitative PCR. However, large-scale comparative studies with the aim to discover statistical differences in bacterial species composition as well as global changes in the coral transcriptome would require the application of more efficient high-throughput technologies. In light of increasing frequencies of coral disease and bleaching events, it is imperative to gain a better understanding of (a) concomitant changes in coral-associated bacterial communities and (b) the molecular responses of coral hosts to such stress events. Here, we introduce the application of 16SrRNA gene microarrays in combination with coral host cDNA microarrays to simultaneously profile both changes in microbial community composition and coral gene expression. Specifically, we are comparing healthy versus both diseased and bleached corals using the Caribbean coral species *Montastraea faveolatea* as a model system. This approach applies statistical tools to identify differentially abundant bacteria in diseased or bleached coral samples and aims to identify genes or gene pathways that are involved in the immune as well as thermal stress response of corals. The expected results may validate the application of these high-throughput tools as a versatile platform for monitoring and assessing the health status of corals, and thus could guide their implementation for effective management strategies to preserve coral reefs.

## 6-10

**Thermal Regulation in Coral Larvae: A Microarray Screening**

**Mauricio RODRIGUEZ-LANETTY*[1,2]**, Saki HARII[3], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]Department of Biology, University of Louisiana at lafayette, Lafayette, [3]Graduate School of Engineering and Science, University of Ryukyus, Naha, Japan

Coral reefs around the world are in decline with much of the mortality attributed to coral bleaching – the loss of photosynthetic algal symbionts – resulting from global warming. To understand how corals may respond to the current global warming threat, we need to understand how the coral/algal symbiont responds to the increase of sea water temperature not only on an organismic and physiological level but also on a molecular and cellular level. Microarrays are currently being shown to be an adequate tool to explore and screen for molecular pathways that are affected and change in response to increases in temperature. In this study, we have conducted a microarray experiment to document the changes of gene expression that occur in the coral host cell during the first hours of thermal stress. This study focuses on determining the direct effect of temperature on the host cell and not those secondary effects arising from physiological impaired algal symbionts after being exposed to high temperature. In order to dissect these two effects with different origins, we conducted our thermal stress experiments on aposymbiotic (lacking of symbiont) coral larvae from the scleractinian coral Acropora millepora. Results from this study show the cellular dynamics of coral larvae gene expression in the first hours after being challenged in a thermal stress experiment.

## 6-11

**The Genomic Bases Of Stress Tolerance And Temperature Adaptation in Corals**

**Eli MEYER*[1]**, Shi WANG[1], Galina AGLYAMOVA[1], Mikhail MATZ[1]

[1]Biological Sciences, University of Texas, Austin, Austin, TX

Reef building corals are extremely sensitive to thermal stress, but the potential for these ecologically important animals to adapt to increasing ocean temperatures remains uncertain. We are characterizing the genetically determined natural variation in responses to thermal stress and settlement cues to better understand the traits under selection during climate change. We used reciprocal crosses between colonies of the coral *Acropora millepora* to produce larvae that we maintained in culture at standard (28°C) and constant elevated temperatures (32°C). Direct measures of thermal tolerance were obtained from measurement of survival during short (2 d) periods of temperature stress (34°C). These different stress phenotypes were further characterized by measuring changes in protein content and RNA:DNA ratios during development and growth under these conditions. Physiological measurements of metabolic activity and temperature response were simultaneously obtained for large numbers of individual larvae, allowing estimation of individual, genetically determined, and environmentally induced variation within a single experiment. To understand the genomic bases of these responses, we are sequencing the larval transcriptome and measuring global gene expression profiles. These profiles, in combination with the whole-genome genotyping methods currently being developed in our lab, will allow us to establish links between genetic markers, gene expression, and thermal tolerance. These data will help to build a framework for understanding the long-term impacts of climate change on coral reefs.

## 6-12

**Using A Stressed-Focused Microarray To Characterize Coral Responses To Copper**

**Michael MORGAN*[1]**, Sara EDGE[2], Alexander VENN[3], Ross JONES[3]

[1]Berry College, Mount Berry, GA, [2]Harbor Branch Oceanographic Institute, Ft. Pierce, FL, [3]Bermuda Institute of Ocean Sciences, Ferry Reach, St George's, Bermuda

Copper is a well recognized marine pollutant, having been used extensively in antifouling paints of boats. In corals it is known to induce bleaching at very low concentrations, but the mechanism associated with this response, and how it differs from warm-water induced bleaching of corals is presently unknown. A stress-focused microarray composed of 153 genes was used to investigate which coral genes are most responsive to copper. In this study, small fragments of *Montastraea franksi* were exposed to different concentrations of copper (0, 0.3, 3.0, and 30 ppb) for various exposure periods (2 h, 24 h, and 7 d). Exposure treatments were conducted under natural light in temperature controlled, Teflon®, dosing chambers developed at the Bermuda Institute of Ocean Sciences (BIOS). Some coral stress genes on this microarray have previously demonstrated responses to elevated copper concentrations. Results presented will illustrate how this study represents a first attempt to characterize the expression profiles of various genes (a) under different concentrations of copper (b) on different temporal scales and (c) within and between colonies.

## 6-13

**Microarray Characterization Of Gene Expression in *montastraea Cavernosa* Through Space And Time**

**Sara EDGE*[1]**, Michael MORGAN[2], Joshua VOSS[1], Terry SNELL[3]

[1]Robertson Coral Reef Program, Harbor Branch Oceanographic Institute at Florida Atlantic University, Fort Pierce, FL, [2]Department of Biology, Berry College, Mount Berry, GA, [3]School of Biology, Georgia Institute of Technology, Atlanta, GA

Coral communities are increasingly impacted by a variety of natural and anthropogenic stressors acting on local or global scales. Based on the nature of stress and scale of impact, corals exhibit variable responses. Through the application of microarray technology, gene expression profiles can be used to diagnose stressors impacting coral populations in the field. Changes in gene expression are key elements of the stress response, often occurring before physiological damage is evident. Furthermore, responses such as bleaching or tissue loss may result from a multitude of factors, whereas the regulation of gene expression can be directly related to the causative agent of stress. In this study, a stress-focused microarray was used to detect gene expression patterns of *Montastraea cavernosa* on South Florida reefs at different sites over a fifteen month period. The array consisted of 148 genes involved in a variety of cellular functions, ranging from metabolism and development to the regulation of apoptosis and the stress response. Gene expression patterns revealed a strongly significant, episodic stress response at three of the five sites investigated. In addition, a significant correlation between the expression of symbiont genes and the expression of coral stress response genes was evident across all dates and sites. To our knowledge, this is the first study to use a Cnidarian microarray to detect changes in the physiological condition of coral in the field associated with seasonal events as well as point source stress.

## 6-14

**Preliminary Characterization Of The Genomic "Defensome"in A Model Cnidarian, Nematostella Vectensis, And Predicted Stress Response Genes in Reef-Associated Corals**

**Nikki TRAYLOR-KNOWLES*[1]**, Adam REITZEL[2], James SULLIVAN[1], Les KAUFMAN[1], John FINNERTY[1]

[1]Department of Biology, Boston University, Boston, MA, [2]Wood Hole Oceanographic Institution, Woods Hole, MA

There is a pressing need for quantitative stress and resilience indicators in globally embattled coral reefs to be used to track the efficacy of conservation efforts. One way to start addressing this issue is to use genomics and bioinformatics. *Nematostella vectensis* is a burrowing anemone common to estuarine habitats along the east coast of North America, from Nova Scotia to Louisiana. It's a superb model for studying the evolution and ecology of cnidarian stress response because (1) it is easy to cultivate in the laboratory and collect in the field, (2) it inhabits hyper-variable habitats across a wide geographic range, (3) it is known to exhibit pronounced genetic structure at small spatial scales, and (4) its genome has been sequenced. Comparing the genomic complement of stress-genes in *Nematostella* and Triploblastica will help illuminate the stress-response system of early animals, perhaps revealing the importance of transcriptional control. Furthermore, the stress-response genes in *Nematostella* are likely to exhibit a homologous function in other cnidarians, including tropical reef-associated corals. A bioinformatics screen of the *Nematostella* genome identified 110 predicted chemical response proteins, 384 predicted wound healing proteins, and 128 predicted innate immunity proteins. Key elements of the innate immune system were identified, including members of the Toll and interleukin signaling cascades: IRAK, TRAF, ECSIT, IKK, MKK, JNK, IKB, p38, NF-κB and AP-1. Complements of genes active during wound healing in vertebrates were also identified. The highly conserved transcription factor, *Grainy head* has been shown to be a critical component in the formation of an epithelial barrier and can be recognized by the possession of a highly conserved CP2 domain. A search for this domain identified a single significant match. Identification and structural characterization of these genes will allow for functional assays to be performed. This work is a contribution of the MMAS Program.

## 6-15

**Coral Reef Metagenomics**

**Forest ROHWER*[1]**, Elizabeth DINSDALE[1], Robert EDWARDS[2], Linda WEGLEY[1], Rebecca THURBER[1], Kristen MARHAVER[3], Stuart SANDIN[3], Dana HALL[1], Florent ANGLY[4], Beltran BRITO RODRIGUEZ[4], Nancy KNOWLTON[3]

[1]Biology Department, San Diego State University, San Diego, CA, [2]Computer Science, San Diego State University, San Diego, CA, [3]Marine Biology, Scripps Intitution of Oceanography, San Diego, CA, [4]Computational Sciences, San Diego State University, San Diego, CA

An increasing body of evidence suggests that microbes are key players in both healthy and degraded coral reefs. We have been using metagenomics (i.e., shotgun sequencing of community DNA) to characterize the microbial communities within the coral holobiont, as well as in the surrounding water column. In the Northern Line Islands, the water column metagenomes showed that the microbial and viral communities changed from an even mix of autotrophs and heterotrophs to predominantly heterotrophs along a gradient of human disturbance and oceanographic conditions. In metagenomic studies of coral-associated microbial communities, we have found that the endolithic fungi are important to nitrogen recycling within the holobiont. Finally, metagenomic analyses of viral communities from corals showed that herpes-like viruses are induced by natural and anthropogenic stressors. Together, these studies demonstrate the power of metagenomics to deconvolute the complex interactions of corals and microbes.

## 6-16

**Settling On The Right Genes: Functional Genomics Of Variation in Marine Invertebrate Larval Settlement**

**Sandie DEGNAN*[1]**

[1]School of Integrative Biology, University of Queensland, Brisbane, Australia

The capacity of marine animals to cope with the rapid environmental challenges they now are facing is likely to be encoded in their genomes. Responses on the generational time scale will rely on natural genetic variation already existing within species and populations, especially where this is manifested as variable gene expression during crucial developmental stages. In the pelagobenthic life cycle shared by most marine invertebrates, a particularly crucial stage is when the dispersing larva settles out of the plankton onto the benthos, and metamorphoses into a reproductive adult. Settlement and metamorphosis cannot proceed without the larva first reaching developmental competency, and then encountering an appropriate inductive cue. The timing and success of these steps directly determine the structure, stability and evolution of natural populations. Variation around this transition is thus likely to be an important source of response to environmental change. We have used microarray gene profiling in two coral reef invertebrates - a haliotid mollusc and a pyurid ascidian - to identify candidate genes underpinning this critical developmental and ecological transition. We have found large numbers of genes that show differential expression associated with the onset of competency and settlement. Of particular interest are genes putatively involved in the innate immune pathway, which appear to be involved in responding to benthic cues, and coping with new challenges presented by the plankton – benthos transition. Importantly, we have documented extensive variation in the expression of these and other settlement genes both within and between populations, much of it correlated with specific environmental conditions. This inherent variation in gene expression is cause for hope that natural populations carry within themselves the capacity to cope with the inevitable changes in coral reef environments.

## 6-17

**Coral Population Genomics: Genome Evolution In Action**

**Mikhail MATZ*[1]**

[1]Integrative Biology, University of Texas at Austin, Austin, TX

Population genomics is a novel integrative approach to study the evolutionary process in natural populations on a whole-genome level. Population genomics integrates information about genes involved in the biological process of interest, variation of their expression in natural populations, genomic determinants of this variation and evolution of the corresponding loci as revealed through population genetic analysis. One of the technical foundations of this workflow is the microarray-based whole-genome genotyping methodology called iDART, developed in my lab. Currently our main focus is evolution of stress resilience and dispersal potential in Acropora millepora in response to climate change. The project takes advantage of the possibility to perform controlled crosses and assess physiological parameters, genotype and profile gene expression in individual A. millepora larvae.

## 6-18

**Examining The Genetic Basis Of Coral Morphospecies: Testing The Core Genome Hypothesis With Microarrays**

**Jason LADNER*[1]**, Madeleine VAN OPPEN[2], Stephen PALUMBI[1]

[1]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [2]Marine Microbiology and Symbiosis, Australian Institute of Marine Science, Townsville, Australia

With extensive cross-specific fertility and multi-species synchronized mass spawning events, reef corals represent an animal taxon unparalleled for its potential for interspecific hybridization. Yet, in the face of potentially homogenizing gene flow between species, high species diversity with extensive sympatry is maintained. One possible explanation is that the morphospecies we recognize are each defined by a core set of genes that must remain together while other regions of the genome can be freely exchanged between species. High-density oligonucleotide microarrays provide a powerful tool to test the core genome hypothesis by allowing rapid, fine-scale genome-wide interrogation of sequence similarity between coral species. We designed an array using the publicly available *Acropora millepora* expressed sequence tag (EST) library to investigate the genomic similarity of two highly cross-fertile coral species: *Acropora millepora* and *A. pulchra*. The arrays consisted of 21,576 unique 60 base pair probes. Twelve individuals from each species were hybridized separately to the array along with a common reference. Results show that 46% of the array probes (9945 of 21,576), speckled across 75% of the ESTs included on the array (4635 of 6156), show significant hybridization differences between *A. millepora* and *A. pulchra*. These probes identify regions that likely exhibit little to no introgression between these species, and therefore, may be responsible for the morphological and physiological differences between them. If confirmed, these results would suggest the core genome for these species is quite large. Additionally, this technique produces a hybridization intensity 'barcode' for each individual that has proven to be reliable for species identification, a task single gene techniques have often failed at in corals.

## 6-19

**Variation in Gene Expression Within And Among Acropora Millepora Populations On The Great Barrier Reef.**

**Line K BAY*[1]**, Karin E ULSTRUP[2], H Bjorn NIELSEN[3], Bette WILLIS[1,4], David J MILLER[1,5], Madeleine VAN OPPEN[6]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]Marine Biological Laboratory, University of Copenhagen, Helsingor, Denmark, [3]Centre for Biological Sequence Analysis, Danish Technical University, Lyngby, Denmark, [4]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [5]Biochemistry and Molecular Sciences, James Cook University, Townsville, Australia, [6]Australian Institute of Marine Science, Townsville, Australia

Gene expression is a fundamental link between the genetic make-up of an organism (genotype) and how it functions in its environment (phenotype) and, when correlated with biological and environmental variables, can provide novel insights into the ecology, evolution and health status of the target organism. Here we used a specific cDNA microarray to investigate natural variation in global gene expression within and among populations of *A. millepora,* a common reef-building coral on the GBR. We examined the roles of acclimatization and adaptation by comparing patterns of gene expression of field sampled coral colonies from two populations with different thermal environments and bleaching histories, with that following a ten-day acclimation in a common environment. ANOVA analyses revealed that four genes were differentially expressed between Populations ($p < 3.86 \times 10\text{-}6$; median absolute fold change (MAFC) = 0.99), 114 between sampling Locations (field vs lab) ($p < 2.48 \times 10\text{-}5$; MAFC = 1.04) and six in the Population by Location interaction ($p < 8.01 \times 10\text{-}5$; MAFC = 1.42). The significant location genes represented a range of functional groups and clustered into three expression profiles. These results suggest that *A. millepora* have substantial potential to up and down-regulate genes through acclimatization when ambient environmental conditions change. We also found potential for local adaptation in gene expression under natural conditions in a few genes in the Population and Population x Location treatments. Because many additional genes displayed large MAFC (>1.5) but low statistical significance in these treatments (No. genes: Population = 14, Population x Location = 51), it is possible that inter-colony variation obscured our ability to detect local adaptation in such genes. We examine inter and intra-colony variation in gene expression in this species in a subsequent experiment.

## 6-20

**Sponge Paleogenomics And The Evolution Of Biocalcification**

**Gert WORHEIDE*[1]**, Luciana MACIS[1], Joachim REITNER[1], Bernard M. DEGNAN[2], Daniel J. JACKSON[1,2]

[1]Courant Research Center Geobiology, University of Gottingen, Gottingen, Germany, [2]School of Integrative Biology, University of Queensland, Brisbane, Australia

The ability to regulate the formation of calcified structures was a key metazoan innovation during the late Precambrian that have, for example, enabled the subsequent development of reef structures throughout the Earth's history until present. However, the evolution of the biosynthetic pathways of biocalcification remain largely enigmatic and it is unknown to what extent the last common ancestor of the Metazoa (LCAM) provided the genetic tools to enable biomineralisation. Sponges, the most ancestral-like metazoans, were prolific calcifying and reef-building organisms during the Paleozoic and Mesozoic, and some of those taxa survive today. We have studied one such 'living fossil', the demosponge *Astrosclera willeyana* which possesses a calcareous basal skeleton, and applied a paleogenomics approach to show that a key molecular component of this biomineralisation-toolkit was the precursor to the diverse α-carbonic anhydrase (α-CA) gene family, one of the most physiologically important and catalytic enzymes known. We show that α-CAs expanded through several independent gene duplication events in sponges and eumetazoans, and that these coralline sponges inherited key components of the first multicellular skeletogenic toolkit from the LCAM. Furthermore, with recent whole genome sequencing efforts of various metazoans, EST collections and targeted gene studies, examples of conserved and lineage specific biocalcification genes are gradually being identified. In some cases we are now able to infer what skeletogenic genes may have been present in the LCAM and discuss this in the context of the evolution of metazoan biocalcification mechanisms and their resilience to ocean acidification.

## 6-21

**Coral Kin Aggregations Exhibit Mixed Allogeneic Reactions And Enhanced Fitness During Early Ontogeny**

**Keren-Or AMAR*[1,2]**, Nanette CHADWICK[3], Baruch RINKEVICH[1]

[1]Biology, Israel Oceanographic and Limnological Research (IOLR), Haifa, Israel, [2]The Mina and Everard Goodman Faculty of Life Sciences, Bar-Ilan University, Ramat Gan, Israel, [3]Biological Sciences, Auburn University, Auburn, AL

Only sparse information exists on the selective forces and ecological consequences of aggregated settlement and chimera formation by kin larvae in marine invertebrates. Kin larvae of the reef-building coral *Stylophora pistillata* settle in aggregations. Upon contact, recruits either fuse, establishing a chimera, or reject one another. Our one-year study on growth and survival of 544 genotypes revealed six types of biological entities: single genotypes, bi-chimeras, bi-rejecting genotypes, tri-chimeras, tri-rejecting genotypes, and multi-partner entities. Analysis of allorecognition responses revealed an array of effector mechanisms from true tissue fusion, transitory fusion, borderline formation, and overgrowth, to rejection and partner death; all with complex ontogeny. We found that young multi-partner entities were the largest. However, at the genotype level, single genotype entities were the largest. Survival rates did not vary significantly among entities, but multi-partner entities exhibited the highest survival rate and single genotypes the lowest. We propose that a driving force for this gregarious kin settlement stems from benefits associated with the increased total size of the entity, forming biological organizations that exhibit, simultaneously, intricate networks of rejecting and fusible interactions.

## 6-22

**Chimera Formation During The Early Life History Of Acropora Millepora And Its Persistence Through Time**

**Eneour PUILL-STEPHAN*[1,2]**, Bette WILLIS[1], Madeleine VAN OPPEN[2], Lynne VAN HERWERDEN[1]

[1]James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

Spawning corals broadcast their gametes typically once a year in high densities with the resulting larvae often settling in aggregations. This provides opportunities for chimera formation: the fusion of genetically distinct larvae into a single colony. This study examines the extent of chimera formation under experimental conditions in juveniles of the coral, *Acropora millepora,* and the frequency of chimeras in natural populations of this species.

When larvae of *Acropora millepora* were settled in aquaria, more than 47% of juveniles (n = 2168 recruits) settled in aggregations (two or more recruits in contact). Fusion within aggregations was assumed when coral tissue was continuous within a colony and when new polyps appeared at the contact margin. In order to assess if different genotypes remained distinct within fused aggregations, 7 microsatellites were used to genotype sub-samples of potential genetic chimeras. Preliminary results highlight the occurrence of genetic chimeras, indicating that *Acropora millepora* juveniles are able to form chimeric entities in their early life history stages.

Although *Acropora millepora* juveniles form chimeras under experimental conditions, screening the extent of genetic chimeras within adult colonies will help to understand if chimerism also arises naturally within populations. Chimerism was assessed in two populations (n=30 adult colonies per population) by comparing the genotypes of branches within colonies (8 per colony) using 7 microsatellites. Chimeric colonies were found to comprise between 3 and 6 percent of each population (or 5% overall). Thus, chimerism occurs naturally at low frequencies in populations of *Acropora millepora* on the Great Barrier Reef. As chimeras represent enhanced genetic diversity within a coral colony, the presence of chimeras within natural populations of spawning corals on the Great Barrier Reef may provide a selective advantage in a heterogeneous environment.

## 6-23

**Symbiodinium – To Be An Alga Or Not, That Is The Question**

**Bill LEGGAT*[1,2]**, David YELLOWLEES[2]

[1]Biochemisry and Molecular Biology, James Cook University, Townsville, Australia, [2]ARC CoE for Coral Reef Studies, James Cook University, Townsville, Australia

Symbiodinium (also called zooxanthellae) seem to conform to our traditional idea of alga should be, they are a small single cell that photosynthesises. However the more we learn about their genetic compliment the more unique they appear. Only recently have large scale surveys of the dinoflagellate genome begun. This study characterises a recent large scale sequencing effort from Symbiodinium and describes some of the unique genetic compliment of Symbiodinium both in culture and in symbio. These unique characteristics include a large percentage of genes which are most closely related to those found in bacteria. These include genes that encode for a number of proteins involved in the transport of metabolites (such as sugars), which may play a key role in the coral symbiosis. The most abundant transcript found in the Symbiodinium transcriptome is also of bacterial origin. Sequence analysis and antibodies indicate that it is localised to the chloroplast where it function is unknown. This study also describes the variety of biochemical pathways that we have characterised from Symbiodinium and how they differ from what we might expect of a "traditional alga", with particular emphasis on those pathways that may be important for the coral-Symbiodinium symbiosis.

## 6-24

**Est Screening And Multigene Analysis Of Symbiodinium Dinoflagellates: A Phylogenomic Approach**

**Xavier POCHON*[1]**, Ruth GATES[1]

[1]Hawaiian Institute of Marine Biology, Kaneohe, HI

Symbiotic dinoflagellates in the genus Symbiodinium are essential components of coral reef ecosystems contributing to the growth, survival and success of a large array of protist and invertebrate phyla. Phylogenies based primarily on multi-copy genes and spacers of the ribosomal DNA operon have defined eight distinct groups within the genus Symbiodinium, referred to as clades A through H. Each of these groups contain multiple ribotypes (ITS types) that are often considered to represent species-level taxonomy. However, intragenomic variation (within an individual) in the rDNA ITS markers potentially results in comparisons of paralogues rather than orthologues and this creates a complex framework for taxonomic interpretation. To address this issue the current work focuses on defining new, functionally relevant and readily interpretable genes for future taxonomic studies. Interchangeable BLAST comparisons of two Symbiodinium and six dinoflagellates EST datasets have resolved 93 new Symbiodinium gene candidates. Eight of these genes (psbA, CoxI, CoxIII, Elongation Factor, Calmodulin, Actin, Alpha-tubulin, and rad24) have been sequenced from Symbiodinium DNAs representing all known clades in the genus. Five markers displayed divergence rates similar to those found in the LSU rDNA region, and three genes (Actin, Calmodulin and rad24) harbor up to four highly variable introns that can potentially resolve within clade Symbiodinium diversity. The identification and phylogenetic comparison of these markers will be presented and discussed.

## 6-25

**The Holobiont Transcriptome Of *aiptasia Pallida***

Shini SUNAGAWA[1], Monica MEDINA[1], Virginia WEIS[2], John PRINGLE[3], **Jodi SCHWARZ*[4]**

[1]School of Natural Sciences, University of California Merced, Merced, CA, [2]Department of Zoology, Oregon State University, Corvallis, CA, [3]Department of Genetics, Stanford University, Stanford, CA, [4]Biology Department, Vassar College, Poughkeepsie, NY

Aiptasia pallida has long served as a model for examining the physiology of coral symbiosis and coral bleaching. To build upon the rich history of this model system, we are examining the transcriptome of symbiotic Aiptasia, using a large insert cDNA library from which we generated a high quality dataset of approximately 8000 ESTs. We have collaborated with our undergraduate students to assemble and annotate these genes, and have characterized a rich set of stress-response, developmental, signaling, and innate immune-related proteins from both the host and the symbiont. This dataset will facilitate genomic-level examination of host-symbiont interactions and the bleaching response. Currently, using this EST dataset, we are examining both physiological and transcriptome-level pathways of the stress response under different stressors, including temperature and heavy metal contamination.

## 6-26

**Exploring Symbiotic Interactions in the Sea Anemone-Zooxanthellae Model by Large-Scale ESTs Analysis**

Philippe GANOT[1], **Aurelie MOYA*[1]**, Emeline DELEURY[2], Denis ALLEMAND[3], Paola FURLA[1], Cecile SABOURAULT[1]

[1]ECOMERS, Nice Sophia Antipolis University, Nice cedex2, France, Metropolitan, [2]UMR 1112 ROSE, INRA, Sophia Antipolis, France, Metropolitan, [3]Scientific Centre of Monaco, Monaco, Monaco

To characterize genes involved in the symbiotic association between the cnidarian sea anemone *Anemonia viridis* and its dinoflagellate symbiont (zooxanthellae) *Symbiodinium* sp., a large EST collection was generated. A cDNA library was constructed from total mRNAs (cnidarian and zooxanthellae) isolated from symbiotic, aposymbiotic (bleached) and stressed (temperature) animals. A total of 39,939 ESTs compiled in 4,614 contigs and 10,976 singletons sequences were analyzed. Comparison to the genomic *Nematostella vectensis* database and to all other annotated expressed sequences (UniProt) indicates that our *A. viridis* dataset comprises sequences related to metazoan, protists and prokaryotes, respectively 51%, 8% and 3.9%, as well as 35.1% without known homology to any sequences. Interestingly, long 3' UTR often containing a miniature non-autonomous transposon element (MITE related) are overrepresented in our Anemonia–assigned sequences. A subset of 2,000 genes, potentially involved in symbiosis (heterotrophic metabolism, transporter, cell cycle control …), were used to design a 60 mer oligonucleotides dedicated microchip. Comparative gene expression through microarrays analysis between symbiotic, aposymbiotic and stressed animals are currently underway.

## 6-27

**Genomic Insight Into Drupella Sp.: Establishment And Analysis Of An Est Database**

**Bishoy HANNA*[1]**, Felipe CHAMBERGO[2], Hamza EL DORRY[1], Moshira HASSAN[1], I CHAMBERGO[2], Amira MAHMOUD[1]

[1]American University in Cairo, Cairo, Egypt, [2]University of SÃ£o Paulo, Sao Paulo, Brazil

The corallivorous gastropod Drupella sp. has caused considerable damage to a number of coral reefs in the Red Sea over the last years. These outbreaks have been linked to other diseases, but the underlying cause is still unclear.

In this work, we establish an insight into the genome of Drupella sp. using an EST library.

Surveys were conducted on a heavily infested reef in the northern Gulf of Suez, Red Sea. The total RNA was isolated from a whole organism, which was collected from a colony of Stylophora pistillata. A cDNA library was constructed and 9408 random clones were sequenced. Computational analysis resulted in a total of 3353 sequences of which 2109 received no significant BLASTX match while the other 1244 sequences were further classified according to the Gene Ontology classification. The resulting classification covered most physiological activities carried by the organism. The sequences revealed a group of retrotransposons that were expressed at the time of collection. In addition to neurotoxins and other toxin genes that were expressed, several proteins were found that are expressed as responses to oxidative stress, hypoxia, viruses, and bacterial infections. Some of ESTs found are most likely of non-mollusk origin resembling symbionts and parasites that are part of the organism and the reef community. A website was constructed to cater for the data generated, with a BLAST search interface. The isolated genes can be investigated as potential biomarkers for water contamination and in order to understand the conditions leading to Drupella sp. outbreaks. The retrotransposons found can be compared spatially to establish population barriers. These results will also be used to find useful genes to study population genetics of this organism at different temporal and spatial scales.

## 6-28

**Do Corals Possess The Protective Mucus Encoding Muc Genes?**

**Amita JATKAR*[1]**, John BYTHELL[2], Barbara BROWN[1], Jeff PEARSON[3], Nick MORRIS[4], Reia GUPPY[1]

[1]Division of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]Division of Biology, Newcastle University, Newcastle upon tyne, United Kingdom, [3]Institute for Cell and Molecular Biosciences, Medical School, Newcastle University, Newcastle upon Tyne, United Kingdom, [4]School of Biomedical Sciences, Medical School, Newcastle University, Newcastle upon Tyne, United Kingdom

Mucus functions as first line of defence against infections, amongst other roles. The protective role of mucus depends upon gel-forming properties of mucin molecules that are encoded by the MUC genes. Although the presence of MUC genes has been detected in several vertebrate groups, mucus or a mucus-like extra cellular matrix is believed to be secreted in all groups of animals. The human MUC gene family is comparatively well studied and expanding rapidly, with 19 MUC genes discovered so far. These MUC genes have been grouped into secretory and membrane-bound mucins. Failure of this protective barrier has been associated with changes in structure, function and physical properties of mucins. These changes have been demonstrated as a possible prognostic tool for early diagnosis of diseases such as cancer, tumour and cystic fibrosis in humans. Earlier studies on coral mucus show an inconsistent chemical composition influenced by depth, aging and contamination from the environment. It is well established that coral surface mucus harbours a distinct microbial community that respond to changes in environmental factors. Study of mucus-microbial interactions is critical to understand phenomena such as bleaching and disease. Relatively little information is available regarding MUC gene structure and functions in corals. The present study examines the ways to detect coral MUC genes by tracing the evolution of MUC genes from cnidarians to mammals using bioinformatics and molecular tools. Using a range of bioinformatic techniques, six potential MUC-gene sequences have been recovered from the available coral databases. Three of these are from the hyper-variable tandem repeat (TR) domain or mucin domain and are highly likely to represent human MUC-gene homologues. This study will enhance the understanding of host responses and changes in defensive capabilities due to changing surrounding conditions.

## 6-29

**New Applications For A Proven Tool: Metabolite Profiling And Chemometrics To Characterise Effects Of Turbidity And Sedimentation On The Coral Acropora Millepora**

**Anke KLUETER*[1]**, Jonathon L. NIELSON[1]

[1]Australian Institute of Marine Science, Townsville, QLD, Australia

With constantly increasing levels of land based activities within the GBR catchment there is an increasing need to innovate and explore new methodologies of monitoring reef health and water quality. Metabolomics, a growing research discipline in systems biology, allows us to look at a metabolic response of the cell and organism as a whole. Objects of study are primary and secondary metabolites, necessary for life and the intermediates and end products of cellular regulatory processes. The state of an organisms 'metabolome' at any point in time represents the interaction of the organism's genome with its environment. By taking a 'snapshot' of the metabolic profile of an organism under various environmental stressors it is possible to identify metabolites involved in the organisms biochemical response to stress.

We examined the stress response of Acropora millepora to changing water quality. Using a tank system with controlled environmental conditions, corals from inshore and mid-shelf locations were exposed to shaded and non-shaded conditions with and without suspended particulate matter (SPM). The coral's metabolic response was investigated by preparing acetone/methanol extracts and acquiring Proton Nuclear Magnetic Resonance spectra (HNMR) and Liquid Chromatography Mass Spectrometry (LC-MS) data. Data were subjected to Principal Component Analysis. Significant clustering in relation to treatment was observed in the HNMR data sets. The first principal component was strongly correlated to presence or absence of SPM. Samples showed also a tendency to cluster according to exposure to light or shade. Analysis of LC-MS data showed the strongest correlation between the coral's geographic origin. Here we identified four different metabolites between inshore and mid-shelf colonies.

Our results demonstrate the prospective of metabolomics as a new monitoring technology to assess coral health.

## 7-1

**Patterns of Coral Diseases in the Florida Keys from 1998 – 2005**

**Deborah SANTAVY*[1]**, Susan YEE[1], Mace BARRON[1]

[1]Gulf Ecology Division, US EPA, NHEERL, Gulf Breeze, FL

Diseases have been identified as a major threat to reef-building corals causing morbidity and mortality. Increased mortality has lead to degradation, especially those reefs dominated by several susceptible species. Increased morbidity has reduced the health of reef-building corals making them more vulnerable to other environmental stressors. Reported incidence, prevalence, and distribution of coral diseases have been greatest from the tropical Western Atlantic, with emergent coral diseases, such as aspergillosis and serratiosis originating from terrestrial sources. Epizootiological studies assessed the prevalence of dominant coral diseases in the Florida Keys reef tract from 1998-2005, from the Dry Tortugas to the Upper Keys. Annual assessments were repeated at permanent sites in mid-summer throughout the area. Data were adjusted so coral community composition, specifically the absence of susceptible species, did not bias the results. Canonical correspondence analyses revealed coral diseases patterns related to spatial and temporal parameters. Reef depth was the most discriminating parameter for all coral diseases surveyed. White plague and white-band disease had the highest prevalence on deeper reefs, whereas black-band disease was most prevalent on mid-depth reefs, and red-band disease and white pox were most prevalent on shallow reefs. White-band disease had the highest prevalence in the early years, whereas dark-spots disease had increased incidence in the later years of the study. Dark-spots and yellow-blotch diseases were more common in the Dry Tortugas, whereas black-band disease had the highest prevalence in the Middle Keys. One of the first steps in identifying and managing health threats of reefs is to establish disease prevalence and incidence to understand patterns and associate them with other variables to determine causative factors. In tropical marine systems prevention or control of coral disease can assist in precluding the collapse of important ecological functions and ecosystem services.

## 7-2

**The Role Of Diseases in Coral Community Structure Shifts in Mexican Caribbean Reefs**

**Eric JORDÁN-DAHLGREN*[1]**, Rosa RODRÍGUEZ-MARTÍNEZ[2], Adan Guillermo JORDÁN-GARZA[3], David M. BAKER[4], Jason ANDRAS[5], Leonardo VAZQUEZ-VERA[6]

[1]ICMyL, UAPM, Universidad Nacional A. de México, Puerto Morelos, Mexico, [2]ICMyL, UAPM, Universidad nacional A. de México, Puerto Morelos, Mexico, [3]ICMYL, UAPM, UNiversidad Nacional A. de México, Puerto Morelos, Mexico, [4]Ecology and evolutionary Biology, Cornell University, Ithaca, NY, [5]Ecology and Evolutionary biology, Cornell University, Ithaca, NY, [6]ICMyL,UAPM, Universidad Nacional A. de México, Puerto Morelos, Mexico

Montastraea annularis, M. faveolata and M. franksi, the major local coral reef builders after the demise of Acroporids in the Mexican Caribbean, has decreased more than half in a twenty years span; presumably due to diseases. Recent data (2005-2007) from highly replicated permanent sites spread over a 200km reef tract shows relatively large rates of whole colony and partial mortality for these species, both within and between sampling sites. Yellow Blotch syndrome appears to be the major cause of the observed mortality patterns, although other disease signs also play a role. Species of Acropora, Diploria and Colpophyllia natans, the other potentially important reef builders are also being severely affected by other diseases. In contrast Agaricia agaricites, Porites astreoides and Siderastrea siderea while not being immune to coral diseases show a much higher resistance and mortality rates are comparably low; becoming the dominant components in reefs down to 15m deep. Although variable among sites, comparisons of species size structures indicates that local shifts in dominant species appears to be related to higher survival rates, rather than to increased recruitment rates. Analyzing linkages of the observed patterns with site relative degree of local development, protected and non-protected status and local thermal anomalies shows mixed trends. These findings suggest that global and regional drivers of environmental deterioration may have a stronger influence than local ones in the study area.

## 7-3

**Recent Changes To Montastraea Annularis And M. Faveolata Populations In Southwestern Puerto Rico And Associated Islands From Disease And Bleaching**

**Andrew BRUCKNER*[1]**, Ron HILL[2]

[1]NOAA Coral Reef Conservation Program, NOAA, Silver Spring, MD, [2]Fisheries, NOAA, Galveston, TX

Over the last decade, reefs off southwest Puerto Rico and the associated islands have experienced losses in live coral cover in excess of 50%, primarily due to the decline of M. annularis and M. faveolata. These species were formerly the largest and most abundant corals remaining on these reefs. Outbreaks of coral disease, especially white plague and yellow band disease, affected over 50% of the colonies in some sites during the late 1990s; disease prevalence declined between 2002-2004 and then increased immediately following a 2005 mass bleaching event. These diseases have caused unprecedented rates of mortality, with cumulative losses exacerbated by bleaching and parrotfish predation. In both species, a lack of recruitment and only limited recovery through resheeting have been observed, and exposed skeletal surfaces are being colonized by macroalgae, bioeroding sponges, hydrozoans, and other scleractinian coral recruits (primarily Porites and Agaricia). Unlike acroporids, which have the potential for rapid growth and recovery, M. annularis and M. faveolata are unlikely to recover in our lifetimes and are being replaced by shorter-lived brooding species and other massive and plating species with faster growth and higher recruitment rates. The impacts of these shifts on coral community structure and reef fisheries are unknown. Approaches undertaken to recover acroporids, such as propagation through fragmentation and grow-out of sexual recruits, are less likely to work for M. annularis (complex) - species with slow rates of growth and limited recruitment. To avoid a catastrophic and permanent shift in coral community composition, research needs to be directed towards an improved understanding of the causes and impacts of diseases and bleaching, and possible control mechanisms. Managers and policy makers must take steps to mitigate environmental and anthropogenic stressors that increase the spread and severity of disease.

## 7-4

**The Future Of Coral Reefs in The Us Virgin Islands: Why *acropora Palmata* Is More Likely To Recover Than *montastraea Annularis* Complex**

**Caroline ROGERS*[1]**, Erinn MULLER[2], Tony SPITZACK[1], Jeff MILLER[3]

[1]US Geological Survey, St John, Virgin Islands (U.S.), [2]Florida Institute of Technology, Melbourne, FL, [3]National Park Service, St John, Virgin Islands (U.S.)

The Caribbean bleaching/disease event that began in the summer of 2005 caused significant mortality of the two most important reef-building corals in the US Virgin Islands (USVI), *Acropora palmata* and *Montastraea annularis* complex (Macx). These corals characterize the shallow and mid-depth zones of the islands's reefs, and their ability to recover will define the future seascape in the USVI. Research on *A. palmata* from 2003 to 2007 around St. John documented disease prevalence ranging from 0 to 52% with high levels of white pox (and un-described diseases) and very low levels of white band disease that caused major losses 25-30 years ago. Over 94% of the white pox lesions healed at least partially. *Acropora palmata* bleached for the first time in the USVI in 2005. Forty-five percent of 460 colonies from several sites bleached, and 8% died. Bleached corals had greater disease mortality than unbleached. *Acropora palmata* had high genotypic variation, and evidence of limited, recent sexual recruitment. Survival of fragments ranged from 29 to 60%. Deeper reef zones dominated by Macx showed greater coral bleaching and mortality (primarily from white plague) following the record-high seawater temperatures in 2005. Over 98% of the Macx bleached, and ca. 90% of the disease mortality was seen on Macx. Healing of disease lesions was not observed. Over the next 50 to 100 years, *A. palmata* has a greater potential to recover than Macx because of its higher growth rate, greater ability to colonize new areas through fragmentation, and lower vulnerability to bleaching and disease. The future of these major reef-building corals and of USVI reefs will depend also on the connectivity between these reef zones and sources of coral larvae.

## 7-5

**Coral Yellow Band Disease; Current Status in The Caribbean, Outbreaks And The Links To New Indo-Pacific Lesions**

**Angela RICHARDS DONA*[1]**, J.M. CERVINO[2,3], Vicky KARACHUN[2], Elizabeth LORENCE[2], Erich BARTELS[4], Konrad HUGHEN[5], Garriet SMITH[6], Thomas GOREAU[7]

[1]Biological Sciences, Pace University, Brooklyn, NY, [2]Biological Sciences, Pace University, NY, NY, [3]Geochemistry, Woods Hole Oceanographic Inst., Woods Hole, [4]Mote Marine Lab, Summerland Key, FL, [5]Geochemistry, Woods Hole Oceanographic Inst., Woods Hole, MA, [6]Biological Sciences, University of South Carolina, Aiken, SC, [7]Global Coral Reef Alliance, Cambridge, MA

Yellow band disease (YBD) has had a severe impact on the major reef building corals in the Caribbean. Recent data from Lesser Antilles indicates that this disease is still in a severe epidemic phase showing similar trends compared to the late 1990s. Ten meter belt transects taken at varied depths of *Montastraea* spp. indicate high indices of yellow band lesions. At 5m depth, the largest number of live *Montastraea spp*. were found. Yellow band rings and lesions were positively identified to be affecting an average of 8.4 (79%) colonies per transect. Only an average of 2.2 (21%) colonies in this depth range appeared healthy. At 10m depth *Montastraea* colonies which could be positively identified with distinct YB lesions seem to be more numerous than at deeper depths. An average of 1.2 (16%) healthy colonies and 6.2 (84%) colonies affected by YBD per 10m transect were counted. At 15m there was an average of 1.2 (44%) healthy colonies and 1.5 (56%) colonies affected by YBD per 10m transect. These data coincide with recent severe outbreaks in the Indo Pacific where identical lesions were found on the surfaces of *Diploastrea spp*., *Herpolitha spp.*and *Fungia spp.* Cytological analysis and histological sections reveal identical cell death mechanisms as shown in Caribbean YBD coral specimens. Inoculation experiments of Indo-Pacific bacterial isolates under ambient temperatures in aquaria cause the induction of YB lesions onto *Montastraea spp. in vitro*. This recent research indicates that YBD continues to be in an infectious stage in the Caribbean and has been found to cause infection in Pacific coral genera.

## 7-6

**Coral Health And Disease Assessment In The U.S. Pacific Trerritories And Affiliated States**

**Bernardo VARGAS-ANGEL*[1]**, Benjamin WHEELER[2], Jean KENYON[1], James MARAGOS[3], Bonnie DEJOSEPH[1]

[1]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Department of Oceanography, University of Hawaii, Honolulu, HI, [3]Remote Islands National Wildlife Refuge Complex, USFWS, Honolulu, HI

In 2006 and 2007, quantitative coral disease assessments were conducted at 40 different coral islands, banks, and atolls (Johnston, Palmyra, and Wake Atolls, Howland, Baker, and Jarvis Islands, Kingman Reef, the Main Hawaiian Islands, the Northwestern Hawaiian Islands, Guam, and the Commonwealth of the Northern Mariana Islands), spanning over 3500 km and nearly a 20º latitudinal gradient. Distribution and prevalence were determined from 25 m belt transects at 316 sites, totaling an area of over 90,000 m2 of reef habitat. Ten broad disease categories were recognized, affecting 27 different anthozoan genera; prevalence was computed based on the estimated total number of coral colonies per survey area. The most geographically and taxonomically widespread disease was the skeletal growth anomalies, detected at nearly 60% islands/atolls and on 8 different anthozoan genera. In contrast, the most prevalent disease was the acute tissue loss, aka white syndrome, which exhibited a diverse range of host genera, including *Acropora*, *Montipora*, *Pocillopora*, *Goniastrea*, and *Platygyra*. Band diseases were rare, with only two cases enumerated for all the regions on *Porites* and *Coscinaraea*. The overall abundance of coral diseases in the US Pacific is low. However, patterns of prevalence vary among coral genera and indicate that only a few taxa are disproportionately affected by disease, namely the Acroporidae and Poritidae. Of potential concern is the white syndrome, which results in severe and rapid tissue loss, particularly on the tabular *Acropora cytherea* at Johnston Atoll and French Frigate Shoals.

## 7-7

**Guam Reefs Show A Link Between The Dominant Genus Porites And Disease Prevalence**

**Roxanna MYERS*[1]**, Laurie RAYMUNDO[1]

[1]Marine Laboratory, University of Guam, Mangilao, Guam

Coral diseases are considered to be a major cause, and often a result, of the recent worldwide decline of coral reef health and productivity. Relative to the Caribbean little is known about the impacts of coral diseases on Indo-Pacific reefs which are more widespread with greater diversity and are often more impacted by dense human coastal populations. Therefore, understanding the impact of coral diseases on Guam reefs was considered an important management issue for local scientists. Initial surveys of 12 Guam reefs conducted in 2006-07 revealed mean disease prevalence as highly variable, both within and between sites possessing a weak relationship with live hard coral cover ($R2 = 0.01$; $p>0.05$). Coral composition consisted of 13 major families and total disease prevalence ranged from a low of 2% (Pago Bay) to a high of 38% (Cocos Lagoon). Four sites were selected for long-term monitoring of disease prevalence, changes in benthic composition and temperature. Results from the first year of monitoring on Luminao Reef suggest highest disease prevalence corresponding to the period of warmest temperatures (30.1 + 1.0 ºC), with prevalence increasing from 6% to 30% in one year. Guam reefs were taxonomically diverse, but dominated by the genus *Porites*. They displayed a strong link between total disease prevalence and generic abundance per family ($R2=0.89$; $p<0.0001$). Five out of six diseases described on Guam affected various species within *Porites* (mean prevalence: 9.1% $\pm$ 4.1%). The fact that this genus is the primary reef builder on Guam reefs suggests that coral diseases which result in partial or full colony mortality have the potential to have significant long-term effects on community structure.

## 7-8

**Characterizations Of The Major Coral Diseases Of The Philippines: *porites* Ulcerative White Spot Syndrome And Novel Growth Anomalies Of *porites***

**Longin T. KACZMARSKY*[1]**, Raju SEKAR[1], DeEtta K. MILLS[2], Esther C. PETERS[3], Laurie L. RICHARDSON[1]

[1]Biological Sciences, Florida International University, Miami, FL, [2]International Forensic Research Institute, Florida International University, Miami, FL, [3]Tetra Tech, Inc., Fairfax, VA

Porites are important dominant reef-builders on Indo-Pacific reefs. Recently, Porites Ulcerative White Spots Syndrome (PUWS) and Growth Anomalies (GAs) have occurred at high prevalence on Philippine reefs. Yet, little is known about these coral-killing diseases. We applied an integrative approach to characterize environmental correlates and histological, microbiological and molecular aspects. We hypothesized that differences in coral-associated microbial communities might explain the diseases. Previous research suggested transmission of GAs between Porites colonies and thus the possible involvement of a pathogen. To manage these diseases, pathologic diagnosis and characterization are needed. In 2005, diseased and non-diseased tissues were collected. Microbial community profiling using amplicon-length heterogeneity-PCR and cloning and sequencing of 16S rRNA genes revealed differences between the diseased and non-diseased communities. Compared to healthy coral, clones from GAs included more sequences of Pseudomonas and Vibrio and an absence of Alteromonadaceae (known to have antimicrobial properties) suggesting Alteromonadaceae confer some protection. PUWS-infected tissue yielded fewer Vibrio but an abundance of Roseobacter not found in healthy corals. Cultured isolates unique to healthy coral included Bacillus and Vibrio strains. PUWS-infected tissue isolates included Roseobacter and V. harveyi. GAs yielded V. shiloi, V. harveyi, Pseudoalteromonas and distinct Bacillus strains. Antibacterial/synergism assays revealed Pseudoalteromonas from GAs inhibited Bacillus from healthy coral. One V. harveyi strain from GAs and PUWS-infected coral stimulated the growth of a different V. harveyi strain. Histologically, GAs exhibited severe vacuolation, mucocyte hyperplasia and hypertrophy, lower zooxanthellae density, altered chromophores, and calicodermal hypereosinophilia. Epidermal hypertrophy suggests hydropic changes resulting from damaged cell membranes. Analyses of water samples revealed positive correlations between high disease prevalence and high nutrient levels. Our results suggest some key factors involved in these diseases and provide direction upon which to focus future studies.

## 7-9

**Coral Disease At Palmyra Atoll in The Remote Central Pacific: Patterns Of Distribution And Histological Characterization**

**Gareth WILLIAMS*[1]**, Greta AEBY[2], Thierry WORK[3], Simon DAVY[1]

[1]Victoria University of Wellington, Wellington, New Zealand, [2]Hawaii Institute of Marine Biology, Kaneohe, HI, [3]US Geological Survey, Kaneohe, HI

Coral diseases are an ever increasing threat to coral reefs. This is clearly a concern for conservation and management of these systems and their reef associated organisms. This baseline survey was aimed at quantifying, in detail, the relationship between coral disease occurrence, environmental variables and coral community structure. Work was conducted over six weeks at the Palmyra Atoll National Wildlife Refuge, Central Pacific, during June to July 2007. Fifty-eight belt transects were haphazardly placed at 11 key sites (5 backreef and 6 forereef) established for long term monitoring around the atoll. Environmental variables measured were temperature, salinity, turbidity and chlorophyll *a* concentration. Sedimentation levels were also measured for all back reef sites. Growth anomalies were recorded on four coral genera (*Astreopora*, *Montipora*, *Fungia* and *Acropora*). In addition, tissue loss was seen on colonies of encrusting *Montipora* sp. These diseases were restricted to the backreef sites and occurred with an overall prevalence of 0.39 %, with prevalence at individual sites ranging from 0.2 – 1.0 %. This presentation will discuss how prevalence of coral disease relates to the environmental variables and coral community structure using an array of multivariate statistical techniques. Histological characterisation of the *Astreopora* growth anomalies will also be presented because this type of characterization is crucial to advancing our understanding of how diseases affect coral at a cellular level. Palmyra Atoll represents a location where the prevalence of coral disease and the impacts of environmental variables on this prevalence can be monitored in circumstances where more recent major anthropogenic impact has been greatly reduced. Moreover, knowledge of coral disease at this important wildlife refuge will aid its future monitoring and management.

## 7-10

**Effects Of Quick And Slow Diseases At Acropora Cytherea in Kerama Islands.**

**Akiyuki IRIKAWA*[1]**

[1]Department of Research, Association for Kerama coral Reef Conservation, Naha-Okinawa prefecture, Japan

In order to estimate effects of bleaching, *Acanthaster planci*, and diseases in a population of the reef-building coral *Acropora cytherea*, decadal monitoring researches have been conducted. The most severe impacts in the *A. cytherea* population are progressive diseases.

Skeletal anomalies (SAs) in *A.cytherea* develop mainly as white masses. On the surface of SAs, orderly skeletal structure and alignment of polyps became lost, and swelling SAs covered normal area like an avalanche. Negative aspects of SAs are lower potential in productivity and lack of fecundity. Although linear annual growth were 1.2～1.4cm/yr, multiple SAs became fused with neighboring ones. SA tended to start to die over 10cm diameter. If *A.cytherea* colonies keep usual growth rate, the impact by Sas are acceptable.

White syndrome (W.S.D.) arised at 2003, and became widespread at 2004. Approximately 70% colonies of *A.cytherea* have been killed by W.S.D for recent 3 years. By contrast with SAs, W.S.D have severe impact in a population of *A.cytherea*. On the lesioned part appearing white band, coral tissues are broken off. White band spread at the rate of up to 20cm centimeters per a month.

If W.S.D. does not blow over, A population of *A.cytherea* in Kerama Islands will be crushed within 10 years by interaction of bleaching, Acanthaster, and disease impacts.

## 7-11

**Prevalence And Potential Origin Of The White Pox Disease Pathogen in The Florida Keys, Usa**

**Kathryn SUTHERLAND*[1]**, James PORTER[2], Jeffrey TURNER[2,3], Brian THOMAS[1], Erin LOONEY[4], Trevor LUNA[1], Victoria WATSON[1], Erin LIPP[4]

[1]Department of Biology, Rollins College, Winter Park, FL, [2]School of Ecology, University of Georgia, Athens, GA, [3]Department of Environmental Health Science, University of Georgia, Athens, [4]Department of Environmental Health Science, University of Georgia, Athens, GA

Serratia marcescens is a causal agent of the coral disease, commonly known as white pox and etiologically known as acroporid serratiosis, that affects the Caribbean elkhorn coral Acropora palmata. The purpose of this study is to elucidate the prevalence and the source of the bacterium in the marine environment. Nearshore marine and reef environments in the Florida Keys and raw sewage were screened for the presence of the bacterium. S. marcescens were cultured and identified from environmental samples using a three-step method: culture on MacConkey Sorbitol agar followed by culture on DNase with Toluidine Blue agar followed by Serratia-specific PCR. PCR products from a sub-sample of confirmed isolates were sequenced to verify identity. Restriction endonuclease digestion (SpeI) followed by pulsed-field gel electrophoresis (PFGE) was used to determine genetic similarity among and between strains and potential source areas. A total of 383 S. marcescens were isolated from the surface mucopolysaccharide layers of the scleractinian corals Siderastrea siderea and Solenastrea bournoni, the corallivorous snail Coralliophilia abbreviata, seabird guano, beach water, canal water, and sewage. The majority of S. marcescens (72%) were obtained from sewage and contaminated nearshore sources. A total of 118 distinct PFGE patterns were identified, indicating that S. marcescens is genetically diverse in environments of the Florida Keys. Eleven groups (strains) contained two or more identical isolates, and one of these strains included isolates collected from sewage, C. abbreviata, S. siderea, and S. bournoni. This strain, isolated from both reef and sewage sources, establishes a definitive connection between human sewage and the reef ecosystem.

## 7-12

**Epizootiology Of *montipora* white Syndrome in Kaneohe Bay, Oahu, Hawaii**

**Greta AEBY*[1]**, Megan ROSS[2], Thierry WORK[3], Teresa LEWIS[1]

[1]Hawaii Institute of Marine Biology, Kaneohe, HI, [2]University of Hawaii, Honolulu, HI, [3]USGS, Natl Wildlife Health Center, Honolulu, HI

Coral disease is emerging as a problem in the Indo-Pacific yet little is known about the ecology of these diseases or factors that may be affecting disease levels. *Montipora* white syndrome (MWS) is a coral disease resulting in tissue loss that was identified in Kaneohe Bay, Oahu, Hawaii in 2004. Kaneohe Bay has a north-south gradient in anthropogenic stressors and so provided a model system to examine the relationship between proximity to potential stressors and disease prevalence. The objectives of this study were to document the distribution and abundance of *Montipora* white syndrome on reefs throughout Kaneohe Bay, examine the relationship between disease prevalence and environmental stressors and determine the ultimate damage to coral colonies from this disease. *Montipora* white syndrome was found in all regions of Kaneohe Bay but prevalence was highest in south Kaneohe Bay, the region most subject to terrestrial run-off. MWS was present on corals throughout the year with no significant difference in disease prevalence in Fall vs. Spring. Fifty-four out of 57 tagged coral colonies infected with MWS experienced progressive tissue loss ranging from 1% of the colony to complete mortality (avg. loss=36.7%) within one year. Average rate of tissue loss was 3.1% per month with one third of the colonies losing 90% or more of their tissues resulting in partial to complete colony collapse within one year. MWS was found to stop and re-start on individual colonies suggesting there are intrinsic and/or extrinsic factors controlling its progression. We also discovered differential susceptibility to MWS between two color morphs of *Montipora capitata.*

## 7-13

**Black Band Disease (BBD): A Possible Polymicrobial Disease**

Orit BARNEAH[1], Eitan BEN-DOV[1], Esti KRAMARSKY-WINTER[2], Yossi LOYA[2], **Ariel KUSHMARO*[1]**

[1]Department of Biotechnology Engineering, Ben-Gurion University, Beer-Sheva, Israel, [2]Department of Zoology, Tel-Aviv University, Ramat Aviv, Tel Aviv, Israel

Microbial communities associated with black band disease (BBD) in massive stony corals from the Northern Red Sea (Eilat) were examined for the first time using microscopy, microbiological and molecular tools. A high microbial diversity was revealed in the affected tissue in comparison with the healthy area of the same colony. Microscopy revealed the penetration of cyanobacteria into the coral mesoglea and adjacent tissues. Cyanobacterial sequences from Red Sea BBD-affected corals formed a cluster with sequences previously identified from black band and red band diseased corals from the Indo-Pacific and Caribbean. In addition, 11 sequences belonging to the genus Vibrio, a group previously documented as being pathogenic to corals were retrieved. The distribution and diversity of sulfate-reducing bacteria, a group known to be associated with BBD and produce toxic sulfide, were studied using specific primers for the amplification of the dissimilatory sulfite reductase gene (dsrA). This technique facilitated and improved the resolution of the study of diversity of this group. All the sequences obtained were closely related to sequences of the genus Desulfovibrio and 46% showed high homology to Desulfovibrio desulfuricans. The complex nature of BBD and the lack of success in isolating a single causative agent suggest that BBD may be a polymicrobial disease.

## 7-14

**Black Band Disease Dynamics And Variation in The Pathogenic Microbial Community**

**Joshua D. VOSS*[1]**, DeEtta K. MILLS[2,3], Sara E. EDGE[1], Laurie L. RICHARDSON[2]

[1]Robertson Coral Reef Program, Harbor Branch Oceanographic Institute at Florida Atlantic University, Fort Pierce, FL, [2]Biological Sciences, Florida International University, Miami, FL, [3]International Forensic Research Institute, Florida International University, Miami

Black band disease (BBD) is a pathogenic microbial assemblage that infects scleractinian corals on reefs worldwide. After more than thirty years of BBD research, involving multiple teams and approaches, the microbial composition of this assemblage, the mechanisms of pathogenicity, and the environmental conditions that promote infection remain elusive. A growing number of published studies report differences in the microorganisms that comprise BBD assemblages. While some biogeographic trends have emerged, relatively small sample sizes and differences in methodologies limit the inferences that can be made from these divergent data sets. This study utilized length heterogeneity polymerase chain reaction (LH-PCR) to provide robust, reproducible, and efficient profiling of BBD microbial communities from various sites in the Caribbean. LH-PCR differentiates organisms based on natural variation in the 16S rRNA gene and allows more rapid comparisons of community structure among multiple samples as compared to cloning and sequencing approaches, albeit with the associated limitation of discriminating taxa more broadly. The goal of this study was to assess patterns of variation in BBD microbial assemblages with respect to geographic location, host species, and time. Multivariate ordination and nonparametric analyses of the LH-PCR profiles revealed significantly distinct BBD microbial communities sampled from different geographic regions of the Caribbean. Although significant variation also exists between BBD infections on different coral species, geographic location appears to more strongly influence microbial community structure than host species. Despite minor temporal community variations within individual BBD infections, significant differences between regions persist. Together with findings of previous and ongoing molecular analyses of BBD bacterial communities, these results evidence the intrinsic complexity of this dynamic microbial assemblage.

## 7-15

**The Origin Of *Aspergillus Sydowii*, An Opportunistic Pathogen Of Caribbean Gorgonian Corals**

**Krystal RYPIEN*[1]**, Jason ANDRAS[1], Ginger GARRISON[2], C. Drew HARVELL[1]

[1]Cornell University, Ithaca, NY, [2]USGS Center for Coastal & Watershed Studies, St. Petersburg, FL

Coral reefs are increasingly suffering outbreaks of disease, causing dramatic declines in population abundance and diversity. One of the best-characterized coral diseases is aspergillosis, caused by the fungus *Aspergillus sydowii*. *A. sydowii* is a globally distributed saprophyte commonly found in soil, so its presence in marine systems raises questions about its origin. Using microsatellite markers, I analyzed the population structure of *A. sydowii* from diseased sea fans, diseased humans, and environmental sources worldwide. The results indicate that *A. sydowii* forms a single global population, with low to moderate differentiation between isolates from sea fans and those from environmental sources. Past researchers have suggested that *A. sydowii* originates from African dust blown into the Caribbean, and have identified *Aspergillus* from dust samples, although only to the genus level. To test this hypothesis, I isolated fungi from dust samples collected in Mali and St. Croix. Although a diversity of fungi were documented from African dust, including seven species of *Aspergillus*, none of the samples contained *A. sydowii*. Taken in conjunction with recent molecular evidence suggesting lack of a single point source of the fungus, these data indicate that there are likely multiple sources and introductions of this pathogen into marine systems.

## 7-16

**Fungi in Healthy And Diseased Sea Fans (Gorgonia Ventalina):**

**Carlos TOLEDO-HERNÁNDEZ*[1]**, Adelmari BONES-GONZÁLEZ[1], José RODRIGUEZ[1], Anabella ZULUAGA-MONTERO[1], Alberto SABAT[1], Paul BAYMAN[1]

[1]Biology Department, University of Puerto Rico, San Juan, Puerto Rico

The coral disease literature has mostly focused on identifying causative agents. However, lack of knowledge of microbes associated to healthy corals has undermined the ability to understand the changes in composition of microbes and their roles when colonies become diseased. This study addresses the following questions. Is the fungal community of healthy Gorgonia ventalina colonies different in diversity and composition than that of diseased ones? Within colonies with aspergillosis, does the fungal community of healthy tissue differ from that of diseased tissue? Is A. sydowii part of the resident mycoflora of healthy sea fans? Can aspergillosis also be caused by other species of Aspergillus, or by a consortium of fungi? Fungi were isolated from healthy and diseased fans found in 15 reefs around Puerto Rico, and identified morphologically and by DNA sequencing (the nuclear ribosomal ITS region) and BLAST searches in GenBank. Fungal community of healthy fans is distinct and more diverse from diseased one, and within diseased fans, fungi from diseased tissue is distinct and more diverse than from healthy tissue. Three mechanisms may explain these results: host immune depression allows pathogens to increase outcompiting other microbes; environmental factors favor some microbes over others; shift in diversity is not a cause but a consequence. An unexpected result was that A. sydowii was found in healthy sea fans and never in diseased one. A possible explanation is that the strains found in healthy fans were not pathogenic. Or others fungi may be causing the diseases since no a single fungus was consistently associated with diseased colonies. Given that it is not clear that Aspergillus is the sole pathogen, calling this disease aspergillosis is an oversimplification at best.

## 7-17

**Spatial variation in aspergillosis and the mycoflora associated to Gorgonia ventalina in Puerto Rico.**

**Anabella ZULUAGA-MONTERO*[1]**, Carlos TOLEDO-HERNÁNDEZ[1], Jose Antonio RODRÍGUEZ[1], Paul BAYMAN[1], Alberto SABAT[1]

[1]Biology, University of Puerto Rico, San Juan, Puerto Rico

Most of the coral disease literature has focused on identifying potential pathogens or environmental factors linked to disease. However, to better understand the etiology of coral diseases it is also necessary to increase our knowledge of the basic ecology of marine microorganisms. Many fungal species reported in marine organisms are common in land, but very little is known about their distribution in marine ecosystems. The objectives of this study were to determine the spatial variation in prevalence of aspergillosis, and relate it to the mycoflora associated with healthy and diseased colonies. We measured prevalence at three times during one year at six reefs sites. Colonies were tagged, photographed and categorized as healthy or diseased. The mycoflora associated to G. ventalina was identified by morphology and sequencing of the ITS region. We found significant differences in aspergillosis prevalence among sites. We also found significant spatial variation in the composition of the fungi community, and between healthy and diseased sea fans. However, sites with high or low prevalence did not have a distinctive mycoflora. Aspergillus flavus was an ubiquitous isolate at almost all sites, as well as in diseased and healthy colonies. A. sydowii was not isolated from diseased colonies. The main cause of colony death was detachment, followed by colonies that were overgrown by fouling organisms, and least by aspergillosis. The significant spatial variation in the fungi community suggests that local environmental factors are influencing the fungal composition of sea fans. The fact that A. sydowii was not isolated from diseased tissue from any reef site supports the argument that aspergillosis may be caused by a polymicrobial consortium. The data also indicates that aspergillosis is not a significant cause of mortality for sea fans in Puerto Rico.

## 7-18

**Emerging Infectious Diseases Of Coral Reef Sponges: *aplysina* Red Band Syndrome On Caribbean Reefs**

**Deborah J. GOCHFELD*[1,2]**, Robert W. THACKER[3], Julie B. OLSON[4]

[1]National Center for Natural Products Research, University of Mississippi, University, MS, [2]Environmental Toxicology Research Program, University of Mississippi, University, [3]Department of Biology, University of Alabama at Birmingham, Birmingham, AL, [4]Department of Biological Sciences, University of Alabama, Tuscaloosa, AL

A substantial and increasing number of reports have documented dramatic changes and continuing declines in the health of Caribbean coral reef communities over the past few decades. Disease is often implicated as a major factor contributing to these declines. To date, most disease reports have focused on scleractinian corals, whereas sponge diseases have been less frequently documented. Here we describe Aplysina Red Band Syndrome (ARBS), which affects Caribbean rope sponges. Visible signs of disease presence include one or more rust-colored leading edges, with a trailing area of necrotic tissue, such that the lesion forms a contiguous band around a portion or the entire sponge branch. Microscopic examination of the leading edge of the disease margin indicates that filamentous cyanobacteria are responsible for the coloration. Although the presence of this distinctive coloration is used to characterize the diseased state, it is not yet known whether this cyanobacterium is directly responsible for disease causation. Approximately 10% of the Aplysina cauliformis sponges on reefs near Lee Stocking Island, Bahamas, are affected by ARBS, and the disease has also been observed on reefs at other Caribbean sites. Transmission studies in the lab and field demonstrated that contact with an active lesion's leading edge was sufficient to spread ARBS to a healthy sponge, suggesting that the etiologic agent, currently undescribed, is contagious. Population studies indicate clumping of diseased individuals on the reef, but the presence of affected individuals in isolation suggests that waterborne transmission is also likely. Studies to elucidate the etiologic agent of ARBS are ongoing. Sponges are an essential component of coral reef communities and emerging sponge diseases have the potential to impact benthic diversity and community structure on coral reefs.

## 7-19

**The Pathological Studies Of Skeletal Anomaly in The Coral *porites Australiensis***

**Naoko YASUDA*[1]**, Yoshikatsu NAKANO[2], Hideyuki YAMASHIRO[3], Michio HIDAKA[4]

[1]Department of Marine and Environmental Science, Graduate School of Engineering and Science, University of the Ryukyus, Nishihara, Japan, [2]Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, Motobu, Japan, [3]Department of Bioresources Engineering, Okinawa National College of Technology, Nago, Japan, [4]Department of Chemistry, Biology and Marine Science, Faculity of Science, University of the Ryukyus, Nishihara, Japan

The skeletal anomalies (SAs) of the scleractinian corals have been reported from reefs throughout the world and have been commonly referred to as 'tumors'. The SAs are characterized by swelled and abnormal skeletal structures, reduced number of polyps, and fewer zooxanthellae as compared with healthy parts. Causative agents of SAs have not been identified. In this study, the pathological characteristics of the SAs developed on a colony of *Porites australiensis* in the reef at Kayo, Okinawa, Japan were investigated. The polyp density was reduced in the SA due to enlargement of both calices and the coenosteum. Corallites in the SA region lost the skeletal architecture characteristic to *Porites australiensis*. The soft tissue in the SA region contained fewer and smaller spermaries and thinner gastrodermis containing lower density of zooxanthellae than the adjacent ordinary tissue. The gross production of SA tissues was lower than that of ordinary tissues and it decreased to almost 0 in 9 days after isolation. However, when SA fragments were brought into contact with ordinary fragments from the same colony, they fused and both SA and ordinary regions grew. The growth rate of ordinary regions was lower when they were fused with SA fragments than those fused with ordinary fragments. The present results suggest that SAs may be maintained by energy supply from the surrounding healthy tissue. The SAs of the coral may act as parasite for host corals and eventually decrease the fitness of the host coral.

## 7-20

**Is Increased Scarring Of Hard Corals From Disease Associated With Subsequent Declines in Coral Cover On Reefs Of The Great Barrier Reef.**

**Ian MILLER*[1]**, Andrew DOLMAN[1]

[1]Long Term Monitoring, Australian Institute of Marine Science, Townsville, Australia

Increased reports of disease induced hard coral mortality in recent years have highlighted the emerging threat coral disease poses to reef ecosystems. To study the effects of coral disease on the Great Barrier Reef (GBR) the Australian Institute of Marine Science monitored causes of coral mortality on a suite of 48 reefs throughout the Great Barrier Reef (GBR) annually from 1999 to 2005 and on a further 48 reefs biannually from 2006. Sampling consisted of categorising corals scars according to signs commonly associated with coral disease (white syndromes and black-band disease), crown-of-thorns starfish (COTS), *Drupella* spp. feeding activity and scars that could not be assigned directly to any of these categories. In 2005 sampling was extended to include signs of recently defined disease formerly classified as white syndromes or band diseases (brown band disease, skeletal eroding band disease and atramentous necrosis). Of those categories recorded only increases in COTS scars were independently associated with subsequent declines in coral cover on survey reefs. Between 1999 and 2005 there was no clear evidence to suggest there were any disease outbreaks that had a significant impact (above background levels) on live coral cover on survey reefs. This is despite the fact that scaring due to disease constitutes a relatively high proportion of the scars observed. This suggests that though disease plays an important role in GBR coral communities it mainly contributes to "background" levels of coral mortality. The relative proportion of scars recorded show that white syndrome and unknown scars make up the most common category of scars observed. The high proportion of scars from unknown sources suggests that the causes of many corals scars remain unexplained and highlights the difficulty classifying coral scars based on visual signs.

## 7-21

**Coral Host Processes Associated With Disease Pathology And Patterns Of Tissue Loss.**

**Tracy AINSWORTH*[1]**

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

Recent advances in sequencing cnidarian transcriptomes have revealed the unexpected genetic complexity of these morphologically simple basal organisms and have the potential to provide novel insights into the biology of these economically and ecologically important organisms. The emerging insights into cnidarian genomics provide the opportunity to develop an array of tools that can be applied to better understand the physiology, molecular biology and cellular responses of corals, and also to improve our understanding of the pathological changes that are seen on coral reefs today. Patterns of disease, tissue loss and bleaching have been described on coral reefs worldwide and appear to be increasing under increased environmental pressures. The apparent link between environmental stress and degraded coral health, and the recent information demonstrating the complexity of the cnidarians, highlights the need to understand the biology of the coral host and host responses in these patterns of change. Here we combine genome biology and pathology tools to investigate the host responses associated with coral diseases. We outline the diversity of responses that occur at the molecular and cellular level that are involved in different stages and types of disease and tissue loss. We have identified the coral homologs of many of the key molecules that are involved in the recognition of pathogen associated molecular patterns, in extrinsically and intrinsically activated apoptotic pathways, and pro- and anti-apoptotic molecules in mammals. This study demonstrates the complexity of the coral host biology associated with disease, and highlights the requirement for better understanding of the underlying physiological processes associated with coral diseases.

## 7-22

**Natural Resistance To Disease in The Endangered Staghorn Coral *acropora Cervicornis***

**Steve VOLLMER*[1]**, David KLINE[2]

[1]Marine Science Center, Northeastern University, Nahant, MA, [2]Centre for Marine Studies, University of Queensland, St. Lucia, Australia

Disease epidemics are reshaping tropical coral reefs from the reef corals on up, and yet we know very little about the abilities of the coral host to respond or resist disease infection. Understanding the potential for natural disease resistance in corals is particularly important in the Caribbean where the two ecologically dominant shallow-water corals *Acropora cervicornis* and *A. palmata* have suffered an unprecedented mass die-off due to White Band Disease and are now listed as threatened on the US Endangered Species Act. We examined the potential for natural resistance to WBD in the endangered staghorn coral *Acropora cervicornis* using *in situ* transmission assays and field monitor of WBD on tagged staghorn coral genotypes and present evidence for the occurence for WBD resistant genotypes. This WBD resistance demonstrates that staghorn corals have an innate ability to respond to the WBD epidemic, and that the propagation of WBD resistant genotypes can be used to facilitate the recovery of these endangered corals.

## 7-23

**Differential Gene Expression Displayed By *pocillopora Damicornis* in Response To Infection By *vibrio Coralliilyticus***

**Angela POOLE*[1]**, Sara EDGE[2], Amy LANE[3], Joshua VOSS[2], Michael MORGAN[1]

[1]Berry College, Mount Berry, GA, [2]Harbor Branch Oceanographic Institute, Ft. Pierce, FL, [3]School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA

Coral degradation is occurring worldwide at an alarming rate and one of the contributors is the increasing frequency and severity of disease. Previous studies have demonstrated that the coral *Pocillopora damicornis* is susceptible to a temperature-dependent infection by the bacteria *Vibrio coralliilyticus*, which induces both bleaching and lysis of the tissue. Molecular investigations can provide additional information about the coral's response to this infection. In this project, RDA (Representational Difference Analysis) was used to detect differentially expressed genes in *P. damicornis* as a result of the infection by *V. coralliilyticus*. Coral samples were collected from Fiji in August of 2006 and exposed to *V.coralliilyticus* in the laboratory. The RDA protocol successfully isolated 90 uniquely different gene fragments. Results from Northern Dot Blot analysis have confirmed differential expression for several of the isolated RDA products. Expression profiles for individual genes reveals that some of these transcripts can also be detected in other diseased conditions. These results suggest that some of these genes maybe useful biomarkers of disease pathology.

## 7-24

**Pigmentation As Part Of A General Immune Response in Scleractinians**

**Caroline PALMER*[1,2]**, John BYTHELL[1], Bette WILLIS[2]

[1]School of Biology, Newcastle University, Newcastle, United Kingdom, [2]ARC Centre of Excellence for Coral Reef Studies and School of Marine and Tropical Biology, James Cook University, Townsville, Australia

The ability of hard coral to resist infection and to recover from injury remains poorly understood, yet with the increase in coral disease and coincident global reef degradation, a greater understanding of the immune capabilities of corals is becoming increasingly important. Many invertebrates induce a basic inflammatory response to tissue invasion using the melanin producing signalling pathway and phagocytosis to encapsulate and remove the invading foreign organism. The presence of potential defence mechanisms in two different types of scleracatinian coral, *Acropora millepora* and *Porites* sp. was investigated. Compromised tissue was compared to healthy tissue using enzyme activation assays for the presence of the phenoloxidase pathway. Histological samples of compromised and healthy tissue were taken to assess differences at a cellular level using the Fontanna-Masson stain and cryo-histology. The phenoloxidase pathway was found in healthy tissue of both *A. millepora* and the *Porites* sp., with an up-regulation in compromised tissue of *A. millepora*. Histological examinations show reduced numbers of zooxanthellae in compromised tissue of both species. In addition, investigations also suggest the presence of putative ameobocytes in both corals, conclusively determined the presence and location of melanin in *Porites* sp., and the presence of a red fluorescent protein responsible for the non-normal pigmentation observed macroscopically in areas of wound healing. These results indicate that the prophenoloxidase pathway is activated in compromised tissue of scleractinian coral, and suggest the presence of fluorescent proteins as part of a generalised defence response to localised stress. This study demonstrates the presence of general immune response mechanisms in scleractinian corals and also contributes to current understanding of how differential development of innate immunity might influence ecological and life history differences among coral species.

## 7-25

**Cytotoxcity in The Innate Immune Responses Of The Sea Fan Coral To Infection By A Fungal Pathogen**

**Laura D. MYDLARZ*[1]**, Laura R. HUNT[1], C. Drew HARVELL[2]

[1]Department of Biology, University of Texas at Arlington, Arlington, TX, [2]Ecology and Evolutionary Biology, Cornell University, Ithaca, NY

The sea fan *Gorgonia ventalina* possesses effective innate immune mechanisms to fight infection by the opportunistic fungus *Aspergillus sydowii*. Some of the innate immune responses, while efficient at halting pathogen growth and invasion, can lead to cytotoxicity and self harm in the coral host. Of specific interest are immune mechanisms which produce reactive oxygen and concomitant production of anti-oxidants to mitigate the toxic effects. We have recently characterized an oxidative burst in the sea fan in reaction to fungal signals and have elucidated several roles for the released reactive oxygen which include halting growth of the fungus and signaling apoptosis. In addition using corals naturally infected with fungus, we have described cellular immune mechanisms such as amoebocyte aggregation, activation of the prophenoloxidase cascade, apoptotic events and increased production of anti-oxidants to reduce the potential for self harm. The successful use of the sea fan as a model for uncovering resistance and immune mechanisms and relationships to other coral diseases will also be summarized.

## 7-26

**Production of Cyanotoxins by Black Band Disease Cyanobacteria**

**Laurie RICHARDSON*[1]**, Miroslav GANTAR[1], Jamie MYERS[1], Aaron MILLER[1]

[1]Biological Sciences, Florida International University, Miami, FL

Black band disease (BBD) of corals is a cyanobacterial dominated microbial mat that migrates across coral colonies, killing and lysing coral tissues. While it is known that sulfide, produced by sulfate reducing BBD bacteria, is lethal to coral, inhibition of sulfate reduction in active BBD infections does not stop tissue lysis or disease progression. Therefore, there must be additional toxin(s) produced. Using HPLC/MS we detected the cyanotoxin microcystin in 22 field samples of BBD collected from five coral species on nine reefs of the Florida Keys and Bahamas. Two cyanobacterial cultures isolated from BBD, *Geitlerinema* and *Leptolyngbya* spp., contained microcystin based on HPLC/MS, with toxic activity confirmed using the protein phosphatase inhibition assay. DGGE analysis revealed that the cultured *Geitlerinema* and *Leptolyngbya* strains were present in BBD field samples. HPLC analysis identified the microcystin variants -LY, -LR, -LF, -LW and –RR in the field and laboratory samples. Exposure of coral fragments to purified microcystin resulted in tissue stress, which was exacerbated by co-exposure with sulfide. Cyanobacterial toxicity was further tested on a comparative basis using 10 strains that were isolated from BBD and 10 strains from non-BBD sources on coral reefs, including benthic mat forming cyanobacteria and non-pathogenic cyanobacterial patches on healthy corals. Toxicity was measured using cell extracts and included ELISA, the protein phosphatase inhibition assay, and HPLC. We found toxicity in both BBD and non-BBD strains, with levels that varied from non-detectable to 3.5 ug/g of dry biomass within each group (BBD and non-BBD). The ELISA assay was microcystin and nodularin congener-independent, and discrimination between these two toxins is underway. The variant and relative toxicity of microcystins and other cyanotoxins can be dependent on cyanobacterial physiology and environmental factors, which may play a role in the pathogenicity of BBD.

## 7-27

**Significance Of Immunological Responses in The Black-Spined Sea Urchin, *diadema Antillarum*, To Caribbean-Wide Mass Mortality**

**Gregory BECK*[1]**, Robert MILLER[2], Aaron ADAMS[3], John EBERSOLE[1]

[1]Biology, University of Massachusetts - Boston, Boston, MA, [2]Marine Science Institute, University of California - Santa Barbara, Santa Barbara, CA, [3]Mote Marine Laboratory, Pineland, FL

Mass mortality of the grazer *Diadema antillarum*, probably caused by a water-borne pathogen, was a major factor leading to a phase shift from coral to algal domination of Caribbean reefs. Recovery or restoration of *Diadema* may be critical to reef restoration. Recent initiation of recovery of *Diadema* in St. Croix allows research that addresses basic questions on how recovery/restoration may be influenced by immunological processes. What are the basic features of immunological responses in *Diadema*? How does strength of immune responses in *Diadema* compare to other Caribbean urchins that did not die off (*e.g.*, *Tripneustes ventricosa*, *Echinometra lucunter*, or *Echinometra viridis*)? How does strength of immune response vary among reefs with strong versus weak recovery, large versus small individuals, healthy versus sick/dying individuals?

We used coelomic fluid and coelomocytes (blood cells) extracted from *Diadema* and other urchins from several locations on St. Croix to test humoral immune responses. Coelomocyte concentrations did not differ consistently between *Diadema* and the other urchins. Protein levels in coelomic fluids were higher in *Diadema* than the other urchin species. All urchins released O2-, antimicrobial peptides, and phenoloxidase when stimulated by various agents - with one conspicuous and statistically significant exception: *Diadema* from all locations did not respond as efficiently as other urchins to lipopolysaccharide (a typical component of bacterial cell walls). These results suggest a defect in immune response that is specific to *D. antillarum* and independent of stressors associated with particular environments.

These studies will provide the information required to understand whether a weakened immune system was responsible for the mass mortality, and how much strengthening of immune systems has occurred since. Effective management of a recovery may depend on knowing whether diseases continue to impact *Diadema* population growth due to weak immune responses, and whether an abundant recovered/restored population could experience another die-off.

## 7-28

**Cleaner Shrimp *periclemenes Pedersoni* Reduce Ectoparasite Loads On A Caribbean Reef Fish**

Amber MCCAMMON[1], **Donna NEMETH*[2]**, Paul SIKKEL[3]

[1]Department of Biology, Florida Atlantic University, Boca Raton, FL, [2]Science and Math, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [3]Department of Biology, Centre College, Danville, KY

Reef fish are known to make regular visits to 'cleaning stations', yet the benefit to the fish is not well studied in Caribbean species. *Periclemenes pedersoni* cleaner shrimp associate with the anemone *Bartholomea annulata*, and have been hypothesized to participate in cleaning symbioses. Experiments were conducted in a seminatural environment to determine the effectiveness of these cleaner shrimp at removing parasitic monogeneans trematodes from host reef fish, *Acanthurus coeruleus*. Wild-caught fish were exposed to seawater flow from an open system aquarium exhibit containing high densities of monogenean eggs and larvae (*Neobenedenia*). Fish were assigned to one of two treatments: one giving fish access to cleaner shrimps that also included the anemone *Bartholomea annulata* for cover, and one that included anemones with no shrimps. After 15 days, fish were fresh-water dipped to remove parasites, which were preserved in ethanol and counted under a microscope. Average monogenean loads were 4 times higher on fish without access to cleaners, compared to fish with access to cleaners (monogeneans load per fish averaged 101 vs. 26, respectively, ANOVA $p<0.001$). Ectoparasite size was also significantly smaller on fish that had access to cleaners, compared to those that did not visit cleaner shrimp. These results suggest that anemone-shrimp cleaning stations can play a significant role in the biological control of ectoparasites on Caribbean reef fishes. Through their effect on ectoparasite size, cleaning shrimp could potentially reduce monogenean parasite populations by reducing numbers of larger, more fecund, individuals from the population. Density of shrimp cleaning stations may thus be an important factor to consider in studies of reef 'habitat quality' because of their ability to reduce ectoparasites loads and influence fish health.

## 7-29

**Can the Presence of Disease Signs Explain Levels of Tissue Fragmentation on Colonies of the Genus *Montastraea* spp.?**

**Adán JORDÁN-GARZA*[1]**, Eric JORDÁN-DAHLGREN[1]

[1]Laboratorio de Sistemas Arrecifales Coralinos, Universidad Nacional Autónoma de México, Puerto Morelos, Mexico

A disease is a disruption of the normal structure or function of an organism. On scleractinian corals diseases are diagnosed through signs on the coral tissue with an associated rate of partial mortality. In a coral with low resistance to the pathogen(s), disease progression may result in dead. Otherwise if progression rate is low or halted, the original coral might have been fragmented into smaller colonies (sensu Connell), with reduced fecundity and higher probability of dead by infections or other causes. This study quantified the degree of tissue loss associated to different disease signs in fragmented and non-fragmented corals. On *Montastraea faveolata*, *M. annularis* and *M. cavernosa* permanent marks were laid along the colony edge in order to measure lateral tissue growth or loss. The presence of disease signs on the edge-tissue was recorded and the sign was classified as typical (known to be potentially lethal) or non-typical (might be potentially lethal or harmless). A total of 546 marks on *M. faveolata*, 79 on *M. annularis* and 161 on *M. cavernosa* were followed for a year. Rates of tissue loss depended on the disease sign, time of year and habitat. In general, prevalence of signs and tissue loss was higher on *M. faveolata* (rate of tissue loss -2.44±6.9 mm/y, MEAN±SD, n=382) than on *M. annularis* (-0.52±0.5 mm/y, n=69) and *M. cavernosa* (-0.1±0.8 mm/y, n=96) but colonies of *M. faveolata* with low prevalence of disease signs, showed lower rates (-0.56 ± 1.4 mm/year). A continuous trend of tissue loss, like the one observed during this study, leads to colony shrinkage and fragmentation and a simulation shows that it can have serious effects on populations of this key reef-building corals.

## 7-30

**White Band Syndromes in *Acropora cervicornis* off Broward County, Florida: Transmissibility and Rates of Skeletal Extension and Tissue Loss**

**Abraham SMITH*[1]**, James THOMAS[2]

[1]Oceanographic Center, Nova Southeastern University, Hollywood, FL, [2]Oceanographic Center, Nova Southeastern University, Dania Beach, FL

The high latitude thickets of *Acropora cervicornis* off Broward County flourish despite the presence of natural and anthropogenic impacts. These populations provide a unique study opportunity which stands out against the disease stricken areas of the Florida Keys. This study uses time sequenced photographs to examine how *A. cervicornis* is coping with white band syndrome stressors. Variables being monitored include healthy colony skeletal extension rates, diseased colony skeletal extension rates, and tissue loss. The transmissibility of the white band syndromes is being examined through tissue grafting including healthy controls. Healthy skeletal extension rates rage from 0.3-5.2 mm/month. Diseased skeletal extension rates range from 0.5-4.8 mm/month. Tissue loss from disease signs range from 0.6-4.5 mm/day. Transmission experiments show that not all direct tissue contact results in the transfer of white band syndrome signs. Up to 60% show mild to no disease sign transmission. The *A. cervicornis* thickets in Broward County are growing slower compared to most studies in other areas of the Western Atlantic. Tissue loss is also low compared to other reports. White band syndromes are always present in Broward County, but the low incidence of transmission of the syndromes seems to limit its affect on the thickets.

## 7-31

**Dynamics And Ecological Relevancy Of A Viral Disease in Caribbean Spiny Lobster**

Mark BUTLER[1], **Behringer DONALD*[2]**, Thomas DOLAN[1], Jeffery SHIELDS[3], Robert RATZLAFF[1]

[1]Department of Biological Sciences, Old Dominion University, Norfolk, VA, [2]Department of Fisheries & Aquatic Sciences, University of Florida, Gainesville, FL, [3]Virginia Institute of Marine Science, Glouchester Point, VA

Coral diseases have deservedly garnered much attention, yet ecologically significant diseases also occur among reef-dwelling motile taxa within which disease dynamics may be quite different from corals. In 2000, we discovered a deadly virus (PaV1) that infects Caribbean spiny lobster (Panulirus argus), and we have confirmed infections in Florida, Mexico, Belize, and the US Virgin Islands. PaV1 is the first viral disease known for any species of lobster, and it alters the behavior and ecology of this species in fundamental ways. The prevalence of infection varies with ontogeny, with most infections occurring among the smallest size classes. In Florida, mean prevalence of PaV1 in early benthic juvenile lobsters approaches 25% compared to < 1% in adults. The virus is pathogenic with successful transmission demonstrated via injection of hemolymph from infected donors, ingestion of infected tissue, contact with infected lobsters, and – among the smallest lobsters – over short distances in the water. Decapods that co-occupy dens with lobster (stone crab, Menippi mercenaria; channel clinging crab, Mithrax spinomosissimus; spotted lobster, P. guttatus) do not harbor the virus. Most remarkable is that healthy lobsters, which are normally social, chemically detect and avoid diseased conspecifics prior to their becoming infectious. This behavior along with lethargy in infected lobsters may break the expected density-dependence of infection. Traditional epizootiological models are not applicable in this and presumably other situations because of their dependence on mass-action principals, so we developed a unique spatially-explicit, individual-based model simulating PaV1 dynamics among lobsters in the Florida Keys. We are using the model to examine the: (a) role of risk avoidance behavior in pathogen transmission, (b) effect of fishing on PaV1 transmission, and (c) effect of large-scale degradation of nursery habitat structure on disease dynamics in lobster.

## 7-32

**Blood Parasite Infection Dynamics Of Fish in The Indo-Pacific Region**

**Lynda CURTIS*[1]**, Angela DAVIES[2], Nico SMIT[3], Alexandra GRUTTER[1]

[1]School of Integrative Biology, University of Queensland, Brisbane, Australia, [2]Biomedical and Pharmaceutical Sciences, Kingston University, Kingston, United Kingdom, [3]Department of Zoology, University of Johannesburg, Johannesburg, South Africa

To date there has been little work done on Haemogregarine blood parasites in coral reef fish. Traditionally, haemogregarines have a two host life-cycle with a vertebrate intermediate host and an invertebrate definitive host vector. This study conducted a survey between March 2005 and August 2007 throughout the Indo-Pacific to determine the variability in intensity and prevalence of haemogregarine infections, spatially and temporally. To test whether gnathiid isopods are the vector of blood parasites in coral reef fish transmission experiments were conducted at Lizard Island on the Great Barrier Reef, Australia. Gnathiid isopods, not previously exposed to blood parasites, were allowed to feed on the blood of fish infected with blood parasites. The gut contents of these gnathiid isopods were then examined from one to ten days post-feeding to determine if transmission had taken place. While there were variations in the intensity of the blood parasite infection over time in triggerfish at Lizard Island this was not associated with season. Therefore water temperature does not appear to play a role in the differences detected. There was also a difference in the intensity of the blood parasite infection in the triggerfish sampled at different geographical locations. These variations could be related to the distribution of the potential vector, the gnathiid isopod, at particular sites. We found convincing evidence for the theory that gnathiid isopods are the vector, as various stages of development of the blood parasites were found from four days post feeding in the gnathiid gut contents. This study is the first quantitative investigation into the blood parasites of coral reef fish and will hopefully increase our understanding of coral reef fish blood infections and their impact on host ecology.

## 7-33

**Dynamics Of A Back Band Disease Outbreak At Pelorus Island On The Great Barrier Reef**

**Yui SATO*[1]**, David BOURNE[2], Bette WILLIS[1]

[1]School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]Australian Institute of Marine Scinece, Townsville, Australia

Black band disease (BBD) is challenging the health of reef building corals worldwide and reaching outbreak proportions for the first recorded time at several sites on the Great Barrier Reef (GBR). Although abundance of BBD on the GBR is generally low, long term monitoring of infected coral populations is required to assess the potential consequences of the disease for this reef system. This study examined detailed dynamics of a BBD outbreak in plating *Montipora* species at Pelorus Island, located at approximately 18°33′N, 146°30′E, in the central section of the Great Barrier Reef Marine Park. Individual diseased colonies were tagged and monitored over 2 years within permanent quadrats, each of which was 10m x 10m. Abundance of BBD-infected colonies and linear progression rate of the BBD band across colonies were recorded approximately monthly. Temporal patterns in BBD abundance were striking and tightly correlated with seasonal changes in seawater temperature. Abundance was higher in the Austral summer (15 cases/100m2) than winter (0 case/100m2), and it was stable at low levels during cooler months. Similarly, progression rate of the BBD band was greater in summer (3.0 mm/day) than winter (0.5 mm/day). Temporal patterns in progression rate were positively correlated with seasonal patterns of seawater temperature and light levels. Results suggest that both water temperature and light incidence are environmental drivers of BBD activity. If seawater temperatures continue to rise with global warming, the consequences of BBD for host coral populations is likely to be severe, even in this well-managed coral reef system. Knowledge of seasonal variability of BBD prevalence and environmental drivers is essential to provide accurate assessment of reef health and to develop effective reef management.

## 7-34

**Dynamics Of The Coral Disease White Plague; Insights From A Simulation Model**

**Marilyn BRANDT*[1]**, John MCMANUS[1]

[1]Division of Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami, Miami, FL

Understanding the dynamics of coral diseases among the heterogeneous populations in which they act is critical for determining how the structure of reef communities has changed as a result of enzootic or epizootic levels of these important sources of mortality. This information can also form a basis for predicting the impact of disease in the near future. The work presented here combined field studies with the development and testing of a spatially-explicit, individual-based epizootiological computer model with the aim of providing a useful tool for exploring disease dynamics in reef communities of the past, present and future. This study focused on the disease white plague, a significant source of mortality on reef-building corals in the Caribbean. Field studies focused on the incidence and distribution of all sources of coral mortality, including white plague (type II) *in situ*, at Little Cayman Island (Cayman Islands, British West Indies). Results indicated that white plague was the most significant source of mortality during the monitoring time period, and that it is likely contributing to major structural changes. The simulation model was developed using this data, and results of model calibration indicated that white plague on these reefs is transmissible between colonies within a limited field and requires a yearly input from an outside source, and that host susceptibility to infection is low and likely not variable among species. Parameters describing the distribution and composition of the simulated coral population were then varied, and results showed a significant effect of colony density, aggregation, and mean size on the impact of disease. Scenario testing of various disease management strategies indicated that should local prevention measures be developed in the future, it is they, and not treatment, that will likely be the most effective in limiting the impact of disease.

## 7-35

**Metapopulation Dynamics Of Coral Infectious Disease**

**Susanne SOKOLOW*[1]**, Patrick FOLEY[2], Janet FOLEY[1], Alan HASTINGS[1], Laurie RICHARDSON[3]

[1]University of California Davis, Davis, CA, [2]California State University Sacramento, Sacramento, CA, [3]Florida International University, Miami, FL

Adaptation of epidemiological models to the study of marine diseases represents an underdeveloped field and a research priority for understanding and managing emerging diseases in the world's oceans. Recent evidence suggests that metapopulation models may provide an appropriate framework for modeling coral populations at the regional scale, and we expand this approach to investigate the effects of infectious disease. Some key features that characterize many coral disease systems include: (1) coral reefs are generally patchy, (2) adult coral are predominantly sessile and new recruits represent the main mode of host dispersal to new patches, (3) the pathogens have a hypothesized reservoir which can move widely and independently of the hosts, and (4) environmental factors such as water temperature and seasonality may affect pathogen survival and transmission. Testable predictions emerge when considering coral disease in a metapopulation framework, including thresholds for regional epidemic and endemic disease dynamics. Model results are compared with an original coral disease dataset which spans a decade of patch-level monitoring for white plague type II (WPII) on coral in the Florida Keys, and some qualitative patterns predicted by the model are consistent with empirical evidence. By exploring a mechanistic model with minimal complexity, this research offers preliminary insight for the ecology and epidemiology of coral diseases on reefs, and allows critical evaluation of the long-term effects that disease pressure, environmental change, and management may have on coral health and persistence.

## 7-36

**Applying Medical Geography To Identify Spatial Hotspots Of Coral Diseases**

**Jennifer LENTZ*[1]**, Andrew CURTIS[2,3], Paul SAMMARCO[4], Philippe MAYOR[5]

[1]Oceanography & Coastal Sciences, Louisiana State University, Baton Rouge, LA, [2]Geography, Louisiana State University, Baton Rouge, LA, [3]Geography, University of California, Los Angeles, [4]Louisiana Universities Marine Consortium, Chauvin, LA, [5]Buck Island Reef National Monument, U.S. National Park Service, Christiansted, Virgin Islands (U.S.)

Given the current world-wide decline in coral reef health, it is important to understand those factors contributing to, or directly causing, this decline, so that we can attempt to stabilize our reefs and hopefully restore some of what has been lost. The problem is highly complex, and requires the use of stringent multi-disciplinary analytical techniques. Here, we apply some of the methods of Medical Geography to the problem of coral disease; specifically those used to map and spatially analyze epidemics and general public health concerns to further our understanding of coral reef health. This study compares the results of several spatial analytical techniques applied to the same dataset. We used data regarding white-band diseased (WBD) *Acropora palmata* at Buck Island Reef National Monument, initially presented by Mayor et al's 2006 study. Overall, we found that the Disease Mapping and Analysis Program (DMAP) was the strongest of the spatial analyses performed, resulting in detailed maps of the rates of WBD clustering and Monte Carlo estimated areas of statistically significant ($p<0.05$) and highly significant ($p < 0.01$) WBD clustering. An important difference between DMAP and some of the other methods used was that DMAP utilizes both the WBD (numerator) and underlying *A. palmata* population (denominator) data; while some of the other methods that are based exclusively on the numerator data, such as the Kernel Density Analysis, revealed far less spatial information about WBD. It is our hope that the spatial analyses presented here will provide insight into the spatial nature of WBD and facilitate further epidemiological studies of the disease.

## 7-37

**Developing An Expert System For Predicting Coral Disease Risk On Indo-Pacific Reefs**

**Bette L. WILLIS*[1]**, Scott F. HERON[2], Cathie A. PAGE[3], William J. SKIRVING[2], C. Mark EAKIN[2], C. Drew HARVELL[4], Dean M. JACOBSEN[5], Gregg COLEMAN[6], Ian MILLER[6], Hugh P.A. SWEATMAN[6]

[1]School of Marine and Tropical Biology and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]NOAA Coral Reef Watch, Silver Spring, MD, [3]School of Marine and Tropical Biology and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland, Australia, [4]Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY, [5]College of the Marshall Islands, Majuro, United States Minor Outlying Islands, [6]Australian Institute of Marine Science, Townsville, Queensland, Australia

Coral disease outbreaks represent an emerging risk on Indo-Pacific reefs that is likely to escalate with ocean warming due to climate change. Building on a recent model that links the abundance of coral disease with elevated temperature anomalies and percent cover of coral hosts, we further refine temperature metrics to include both the duration and magnitude of temperature anomalies and to differentiate between the effects of warm versus cool seasonal anomalies on disease risk. Using a 9-year data set of disease records for white syndrome on 48 reefs spanning more than 1000 km along the Great Barrier Reef, we explore patterns in disease abundance with percent coral cover and with deviations from both mean summer and mean winter sea surface temperatures. Analysis showed that each of these factors is necessary but not sufficient to explain patterns in disease abundance. The addition of winter temperature anomalies to the model improved its explanatory power. Disease abundance was greatest in summers following mild winters that deviated by less than 5 °C-weeks from mean winter conditions. We suggest that cold winters may reduce pathogen loads, and consequently the likelihood of disease outbreaks in the following summer. It is less clear why warm winters are correlated with reduced disease abundance, but they may result in enhanced disease resistance of the coral host. Our results indicate that predicting disease risk on Indo-Pacific reefs is complex; nevertheless predictions based on satellite-derived sea surface temperatures can be reasonably accurate, given knowledge of coral cover. With the incorporation of further factors, such as current speed and host susceptibility, our aim is to provide reef managers with an expert system for predicting disease risk on coral reefs.

## 7-38

**A Large Semi-Open Aquarium As A Proxy For Natural Coral Reef Ecosytems: Insights And Implications For The Causes Of Coral Disease**

**Shelley L. ANTHONY*[1]**

[1]Marine and Tropical Biology, James Cook University, Townsville, Australia

Changing water quality parameters of ocean waters have been implicated in the occurrence of some coral diseases, and are an ongoing concern for the future health of coral reefs. However, it is difficult and somewhat haphazard to monitor water quality accurately and continuously in natural reef settings.

The Coral Reef Exhibit (CRE) at Reef HQ Aquarium in Townsville, Australia is the world's largest living coral reef aquarium, containing almost 3,000,000 litres of natural seawater that is open to the atmosphere. The CRE supports thousands of scleractinian and soft coral colonies, as well as other associated reef species, in a semi-closed system that simulates a natural reef environment. This system is constantly monitored for temperature, salinity, pH, alkalinity, dissolved oxygen, turbidity, trace elements, and inorganic nutrients, among others. Additional and potentially complicating factors in coral disease observations - such as snail predation - are easily controlled, making it more efficient to examine the effects of varying conditions on the corals, fish, and other marine organisms.

Analysis of coral mortality data from 1996-2006 in the CRE system clearly shows that White Syndrome is the single leading cause of death for acroporids (the most sensitive group). Extensive water quality records over the same time period were thoroughly examined and compared to mortality data to look for correlations with White Syndrome outbreaks. No significant correlations were apparent for any single water quality parameter, including high temperature. Rather, I suggest that a combination of factors may create a stressful environment, resulting in White Syndrome occurring after a prolonged period. Preliminary evidence also indicates that episodes of poor water circulation are a trigger for tissue sloughing in individual acroporid colonies.

## 7-39

**Ecosystem Function And Disease Resistance in Coral Reefs: What Happens When We Remove Key Players?**

**Laurie RAYMUNDO*[1]**, Aileen MAYPA[2], Andrew HALFORD[1]

[1]University of Guam, Mangilao, Guam, [2]University of Hawaii, Honolulu, HI

The ecological drivers of disease outbreaks are poorly understood. We tested the hypothesis that intact, trophically-diverse marine ecosystems are less likely to sustain disease outbreaks than over-fished systems. Marine Protected Areas (MPAs) are a best practice for managing fish communities, so an additional benefit of this primary tool is a win-win situation for coral reef conservation. This is challenging to test; few MPAs are consistently well-managed so that significant increases in fish diversity can occur. We surveyed 7 reefs containing both an MPA and a fishing ground in the central Philippines for coral disease prevalence and fish taxonomic distinctness. All MPAs had less disease and taxonomic distinctness on par with, or richer than, expected. Conversely, fished reefs contained more disease and fish assemblages of higher variability and lower distinctness. Our findings show that protection from fishing confers protection from disease outbreaks. At present, this is the only option available for managing coral diseases.

## 7-40

**Advancing The Global Coral Disease Database**

**Emily CORCORAN*[1]**, Andy BRUCKNER[2], Nicola BARNARD[3], Michael STRONG[4], Craig MILLS[5]

[1]One Ocean Programme, UNEP-WCMC, Cambridge, United Kingdom, [2]Coral Reef Conservation Program, NOAA, Silverspring, MD, [3]ICRAN, Cambridge, United Kingdom, [4]Informatics, UNEP-WCMC, Cambridge, United Kingdom, [5]Spatial Analysis, UNEP-WCMC, Cambridge, United Kingdom

The Global Coral Disease Database (GCDD) was launched by NOAA and UNEP-WCMC in 2000. Over the last seven years, this partnership has worked to compile and organise published data on the occurrence of coral disease, benefiting managers, scientists and other stakeholders through the provision of the first compilation on the global observations of coral diseases. The database currently contains 7813 data points from 66 countries across the world since 1970, 25% of these data points are observations since 2000.

Whilst excellent advances have been made in developing the GCDD (http://www.unep-wcmc.org/GIS/coraldis/), there exists a need to address the recurrent challenges of quality, accessibility, and completeness of the data, to ensure that this unique GIS tool meets its fulfil potential as a critical global repository for coral reef disease information.

A new twelve-month phase of work will be initiated at ICRS 11 to improve the relevance and importance of the database to users through consultation and a comparative analysis of user needs, information holdings, and data collection. Through partnerships with data collection programmes, and the establishment of an expert advisory group, the project will raise the profile and value of the GCDD to stakeholders, build confidence in the holdings, and provide a mechanism for quality assurance of the data collected. A new visual interface will be demonstrated which will enhance the visibility and functionality of the GCDD with an improved look, feel and progression towards a more sophisticated online analysis. Such analysis would allow ad-hoc spatial querying and analysis, and the manipulation of the coral disease data alongside key biodiversity datasets, such as the World Database on Protected Areas.

## 7-41

**Linking Environmental Factors With Coral Disease Events in The Caribbean**

**Tyler R. L. CHRISTENSEN*[1]**, Scott F. HERON[2], William J. SKIRVING[2], C. Mark EAKIN[2], Bette L. WILLIS[3], C. Drew HARVELL[4], Cathie A. PAGE[3], Peter J. MUMBY[5], Laurie J. H. RAYMUNDO[6], Ernesto WEIL[7], Eric JORDÁN DAHLGREN[8], John F. BRUNO[9], Dwight K. GLEDHILL[1], Alan E. STRONG[2], Jessica A. MORGAN[1], Gang LIU[1]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]NOAA Coral Reef Watch, Silver Spring, MD, [3]James Cook University, Townsville, Australia, [4]Cornell University, Ithaca, NY, [5]University of Exeter, Exeter, United Kingdom, [6]University of Guam, Mangilao, Guam, [7]University of Puerto Rico, Mayaguez, Puerto Rico, [8]Universidad Nacional Autónoma de México, Puerto Morelos, Mexico, [9]University of North Carolina at Chapel Hill, Chapel Hill, NC

Recent evidence indicates that some coral disease outbreaks are linked to occurrences of elevated water temperature, compounding other risk factors such as high coral cover and nutrient enrichment. NOAA's Coral Reef Watch is investigating whether environmental conditions conducive to outbreak events can be predicted using satellite sea-surface temperature (SST) data. With other members of the Coral Reef Targeted Research working groups for Coral Disease and Remote Sensing, we examined the relationship between several novel thermal stress metrics and various disease-related impacts. Previous studies have counted the number of warm SST anomaly occurrences and shown links to disease events. Here we include both warm and cold SST anomalies, and the accumulation of these values; recent extreme anomalies; and accumulations weighted by duration of the anomaly. Increased understanding of the causal factors in coral disease outbreaks will open the door for operational satellite monitoring of disease risk on coral reefs globally.

## 7-42

**Environmental Effects Of Sewage Disposal Practices in Bermuda**

**Ross JONES*[1]**

[1]Bermuda Institute of Ocean Sciences (BIOS), St George's, Bermuda

Coral disease has played a significant role in shaping the present day coral reef communities of Florida and the Caribbean, yet the pathology, etiology and epizootiology of most coral diseases remain poorly understood. In particular, the link between anthropogenic effects, decreased water quality and disease prevalence is not well known. In the wider Caribbean region, domestic wastewater represents the largest point source contributor (by volume) of land-based point sources of marine pollution. The disposal of raw or improperly treated sewage can introduce suspended solids, excessive nutrients, industrial chemicals, pharmaceutically active compounds, personal care products and potential pathogens into the marine environment. In Bermuda, about 2.5 million litres of untreated sewage (about 15% of the sewage generated daily) is disposed of at a single outfall located on a sandy bottom 300 m away from the nearest reefs of the main terrace. A Remotely Operated Vehicles (ROV) was used in addition to Acoustic Doppler Current Profiler (ADCP) and drogue tracking studies to examine and characterize the flow dynamics around the outfall, and select study reefs that are regularly inundated with sewage. Video-surveys were used to quantify benthic cover and species compostion on sewage-exposed and more remote (control) reefs, and reefs in different physiographic reef zones (i.e. lagoonal patch reefs, outer rim reefs etc). Black Band Disease (BBD) and White Plague Type II (WP) in the dominant reef building coral species was also quantified at multiple locations across the platform including those close to, and distant from, the sewage outfall. Overall, there is little or no evidence to suggest any environmental effect on the reefs - in terms of changes in species composition and abundance or coral disease prevalence - caused by the nearby release of millions of litres per day of untreated sewage over the past decade.

## 7-43

**Effects of Fishing and Macroalgae on Coral Disease Dynamics**

**John BRUNO*[1]**, Ivana VU[1], Ernesto WEIL[2], Hugh SWEATMAN[3]

[1]UNC Chapel Hill, Chapel Hill, NC, [2]University of Puerto Rico, La Parguera, Puerto Rico, [3]Australian Institute of Marine Science, Townsville, Australia

Outbreaks of infectious and non-infectious (e.g., bleaching) coral diseases are the primary cause of recent coral losses around the world. There are several potential explanations for the widely observed increase in the severity and frequency of coral epizootics. For example, there is evidence that nutrient enrichment and anomalously high ocean temperature can increase within- and among-colony disease spread rates. Another widely discussed explanation is that decades of overfishing have disrupted the balance of coral reef ecosystems, making them more susceptible to disease outbreaks and other disturbances. More specifically, the removal of herbivores has led to increases in benthic macroalgae that could promote disease outbreaks either by acting as pathogen reservoirs or vectors or by increasing the concentration of Dissolved Organic Carbon. We performed a series of field manipulations in Puerto Rico to test the hypothesis that fishing and macroalgae affect the severity of Caribbean yellow band disease of Montastraea faveolata. The results from all three experiments indicate that macroalge has no effect on yellow band disease prevalence or incidence. In a second case study, we performed a longitudinal epidemiological analysis on the effects of macroalgae, fish density, and ocean temperature on outbreaks of white syndrome across the Great Barrier Reef from 1996 through 2006. Even after accounting for the effect of coral cover, macroalgal cover was strongly negatively related to white syndrome frequency. There was a clear threshold of macroalgal cover of roughly 5%, above which outbreaks never occurred. Thus macroalgae or some factor or process related to macroalgal cover (e.g., grazer density, identity or behavior), may protect coral populations and communities from disease outbreaks. Our results indicate that macroalgae are not the cause of coral disease outbreaks and coral losses and that coral epizootics cannot be effectively controlled with local fisheries management designed to limit algal biomass.

## 7-44

**Temperature-dependent Induction of Virulence Factors in the Coral Pathogen *Vibrio coralliilyticus***

**Nikole E. KIMES*[1,2]**, Lisa KILPATRICK[2,3], Pamela J. MORRIS[1,2]

[1]Marine Biomedicine and Environmental Sciences, Medical University of South Carolina, Charleston, SC, [2]Hollings Marine Laboratory, Charleston, SC, [3]National Institute of Standards & Technology (NIST), Charleston, SC

Coral ecosystems have experienced unprecedented declines due in part to the increased emergence and frequency of diseases throughout the Caribbean region. Increasing ocean temperatures is one of the contributing factors thought to be driving this phenomenon. It is well established that warmer temperatures can increase the abundance and virulence of some pathogens, including water-born *Vibrio* spp. *Vibrio coralliilyticus*, is a temperature-dependent coral pathogen first isolated from the Red Sea and the Indian Ocean. This Gram-negative bacterium has been shown to infect the coral *Pocillopora damicornis* when temperatures reach above 24.5°C, resulting in coral bleaching and lyses. While a previous study correlates increased protease activity with *V. coralliilyticus'* increased virulence when water temperatures rise to 26°C or above**,** we hypothesize that a broader temperature-dependent induction of multiple virulence factors is the mechanism underlying *V. coralliilyticus*' virulence. This study used two-dimensional liquid chromatography coupled with tandem mass spectrometry (2D-LC-MS/MS) to identify proteins produced by *V.coralliilyticus* grown at 24°C and 27°C. We identified 523 proteins expressed by *V. coralliilyticus* at 24°C and 839 proteins expressed at 27°C. Of those proteins, 504 were produced at both growth temperatures; whereas, 19 and 335 proteins were unique to the 24°C and 27°C growth conditions respectively. Additionally, we identified 37 possible virulence factors unique to 27°C, while identifying only two unique virulence factors at 24°C. Our results provide sufficient evidence to conclude that *V. coralliilyticus* cultivated at the higher temperature (27°C) produces more proteins, including known virulence factors, compared to cultivation at the lower temperature (24°C). Recent climate change predictions calling for increases in ocean temperatures and research studies indicating increased observations of infectious diseases in marine ecosystems enhance the significance of this study.

## 7-45

**The Effect Of Sediment And Heat Stress On The Initiation And Spread Of Black Band Disease**

**Aaron MILLER*[1]**, Laurie RICHARDSON[1]

[1]Biology, Florida International University, Miami, FL

Experiments were conducted to determine the effects of heat and sediment stress on the properties of mucus from the coral *Montastraea cavernosa*, and how this relates to the initiation and spread of black band disease (BBD). Three fragments of *M. cavernosa* were placed into each of four treatments: a control (26°C, no sediment), heat stress (30°C, no sediment), sediment stress (26°C, twice daily 150mg/cm$^2$ sediment loading), and a combination of the two stressors (30°C, plus sediment loading). After the three-week experimental period, mucus was collected from each fragment to determine the number of cyanobacterial filaments isolated from BBD (two strains) that adhere to the mucus after one hour. At the end of the experiment, fragments were inoculated with fresh BBD, and were observed for eight days.

There was a significantly greater number of cyanobacteria adhering to the heat stressed mucus than to the controls, while the other treatments did not differ significantly. The control corals showed little spread of the BBD consortium eight days after inoculation. Those fragments exposed to heat stress had complete coverage of the fragment by a biofilm of the BBD microbial consortium within the eight days. In the sediment stressed corals and corals exposed to the combination of stressors there was progressive skeletal exposure (tissue lysis) associated with a very thin line of BBD which was more pronounced with the combination of sediment and heat stress. After the eight day observation period, the control fragments were then placed into the 30°C treatment, and observed for an additional six days. The consortium started to spread in 2/3 of the fragments only after day four. These results indicate that the environmental stressors cause the host coral *M. cavernosa* to be more susceptible to BBD infection.

## 7-46

**Temporal Dynamics Of The Ongoing Caribbean Yellow Band Epizootic Event: Potential Link To Increasing Water Temperatures.**

**Ernesto WEIL*[1]**

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Geographic and local epizootic events affecting corals, octocorals, sponges and other reef organisms have become more frequent and damaging. Two of these events affecting acroporid corals and the urchin Diadema antillarum produced substantial ecological changes in coral reefs throughout the Caribbean in the 1980's. However, the ongoing epizootic event of Caribbean Yellow Band Disease (YBD) could be the most devastating yet. This disease is rapidly killing colonies of three of the four Montastraea species, the most important reef building genus in the region. Eight years of data and observations throughout the region indicate that YBD (1) is present in almost every single coral reef throughout the region, (2) prevalence have increased significantly in most reefs with higher numbers of infected M. faveolata (20-65%) and M. franksi (2-35%) colonies, (3) YBD significantly decreases colony reproductive output (fecundity) and therefore, the potential for recovery, (4) has produced significant coral cover loss (up to 45%) and killed very old (>1000 y) colonies in a relative short time, and (5) etiology has changed through time: a- from a seasonal, sporadic problem to a perseverant, year-long, common affection, b- band advance rates (mortality rates) have increased significantly from 0.7 to 4 cm/month, c- increase in the number of lesions per colony (up to 36), and d- lesion signs (bands) are wider, more white (less zooxanthellae?) with new wide yellow tissue areas now common in most colonies. Most of these changes seem to be correlated with increased monthly average minimum sea water temperature and/or might reflect the disease dynamics over time or epizootic dynamics in high density populations. YBD is today the worst threat to Caribbean coral reefs.

Keywords: Caribbean, Yellow Band Disease,threat epizootic, disease dynamics

## 7-47

**Coral Diseases After The 2005 Caribbean Bleaching Event: Did Prevalence Increased Accordingly With Bleaching Severity?**

**Aldo CROQUER*[1]**, Ernesto WEIL[2]

[1]Biologia de Organismos, Simon Bolivar University, Caracas, Venezuela, [2]Marine Sciences, University of Puerto Rico, La Parguera, Puerto Rico

In the GBR temperature anomalies are correlated with coral diseases, but in the Caribbean, this hypothesis remains controversial. In 2005, a bleaching event affected corals throughout the region but mostly in the eastern and northern areas. Surveys were conducted over permanent belt-transects along a latitudinal gradient from Bermuda to Grenada where bleaching severity (i.e. percentage of corals affected) varied significantly. Surveys were done again in 2006 to test the hypothesis that localities with higher bleaching prevalence in 2005 will show a significat increase in disease prevalence. A 3-way ANOVA with site and depth as crossed and fixed factors and time as a repeated measure, was performed for bleaching and the overall prevalence of coral disease. To look at which specific diseases explained differences between particular sites and depths between years, a one-way ANOSIM and SIMPER analyses were used. Bleaching prevalence significantly decreased by the summer of 2006 at all sites and depth intervals. There was a significant interaction between reef sites, depth and years with significant reductions in the prevalence of coral diseases in 2006 in all sites and depths except in Flamingo Bay (Grenada) where yellow band disease (YBD) prevalence at intermediate and deep habitats significantly increased. All other diseases significantly decreased in 2006 at all sites and depths that had different bleaching levels in 2005. While sites with low bleaching prevalence in 2005 (i.e. Curacao and Bermuda) had less diseases compared to sites where bleaching was more severe (Grenada and Puerto Rico), in 2006 all sites and depths (except deeper and intermediate habitats in Flamingo) experienced a significant reduction in the prevalence of coral diseases regardless of bleaching severity. Thus, our results partly support the hypothesis of coral bleaching as a factor promoting coral epizootics.

## 7-48

**Testing the compromised-host hypothesis during the 2005 Caribbean coral-bleaching and disease event**

**Erinn MULLER*[1]**, Caroline ROGERS[2], Jeff MILLER[3], Robert VAN WOESIK[1]

[1]Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL, [2]United States Geological Survey, St. John, Virgin Islands (U.S.), [3]South Florida/Caribbean Network, National Park Service, St. John, Virgin Islands (U.S.)

Anomalously high-water temperatures can increase coral-disease prevalence by either influencing pathogen concentrations or virulence, or by increasing host susceptibility through bleaching. The 2005 Caribbean coral-bleaching event provided the opportunity to test the compromised-host hypothesis on two species in the US Virgin Islands. At Hawksnest Bay, from 2004-2007, 60 randomly selected *Acropora palmata* colonies were examined monthly for bleaching, disease prevalence, and disease-associated mortality. Also, the number of disease-induced lesions was examined in 20, 2 m by 10 m belt transects, in five *Montastraea* spp.-dominated reefs, from 2005-2007. The prevalence of disease on both bleached and unbleached *A. palmata* colonies was positively related with water temperature; however, bleached *A. palmata* colonies suffered greater disease-associated mortality than unbleached colonies. By November 2005, >98% of the *Montastraea* spp. had bleached, and within five months disease incidence had increased 51 fold. The lack of unbleached *Montastraea* prohibited a comparison between bleached and unbleached colonies, however, disease incidence returned to pre-bleaching conditions once colonies partially recovered (July 2006). These studies indicate disease prevalence and severity increases when colonies bleach, at least for *A. palmata* and *Montastraea* spp., supporting the compromised-host hypothesis.

## 7-49

**The Role Of Injury And Temperature in The Initiation And Prevalence Of The Coral Disease, Skeletal Eroding Band**

**Cathie A PAGE*[1,2]**, Bette L WILLIS[1,2]

[1]ARC Centre of Excellence for Coral Reef Studies, Townsville, Australia, [2]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

Skeletal eroding band (SEB) is the most prevalent coral disease on the Great Barrier Reef (GBR) and affects a greater range of host species than any other coral disease globally to date, yet little is known about its etiology or the environmental factors influencing its prevalence. In this study, both field surveys and experimental studies indicate that warm temperatures enhance the prevalence of SEB. Prevalence was greatest in summer in seasonal disease surveys between 2002-2007 in the northern GBR, supporting a link between warm temperatures and disease prevalence. Moreover, enhanced prevalence when temperatures were greater than summer seasonal means suggests that elevated summer water temperatures drive increases in SEB. This hypothesis is supported by evidence from artificial injury experiments designed to test the role of injury and temperature in the initiation of this disease. Colonisation of injuries by *Halofolliculina corallasia,* the putative pathogen of SEB, was significantly greater on corals maintained in aquaria at 30°C than on those maintained at both 24°C and 27°C. However, summer water temperatures in the northern GBR were not always sufficiently high to enhance ciliate colonisation rates in field experiments. Moreover, ciliates failed to form migrating disease bands accompanied by tissue lysing on any of three coral species tested experimentally, irrespective of water temperature, suggesting that although *H. corallasia* is an early coloniser of recently exposed coral skeleton, it may not be the causative agent of tissue loss. Alternatively, interactions with additional environmental or microbial agents may be required before ciliates become pathogenic. When migrating bands of *H. corallasia* were present, they were however associated with whole colony mortality as well as reduced growth and reproductive output in acroporid colonies in the northern GBR.

## 7-50

**A Disease Outbreak On A Healthy Reef: A Mechanism For Recruitment And Increased Diversity**

**Kathryn ROSELL*[1]**, Laurie RAYMUNDO[2]

[1]Silliman University, Dumaguete, Philippines, [2]University of Guam, Mangilao, Guam

In the Philippines, coral disease outbreaks and impacts to reefs over time have been poorly documented. Here, we present data from a year-long monitoring of an outbreak of Black Band Disease (BBD) in the Marine Protected Area of Apo Island, Negros Oriental. In June 2006, four large colonies of *Echinopora lamellosa* with an average mean diameter of 8.4 ± 5.9 m were observed with multiple Black Band lesions. These colonies were marked, and all other *E. lamellosa* colonies within a 50 m radius from this original reef area were located, mapped and examined for lesions. Disease progression on marked colonies was monitored for one year and other potential hosts were examined periodically. Three of the four original *Echinopora* colonies showed 90-95% mortality at 12 mo, and no other colonies had developed signs of disease. At 12 mo, a large lesion was observed on a nearby colony of *Coeloseris mayeri,* progression was rapid and the colony died within a month later. Therefore, this particular infection showed rapid progression and high mortality limited to very few colonies, in spite of the proximity of other potential hosts. At present, BBD is still progressing on the remaining tissues of the colonies. The exposed skeleton of the dead *E. lamellosa* colonies has begun to show signs of recovery via regrowth of small remaining patches of healthy tissue and via coral recruitment. Disease outbreaks are often catastrophic, resulting in widespread mortality of reef-building corals. However, our observations describe an episode of Black Band Disease in a marine reserve which greatly impacted very few colonies has opened up new substrates for recruitment. We speculate that such an epidemiological pattern may reflect the behavior of a disease on a relatively unimpacted reef and can act as a mechanism for opening up new substrate for recruitment.

## 8-1

**From Bacterial Bleaching To The Hologenome Theory Of Evolution**

Eugene ROSENBERG[1], **Eugene ROSENBERG*[2]**

[1]Mol. Microbiology & Biotechnology, Tel Aviv University, Ramat Aviv, Israel, [2]Mol Microbiol & Biotechnology, Tel Aviv University, Ramat Aviv, Israel

In 1995 we demonstrated that Vibrio shiloi was the causative agent of bleaching the coral Oculina patagonica. Subsequently, it was shown that Vibrio coralliilyticus was responsible for bleaching the coral Pocillopora damicornis in the Indian Ocean and Red Sea. From 1996 to 2002 we studied the infection of O. patagonica by V. shiloi both in the field and laboratory and reported that the pathogen is chemotactic to the coral mucus, adheres to a galactose-containing receptor on the coral surface, and penetrates into the exoderm where it differentiates into the VBNC state, multiplies intracellularly and produces a peptide photosynthesis inhibitor. The marine fireworm Hermodice carunculata is a winter reservoir and spring-summer vector for transmitting the bleaching disease. Starting in 2003, we observed that O. patagonica developed resistance to V. shiloi. Healthy corals taken from the sea could no longer be infected with the pathogen, and V. shiloi could no longer be isolated from corals. When we inoculated corals with V. shiloi, the bacteria adhered, penetrated and then were killed, aborting the infection. To explain these findings we presented the coral probiotic hypothesis, which posits that the corals acquired bacteria in their mucus and/or tissues that can kill V. shiloi. We now generalize from this hypothesis and present the hologenome theory of evolution-the role of symbiotic microorganisms in the evolution of animals and plants.

## 8-2

**Tools For Investigating Nutrient And Signal Exchange Between Corals And Their Associated Microbes**

**Max TEPLITSKI*[1]**, Kim RITCHIE[2], Mengsheng GAO[1], Cory KREDIET[3], Stephanie HALBIG[4], Ali AL AGELY[4]

[1]Soil and Water Science, University of Florida, Gainesville, FL, [2]Mote Marine Laboratory, Sarasota, FL, [3]Interdisciplinary Ecology, University of Florida, Gainesville, FL, [4]University of Florida, Gainesville, FL

The stability of symbioses depends on precisely timed signal exchange among symbiotic partners. To contribute to the development of tools for investigating interactions between corals and associated microbes we 1) developed assays to identify components of Acropora palmata mucus, 2) optimized reporters for identifying bacterial quorum sensing signals and their inhibitors, and 3) developed a broad host range plasmid-reporter for quantifying gene expression in vivo. Because induction of lytic enzymes depends on the availability of a substrate, the identification of enzymatic activity indicates presence of the corresponding substrates and bonds in a complex mixture (such as coral mucus). Incubation of Serratia marcescens with A. palmata mucus resulted in the differential activities of N-acetyl-b-D-galactosaminidase, a-D-galactopyranosidase, b-D-galactopyranosidase, a-D-glucopyranosidase, a-L-arabinopyranosidase, and a-L-fucopyranosidase. These data provide hints about the structure of coral mucus and offer an opportunity to investigate dynamics of coral mucus colonization by pathogens and symbionts. Many symbioses between bacteria and their eukaryotic hosts require a bacterial cell-to-cell communication system called "quorum sensing" (QS). Libraries of coral-associated bacteria were screened for their ability to activate or inhibit bacterial QS reporters. Activities that induced or inhibited QS receptor-based reporters were detected. These observations suggest QS signals, antagonists, or other inhibitory molecules, are present. Since little is known about in situ interactions between bacteria and coral/algal hosts, a portable RIVET (recombinase-based in vivo expression technology) reporter plasmid was developed. RIVET can be used to document and quantify bacterial gene expression in ecological niches that are un-accessible to other common reporter systems.

## 8-3

**Regulation Of Quorum Sensing By Gorgonian Corals: Stimulation And Antagonism**

**Laura HUNT*[1]**, Kelsey DOWNUM[1], Laura MYDLARZ[1]

[1]Biology, University of Texas at Arlington, Arlington, TX

Gorgonian corals synthesize many novel secondary metabolites that may mediate coral-bacterial interactions. One mechanism of control may be to regulate prokaryotic cell-to-cell communication, known as quorum sensing (QS). Many bacteria use QS signals to facilitate colonization of higher organisms. In the present study, we are examining extracts of various healthy gorgonian corals, from the Caribbean for QS regulatory activity, using a specific *Pseudomonas aeruginosa* JP2 QS-*gfp* biosensor system sensitive to long chain acyl homoserine lactones (AHL). Preliminary results using lipid-based extracts of a subsample of our gorgonian collection (*Plexaura flexuosa, Briareum sp., Pseudoplexaura sp.,* and *Eunicea laciniata*) showed a range of activity. *Briareum* and *P.flexuosa* ethanol extracts had the most potent inhibitory effect on QS, with a 90% and 80% reduction in signal respectively. Less pronounced effects (20% signal reduction) were observed with *E.laciniata* extracts. All of these extracts showed a dose-response effect. Interestingly, *Pseudoplexaura* ethanol extracts stimulated QS activity in the absence of AHL with a striking 10-fold increase in signal over background fluorescence. The stimulation of QS by *Pseudoplexaura* or other elements of the holobiont, may encourage colonization or recruitment of specific microbial species. Active coral extracts will be further tested for specific processes controlled by QS that are relevant to the marine environment, such as biofilm formation. The presence of stimulatory and inhibitory compounds, in corals, may indicate ongoing crosstalk between the coral-prokaryotic boundary and interspecies bacterial communication. Overall this has potential implications for microbial ecology and host-pathogen interactions.

## 8-4

**The Host As A Habitat Divided**

**Nathan D. OLSON*[1]**, Tracy AINSWORTH[2], Mali'o KODIS[1], Ruth D. GATES[3], Misaki TAKABAYASHI[1]

[1]Marine Science, University of Hawaii at Hilo, Hilo, HI, [2]University of Queensland, Brisbane, Australia, [3]Hawaii Institute of Marine Biology, Kane`ohe, HI

Scleractinian corals are now viewed as complex holobiont systems comprising the animal host and a consortium of microbial symbionts. This conceptual shift has led us to consider the coral host as a habitat. When viewed as a habitat, the coral can be subdivided into three compartments or interacting systems; the endolith, tissue, and mucus. Microbes in these compartments are speculated to be linked to the rest of the holobiont community through nitrogen interdependency. In order to assess the identity and potential roles of symbiotic microbes in the nitrogen cycle of the coral holobiont, we examined the microbes present in each of these three compartments of Hawaiian corals of genus *Montipora*. The prevalence of endolithic fungi in *Montipora capitata* was analyzed across an environmental gradient present in Kaneohe Bay through the use of culturing techniques. The results indicate a mean prevalence of 75% (n = 120) with no statistically significant difference in prevalence at sites that cross the gradient. The mean prevalence of endolithic fungi is higher in Kaneohe Bay, Hawaii than reported for other reef systems. Within the coral tissue compartment, *nif*H sequence data obtained from *M. capitata* tissue indicates the presence of bacteria capable of nitrogen fixation belonging to the taxa *Vibrio*. Fluorescent *in situ* hybridization of tissue sections of *M. capitata* using probes specific to the bacterial genus *Vibrio* revealed that the bacteria are localized within the coral epidermal tissue layer. Lastly, the diversity of microbial ribotypes present in the mucus of *M. patula* was analyzed using molecular approaches. Collectively, these data contribute a more thorough characterization of the complexity of microbial communities in corals and allow for the generation of hypotheses regarding the role of each microbial member in the nitrogen cycling within the coral holobiont.

## 8-5

**Biofilms: Coral Surface Mucus Layers, Settlers And Their Bacterial Inhabitants**

**Reia GUPPY*[1]**, John BYTHELL[1]

[1]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom

There is growing evidence that the surface mucus layer (SML) bacterial community on corals is deterministic. However, although this community appears to be quite different from the one in the water column, all surfaces support a distinct community to the water column and the extent to which the SML bacterial community is 'cultured' by its host and/or represents a settler community has not been greatly explored. An initial assessment of the 16S rRNA gene bacterial diversity of coral SML taken from five species of coral (*Montastraea faveolata, Diploria strigosa, Goniastrea aspera, Acropora aspera,* and *Porites lutea*) and biofilms developing on glass plates was conducted using a combination of gel profiling and sequencing techniques. Species differences were observed, and non-metric multidimensional scaling (nMDS) of DGGE fingerprints suggested that some overlap exists (~30 %) between the coral SML and biofilm surfaces, but sequencing and ARDRA techniques suggest otherwise (~10%). The presence in the coral SML and not the glass biofilm of several bacterial ribosomal sequences from bacteria that inhabit mucus layers of other organisms also point to a mucus-specific bacterial community rather than passive settlement from the water column.

## 8-6

**Visualising The Coral Surface Mucus Layer**

**John BYTHELL*[1]**, Reia GUPPY[1], Amita JATKAR[1], Barbara BROWN[1], Nick MORRIS[2], Jeff PEARSON[3]

[1]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]School of Biomedical Sciences, Newcastle University, Newcastle upon Tyne, United Kingdom, [3]Institute for Cell and Molecular Biosciences, Newcastle University, Newcastle upon Tyne, United Kingdom

The coral surface mucus layer (SML) plays a number of roles in the biology of reef corals including ciliary-mucus transport and protection from desiccation, pollutants and microbial invasion. Importance of the SML is demonstrated by the fact that the coral invests such a substantial proportion of its carbon and nitrogen budget into mucus production. Recent work also indicates that while there are variations in depth, a mucus layer is continuously present on the coral surface, suggesting that protection is one of the key roles. While there have been numerous studies investigating coral mucus, all of these have used artificial collection techniques or histological techniques that do not preserve the in situ mucus layer in its native state. This is particularly important for understanding the spatial structure and dynamics of microbial communities of the SML. Here we report novel techniques for the preservation and analysis of the SML.

## 8-7

**Bacteria-Bacteria Antagonism Within The Coral Surface Mucus Layer**

**Jessica WARD*[1]**, Farooq AZAM[1]

[1]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla, CA

The discovery of high prokaryote diversity associated with scleractinian corals and consistent associations between coral species and certain bacteria suggest that bacteria may form close associations with corals, including symbioses. One hypothesized role of coral-associated bacteria is disease resistance. Coral-associated bacteria may interact with each other and with 'non-native' bacteria to influence the ability of potential pathogens to colonize and/or proliferate within the mucus layer. Here we test the hypothesis that bacteria-bacteria antagonism occurs among coral-associated bacteria and between coral-associated bacteria and potential pathogens. We further test the effects of temperature on these interactions. Bacteria were isolated from the surface of healthy Montastrea annularis collected in the Florida Keys, USA and 69 were tested for antagonism using Burkholder agar diffusion assays. Of the tested isolates, 47.8% of isolates tested were antagonistic against at least one other isolate. Temperature exerted variable effects on antagonism – 32 isolates were more susceptible to antagonism at 25°C than at 31°C while 12 were more susceptible at 31°C than at 25°C. Three of the isolates obtained from the healthy coral are potential coral pathogens including *Thalassomonas loyana*, a proteobacterium associated with black band disease, and *Vibrio coralliilyticus*. Bacteria-bacteria antagonism may be an important structuring force, both in terms of diversity and spatial structure, within the coral mucus layer. The presence of potential pathogens on apparently healthy coral coupled with our observation that many isolates are antagonistic suggests that antagonistic interactions among bacteria within the community may be an important factor in keeping potential pathogens at bay.

## 8-8

**Potential For Transport Of Bacteria Between Fish Farms And Coral Reefs**

**Melissa GARREN*[1]**, Steven SMRIGA[1], Farooq AZAM[1]

[1]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla, CA

To better understand the interactions between a coral and its associated microbial community, it is useful to examine the microbial environment in which the holobiont exists. Coastal coral reefs are under pressure from many environmental stressors, one of which is pollution. Fish farming is a growing industry that can create point sources of pollution directly on or adjacent to coral reefs. To understand how the presence of fish farms influences coral-microbe interactions, we examined the relationship among a milkfish (*Chanos chanos*) farm, water quality, microbial communities, and coral reefs in Bolinao, The Philippines. We found steep gradients in the concentrations of dissolved organic carbon (70-160µM), total dissolved nitrogen (7-40µM), chlorophyll *a* (phytoplankton biomass proxy; .25-10µg/l), particulate matter (106-832µg/l), bacteria (5x105-1x106 cells/ml), and viruses (1-7x107/ml) that correlate with distance from the fish farms. Dominant members of the microbial communities found on corals, as determined by denaturing gradient gel electrophoresis (DGGE) of 16S rRNA genes, were distinct from the dominant members of the water column community. However, we also observed rare phylotypes (not detected by DGGE) from the water column community using culturing and isolation techniques. Some of these rare water column phylotypes (belonging to the orders alteromonadales and vibrionales) isolated from the fish pens were dominant community members on healthy corals as far as 10km away from the pens. Thus, while corals may exclude many water column microbes from their surfaces, some bacteria phylotypes, present at undetectable levels in the water column by DGGE analysis, may be associated with corals. Fish farms and other point sources of pollution may introduce bacteria to the water column that have the potential to associate with and become abundant on corals. Our study raises the question whether these bacteria may alter the 'normal' coral microbial community, and whether such changes might have important ecological effects.

## 8-9

**Milkfish Feces Share Common Bacteria With Coral Holobiont**

**Steven SMRIGA*[1,2]**, Melissa GARREN[1,2], Farooq AZAM[1]

[1]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla, CA, [2]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla

Effluent from intensive milkfish (*Chanos chanos*) aquaculture is among several environmental stressors that may impact coral reefs near Bolinao, Pangasinan, Philippines. Fish feces are part of this effluent, and since the effects of effluents on coral-associated microbial communities may provide a mechanistic link between fish farms and coral reefs, it is of interest to consider the potential effects of fish feces on corals. We hypothesized that distinct bacterial groups found in fish feces can also be found on corals. Feces were collected from the distal intestines of milkfish, bacterial isolates were obtained from water samples, and coral tissue slurries were collected from diverse coral genera along a quantifiable gradient of effluent. Community 16S rDNA gene profiles from feces were dominated by *Vibrio sp*., while profiles from each of four coral samples were considerably more diverse. Despite these differences, some 16S rDNA genes from feces and corals were >99% similar including *Ralstonia sp.* and *Acinetobacter sp.*. Furthermore, some *Vibrio sp.* sequences were >99% similar among feces, corals, and isolated bacteria. The findings suggest that among these diverse sample types, specific microenvironments may select for the same microbial phylotypes. Alternatively, fish feces may select for specific microbial phylotypes that are then transported into coral ecosystems via water effluents and introduced into the coral holobiont. Fish feces should be considered within conceptual and experimental approaches that address coral-microbial interactions, including those that address coral disease.

## 8-10

**Functional Change in Microbial Communities On Four Coral Atolls**

**Elizabeth DINSDALE*[1]**, Olga PANTOS[2], Robert EDWARDS[3], Steven SMRIGA[4], Florent ANGLY[3], Dana HALL[3], Linda WEGLEY[3], Enric SALA[4], Stuart SANDIN[4], Rebecca VEGA THURBER[3], Bette WILLIS[5], Farooq AZAM[4], Nancy KNOWLTON[4], Forest ROHWER[3]

[1]Biology Department, San Diego State University, San Diego, CA, [2]University of Queensland, Brisbane, Australia, [3]San Diego State University, San Diego, CA, [4]Scripps Institution of Oceanography, San Diego, CA, [5]James Cook University, Townsville, Australia

Replacement of corals by algae is a reoccurring trend on today's coral reefs. The role of microbes in these phase shifts is unknown. Microbial communities were quantified in the water column across four coral atolls displaying different levels of coral cover, using metagenomic, microscopic, and culturing techniques. A 10-fold increase in abundance of virus-like particles, Bacteria, and Archaea and a doubling of the number of protists in the overlying waters occurred from the coral reefs with the highest coral cover to the coral reefs with the lowest coral cover. The metagenomic taxonomic analysis showed that Bacteria and Archaea changed from a balanced community of autotrophs and heterotrophs to a predominantly heterotrophic community where coral cover was low. On the coral reefs with the lowest coral cover the heterotrophic microbes were dominated by potentially pathogenic strains. The relative proportions of the functional genes on each atoll confirmed the non-linear change in the microbial community. On the coral reef with the highest coral cover, the proportion of genes associated with photosynthesis was 3.4 %; they increased to 44.3 % on the coral reef with a moderate coral cover; and decreased to only 0.3 % on the reef with the lowest coral cover. In contrast, genes associated with carbon utilization comprised 24 % on the impacted reef. Where coral cover was high, microbial numbers were low and metabolically providing a diverse range of functions, including photosynthesis and nutrient recycling. Conversely, where coral cover was low, microbial numbers were high and restricted to functions that focused on consuming carbon and nutrients. Corals that remain alive on algae dominated reefs are bathed in water that contains high numbers of heterotrophic microbes. Not surprisingly the health of many of these remaining corals was compromised.

## 8-11

**Exploring Bacterial Community Dynamics in Early Life Stages Of The Caribbean Corals *porites Astreoides* And *montastrea Faveolata***

**Koty SHARP*[1]**

[1]Smithsonian Marine Station, Fort Pierce, FL

Like other marine invertebrates, scleractinian corals have been shown to harbor diverse assemblages of microbes, but neither the specificity of these associations nor the mechanisms that maintain them across host generations is well understood. Bacterial communities in planula larvae of the Caribbean coral *Porites astreoides* were characterized in this study. Molecular techniques were used to identify bacteria associated with *P. astreoides* larvae, and sequence-specific oligonucleotide primers were designed to survey multiple samples for the presence of particular bacterial species. Fluorescence in situ hybridization (FISH) and microscopy revealed the presence of particular localizations of specific bacteria within the larvae, and the relative abundance of various groups of bacteria in the larvae was estimated. In contrast, gamete bundles from the mass-spawning corals *Montastrea spp.* and *Acropora spp.* did not contain bacteria or archaea. Molecular analysis on post-settlement stages of *M. faveolata* was used to characterize the bacterial communities present in juvenile feeding polyps. This study reveals new insights into mechanisms by which microbial assemblages associated with corals are maintained and regulated during host embryogenesis and early development. In addition, these results present the possibility for a bacterial role in larval ecology of some coral species.

## 8-12

**Dom Assimilation By A Coral Reef Sponge And Its Associated Prokaryotes: A Carbon Isotope Tracer Study**

Jasper DE GOEIJ[1,2], Leon MOODLEY[3], Nestor CARBALLEIRA[4], **Fleur VAN DUYL*[1,5]**

[1]Royal Netherlands Institute for Sea Research, Den Burg, Netherlands, [2]The Carmabi Foundation, Curacao, Netherlands Antilles, [3]Netherlands Institute of Ecology, Yerseke, Netherlands, [4]University of Puerto Rico, San Juan, Puerto Rico, [5]Royal Netherlands Institute for Sea Research, Texel, Netherlands

We studied the dissolved organic matter (DOM) assimilation by the common encrusting coral reef sponge *Halisarca caerulea*. *H. caerulea* is found predominantly on the walls and ceilings of coral cavities in the fore reef slope of the coral reefs of Curaçao (Netherlands Antilles) and harbors sponge associated prokaryotes (2.1 *109 prokaryotes.cm-3 sponge). The assimilation and respiration of 13C-enriched glucose and diatom derived dissolved organic matter was followed in incubations. DOM was readily processed by the sponge with assimilation being the major fate. The 13C- enrichments patterns in fatty acid biomarkers revealed that the dissolved organic 13C assimilation by *H. caerulea* was both direct and mediated by sponge associated prokaryotes. Tracer carbon was recovered both in bacteria-specific and non-bacteria specific fatty acids. Phytanic acid was ascribed to the sponge. This is the first direct evidence of DOM incorporation by sponge cells. The sponge-microbe consortium of *H. caerulea* processes bulk dissolved organic matter, meeting up to 90% of their organic carbon demand. Because sponges dominate live cover in cryptic habitats on coral reefs, DOM assimilation by cryptic reef sponges represents an important, largely overlooked, ecological function of coral reefs.

## 8-13

**Assessment Of Coral Microbiota: The Impact Of Untested Assumptions, Unintended Biases, And Undefined Variables**

Shawn POLSON[1,2], Sara POLSON[1], Julie HIGGINS[1], **Cheryl WOODLEY*[1]**

[1]Center for Coastal Environmental Health and Biomolecular Research, NOAA National Ocean Service, Charleston, SC, [2]Marine Biomedicine and Environmental Sciences Center, Medical University of South Carolina, Charleston, SC

The study of microbiology has emerged as an important component of coral biology, with numerous studies examining coral-associated microbial ecology in hopes of understanding the dynamic nature of these communities. Such studies have provided numerous insights into the composition of these communities, but a significant level of project-to-project variability is apparent when reviewing these results. The study presented here utilized culture-dependent (~650 isolates) and independent (~25,000 sequences from 88 16S rDNA libraries) analyses to assess the microbial community structure associated with acroporid corals of the Florida reef tract (USA). The study was designed to allow for the impact of multiple sample variables including sample collection/processing methodology, disease state, acroporid species, regional geography, and limited temporal variation to be simultaneously assessed. Sample processing methodology was found to introduce significant bias into the resulting microbial community composition detected. Lumping coral health states into defined "diseases", based solely upon field observations of similarity in disease signs, was also demonstrated to be a potential source of variation found in the past literature. The existence of marked temporal variation within a population of corals was also detected. The results of this study indicate that future studies of coral-associated microbial communities must take great care to control for numerous variables (many of which are currently poorly understood). Key among these factors is an in depth assessment of the physiological state of the coral during sample collection. Without increased efforts to address the role of such secondary variables on microbial community composition (both actual and detected) it is likely that increased fragmentation in the body of literature will occur, hampering efforts to understand the nature of this important component of the coral holobiont.

## 8-14

**Changes in Coral Associated Microbial Communities During A Bleaching Event**

**David BOURNE*[1]**, Yuki IIDA[1], Sven UTHICKE[1], Carolyn SMITH-KEUNE[1,2]

[1]Australian Institute of Marine Science, Townsville, Australia, [2]Centre of Marine Studies, University of Queensland, Brisbane, Australia

Environmental stressors such as increased sea surface temperatures are well known for contributing to coral bleaching, however the effect of increased temperatures and subsequent bleaching on coral associated microbial communities is poorly understood. Colonies of the hard coral *Acropora millepora* were tagged on a reef flat off Magnetic Island (Great Barrier Reef) and surveyed over 2.5 years, which included a severe bleaching event in January/February 2002. Daily average water temperatures exceeded the previous 10-year average by more than 1ºC for extended periods with field based visual surveys recording all tagged colonies displaying signs of bleaching. During the bleaching period, direct counts of coral zooxanthellae densities decreased by ~64%, before recovery to pre-bleaching levels after the thermal stress event. A subset of three tagged coral colonies were sampled through the bleaching event and changes in the microbial community elucidated. DGGE analysis demonstrated conserved bacterial banding profiles between the three coral colonies confirming previous studies highlighting specific microbial associations. As coral colonies bleached, the microbial community shifted and redundancy analysis (RDA) of DGGE-banding patterns revealed a correlation of increasing temperature with the appearance of *Vibrio*-affiliated sequences. Clone libraries hybridised with *Vibrio*-specific oligonucleotide probes confirmed an increase in the fraction of *Vibrio*-affiliated clones during the bleaching period. Post-bleaching, the coral microbial associations again shifted, returning to a profile similar or identical to the fingerprints prior to bleaching. This provided further evidence for corals selecting and shaping their microbial partners. For non-bleached samples, a close association with *Spongiobacter* related sequences were revealed by both clone libraries and DGGE profiling. Despite *Vibrio* species being previously implicated in bleaching of specific coral species, it is unsure if the relative increase in retrieved *Vibrio* sequences is due to bacterial infection or an opportunistic response to compromised health and changing environmental parameters of the coral host.

## 8-15

**Metagenomic Analysis Of The Microbial Community Associated With The Coral Porites Astreoides**

Linda WEGLEY[1], **Robert EDWARDS*[2]**, Forest ROHWER[1]

[1]Biology, San Diego State University, San Diego, CA, [2]San Diego State University, San Diego, CA

The coral holobiont is a dynamic assemblage of the coral animal, zooxanthellae, endolithic algae and fungi, Bacteria, Archaea and viruses. Zooxanthellae and some Bacteria form relatively stable and species-specific associations with corals. The symbiontic algae, or zooxanthellae, that reside within the coral tissues have been studied extensively, however very little is understood about the other microbes within the coral holobiont. To better understand the roles of the microbes associated with corals, a fractionation procedure was used to separate the microbes, mitochondria, and viruses from the coral animal cells and zooxanthellae. The resulting metagenomic DNA was sequenced using pyrosequencing. Fungi, Bacteria, and phage were the most commonly identified organisms in the metagenome. Three of the four fungal phyla were represented, including a wide diversity of fungal genes involved in carbon and nitrogen metabolism, suggesting that the endolithic community is more important than previously appreciated. In particular, the data suggested that endolithic fungi could be converting nitrate and nitrite to ammonia, which would enable fixed-nitrogen to cycle within the coral holobiont. The most prominent bacterial groups were Proteobacteria (68%), Firmicutes (10%), Cyanobacteria (7%), and Actinobacteria (6%). Functionally, the bacterial community was primarily heterotrophic and included a number of pathways for the degradation of aromatic compounds, the most abundant being the homogentisate pathway. The most abundant phage family was the ssDNA Microphage and most of the eukaryotic viruses were most closely related to those known to infect aquatic organisms. This study provides a metabolic and taxonomic snapshot of microbes associated with the reef-building coral Porites astreoides and presents a basis for understanding how coral-microbial interactions structure the holobiont and coral reefs.

## 8-16

**Comparison of bacterial communities on corals containing different Symbiodinium (Zooxanthellae) clades**

**Raechel LITTMAN*[1]**, David BOURNE[2], Bette WILLIS[1]

[1]Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

Reef-building corals host a variety of micro-organisms, including symbiotic dinoflagellates, Symbiodinium (zooxanthellae) and an array of bacteria. Previous studies have suggested that bacteria can provide many benefits to corals through fixation and passage of nitrogen and carbon to the coral host and production of secondary metabolites such as antibiotics. Many of the coral's nutritional needs are supplied by Symbiodinium, and it has been shown that different genetic types of this algal symbiont differentially affect the physiology of the coral host. For instance, corals containing Symbiodinium clade D tend to be more tolerant to heat stress. However, little is known about how Symbiodinium affects the entire holobiont. Arguably, changes in the algal symbionts may lead to differences in the bacterial populations on corals. For instance, Symbiodinium contributes to the mucus layer, providing nutrients to potentially important bacterial inhabitants. To aid in our understanding of possible interactions between bacterial and Symbiodinium communities, this study compares bacteria community profiles of juvenile Acropora millepora and A. tenuis experimentally infected with two different clades of Symbiodinium, C1 and D. Moreover, bacterial communities are compared on corals containing C1 and D that have been experimentally bleached to determine whether coral-associated bacterial communities are more resilient to change on corals containing heat tolerant algal symbionts. This will aid in understanding the relationships between microbial inhabitants and how these communities can be destabilized if Symbiodinium is lost from the host.

## 8-17

**Bacteria Associated With Symbiodinium Spp. in Culture**

**Kim RITCHIE*[1]**, Roxanna MYERS[2], Carmel NORMAN[3], Joel THURMOND[3]

[1]Mote Marine Lab, Sarasota, FL, [2]University of Guam, Mangilao, United States Minor Outlying Islands, [3]Mote Marine Laboratory, Sarasota, FL

Most dinoflagellates are difficult to grow axenically. These include the red tide toxin producing dinoflagellate, *Karenia brevis*, and the coral endosymbiont, *Symbiodinium* spp. Historically, attempts to achieve axenic cultures using antibiotic treatment, in combination with other physical methods, initially interfere with growth of the dinoflagellate. Over time, bacteria reemerge within successful cultures. It has been suggested that the antibiotic cocktail used in purification may hinder dinoflagellate growth. An alternative hypothesis is that bacteria present in dinoflagellate cultures are required for dinoflagellate growth. To date, no survey of bacteria present in *Symbiodinium* cultures has been undertaken. Bacteria associated with ten *Symbiodinium* cultures, representing 6 different *Symbiodinium* clades, were examined using culture-based methods, denaturing gradient gel electrophoresis (DGGE) analysis and terminal restriction length polymorphism (TRFLP) analysis. Although phylogenetic variation exists among bacterial groups associated with *Symbiodinium* cultures, of interest is that bacteria frequently identified in all ten *Symbiodinium* cultures include members of the Roseobacter clade, *Marinobacter* species, and members of the Cytophaga-Flavobacterium-Bacteroides (CFB) group. These findings indicate a potential mutualistic role for these bacteria with *Symbiodinium* spp.

## 8-18

**Abundance of Zooxanthellae degrading or suppressing bacteria in a High-latitude Coral community and their Effect on Zooxanthellae and Coral host**

**Shashank KESHAVMURTHY*[1]**, Kimio FUKAMI[1]

[1]Graduate School of Kuroshio Science, Kochi University, Japan, Kochi, Japan

Studies carried out on bleaching in corals in the last decade have linked bacteria (bacteria-mediated bleaching) as one of the causes of coral bleaching as a result of degradation/necrosis of zooxanthellae due to bacterial activity. Though many bacterial species have been linked with coral bleaching, it is still not clear about the abundance, diversity and effect of such bacteria on compromised coral holobiont. This study looks at presence of such bacteria that are capable of degrading/suppressing zooxanthellae and their effect on zooxanthellae and coral host. The study was carried out in a high-latitude coral community at Nishidomari, Otsuki (N 32o 46' 45" and E 132o 43' 59") situated in the south of Kochi Prefecture, Shikoku, Japan. Our results showed presence of bacteria effective against zooxanthellae in the order of 102 cells/L. Most of the isolated zooxanthellae degrading/suppressing bacteria belonged to *Gammaproteobacteria*. The effect of three strains of algicidal bacteria (1B, 4-2DW-1 and 4-1SW-1) on temperature stressed zooxanthellae showed 53-86% cell degradation. There was no such strong effect of these strains on the temperature stressed corals. However, tissue loss, reduction in zooxanthellae abundance and lowered pigment concentration was observed in the coral fragments that were incubated for two weeks with zooxanthellae degrading/suppressing bacteria. This study is the first report on the abundance of bacteria that are able to degrade/suppress zooxanthellae. Initial results on their effect on two coral species has shown that they have ability to bleach the coral that were subjected to stress. We conclude that such bacteria that are present in the coral reef areas might be acting as opportunistic pathogens on stressed corals thereby contributing to the coral bleaching phenomenon.

## 8-20

**Microbial Diversity Associated With The Deep-Water Scleractinian *lophelia Pertusa* in The Gulf Of Mexico**

**Christina KELLOGG*[1]**

[1]U.S. Geological Survey, St. Petersburg, FL

Bacteria and archaea are beginning to be recognized as an important part of the total biology of shallow-water corals. Deep-sea corals have a fundamentally different ecology due to their adaptation to cold, dark, high-pressure environments, and as such they have novel microbiota. The goal of this study was to characterize the microbial communities of the deep-sea coral *Lophelia pertusa* in the Gulf of Mexico. This is the first study to include both culture-based and molecular data on deep-sea coral-associated bacterial communities. This is also the first study to detect archaea associated with a deep-sea coral. Additionally, we present a novel method to collect coral samples in individual insulated containers and preserve them at depth in an effort to maintain *in-situ* microbial diversity by minimizing contamination and thermal shock.

There are a few similarities between *Lophelia*-associated bacteria and bacteria from shallow-water corals and deep-sea octocorals. However, both cultured isolates and 16S rDNA clone libraries reveal many novel bacteria associated with *Lophelia*. Many of these bacteria are similar to prokaryotic symbionts of fish, squid, and methane-seep clams. In particular, one bacterial sequence, VKLP1, that is present in all *Lophelia* colonies analyzed to date (n=6), is genetically similar to a sulfide-oxidizing gill symbiont of a seep clam. This apparently *Lophelia*-specific bacterium may link the coral to cold seep communities. Molecular analysis of bacterial community diversity showed a marked difference between the two study sites, even though they are less than 20 nautical miles apart. The dissimilarity between the dominant members of the bacterial communities at these two sites may be evidence of diseased *Lophelia* or thermal stress at one site, or may indicate biogeographical differences.

## 8-21

**Cross-Kingdom Amplification Using Bacterial-Specific Primers: Implications For Coral Microbial Ecology**

**Julia GALKIEWICZ*[1]**, Christina KELLOGG[2]

[1]College of Marine Science, University of South Florida, Saint Petersburg, FL, [2]USGS, Saint Petersburg, FL

In the field of coral microbial ecology, polymerase chain reaction (PCR) amplification of pure bacterial DNA is vital to the study of bacterial interactions with corals. Previous studies of coral-associated bacteria from the Caribbean have used 16S primers 8F or 27F and 1492R to amplify prokaryotic rDNA. Primers 8F and 27F are described as bacterial-specific, while primer 1492R universally amplifies prokaryotic, archaeal, and eukaryotic DNA. In combination, 8F/1492R and 27F/1492R should amplify only bacterial rDNA. However, recent trials have shown that these common primer sets also amplify eukaryotic 18S rDNA.

Samples of the Pacific scleractinian Pocillopora damicornis were collected in American Samoa and preserved in a DMSO/EDTA/salt buffer. Community DNA was extracted using the MoBio Powersoil™ DNA Isolation kit. This extraction procedure was adapted from published procedures that amplified coral-associated bacteria from Caribbean corals but had not been previously applied to Pacific coral tissue. When the resulting clones were sequenced and compared to the GenBank nucleotide database, they were most closely related to Cnidarian 18S rDNA. The 18S sequences were examined and found to contain short sequence homology (12 bp out of a total length of 20 bp) to primers 8F and 27F. This homology apparently allows amplification of coral 18S rDNA, creating an amplicon length of 1.3 kbp, almost identical to that of bacterial amplicons resulting from the 8F/1492R primer set. Because the amplicon lengths are so similar, gel extraction techniques to separate bacterial from cnidarian amplicons are difficult. To circumvent this problem, a different primer set was employed. The bacterial primers 63F and 1542R amplify a bacterial sequence 1.4 kbp in length, whereas coral DNA sequences amplified with these primers have a length of 0.6 kbp, allowing distinct separation on the gel and targeting of bacterial DNA for further analysis.

## 8-22

**Microbial Dynamics of Kiritimati Atoll**

**Tracey MCDOLE*[1]**, Rob EDWARDS[2], Liz DINSDALE[1], Sheila WALSH[3], Mary DONOVAN[4], Forest ROHWER[1]

[1]Cell and Molecular Biology, San Diego State University, San Diego, CA, [2]Math and Computer Sciences, San Diego State University, San Diego, CA, [3]Scripps Institution of Oceanography, UCSD, La Jolla, CA, [4]University of California, Santa Barbara, Santa Barbara, CA

Potential anthropogenic stressors that contribute to coral reef decline include global warming, eutrophication, and overfishing. It is becoming clear that microbes are important factors in all of these scenarios. In 2005, the coral reef-associated microbial community were surveyed in the northern line islands archipelago in the central pacific. A ten fold increase in microbial numbers from kingman (human population = 0), to kiritimati (population ~ 10,000) was observed. This increase in microbial abundance in the water column was correlated with an increase in coral disease prevalence. Kiritimati island itself also provides a gradient of human disturbance, without the latitudinal gradient of the 2005 survey. In 2007, water column samples were collected from 10 meters using scuba from a total of 22 sites encircling the island. At each site, the abundance of microbes and virus-like particles were enumerated using fluorescence microscopy. Increasing microbial and viral density was directly correlated with increasing human population. The maximum fold increase between sites for microbes and virus-like particles was 20 and 40 fold respectively, with the highest numbers of bacteria (5 x 106 cells/ml) and virus-like particles (2 x 107 cells/ml) occurring at the same site. The number of bacteria colonies that grew on media selective for the known pathogens *staphylococcus* spp and *vibrio* spp, as well as enteric bacteria also supported this trend. The abundance of microbes and viruses will be correlated with numbers of fish, prevalence of coral disease, number of coral recruits, and concentration of organic and inorganic nutrients to help develop a model of coral reef microbial and macrobial interactions.

## 8-23

**Reef Community Structure Of Hawaiian Reefs: From The Microscopic To The Macroscopic World**

**Florent ANGLY*[1]**, Mark VERMEIJ[2], Sheila WALSH[3], Stuart SANDIN[4], Meghan DAILER[2], Celia SMITH[5], Forest ROHWER[1]

[1]San Diego State University, San Diego, CA, [2]University of Hawaii, Lahaina, HI, [3]University of California, San Diego, San Diego, CA, [4]Scripps Institution of Oceanography, San Diego, CA, [5]University of Hawaii, Honolulu, HI

The acceleration of coastal urbanization in Hawaii this last decade has resulted in increased nutrient runoff to the ocean and has led to a decrease in coral cover. Such coral reef decline has important ecological as well as economical repercussions that need to be prevented. Recent evidence suggests a role of microbes in the trajectory of decline of coral reefs worldwide. The Line Islands archipelago in the central Pacific, including atolls ranging from uninhabited to moderately inhabited, was previously surveyed and microbially-driven food chains were reported for the most populated islands. We hypothesize that microbial abundance and composition are also a fundamental to understanding the trajectory of decline of Hawaiian coral reef ecosystems. To this end, benthic cover, fish species composition and microbial and viral abundance were assessed for 17 reefs of Maui and Lanai. Water parameters, including dissolved organic carbon and nutrient levels, were also recorded. The data indicated that the reef ecosystems of Maui were overall more degraded and algal-dominated than those of the nearby less populated island of Lanai. Viruses and microbes (including the potentially human pathogenic Vibrio bacterial genus) were more prevalent at degraded sites and their abundance ranged from about the same to twice as many as compared to remote, central Pacific atolls. The larger variation or patchiness in benthic composition of more degraded reefs could be interpreted as a departure from a healthy stable state. Basic functional relationships that are supposed to occur, like herbivorous fish control by fish predators, were mostly lost. The current structure of Hawaiian coral reef ecosystems depicts an intricate relation between the microscopic and the macroscopic world, that together with the very complex history of these reefs largely drives today's observations.

## 8-24

**Biogeography Of Reef Water And Coral-Associated Bacterial Communities Across The Hawaiian Archipelago And Greater Pacific Basin**

**Jennifer L. SALERNO*[1,2]**, Michael S. RAPPE[3]

[1]Zoology, University of Hawaii at Manoa, Honolulu, HI, [2]SOEST, Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, [3]SOEST, Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI

The bacterial community structure within coral and seawater samples collected from six islands and atolls within the Hawaiian archipelago was investigated using a suite of molecular biological and statistical techniques. Overall, we observed significant overlap in bacterial communities associated with the reef-building coral, *Porites lobata*, from the majority of islands and atolls within the Hawaiian archipelago and uncovered significant variation amongst different colonies within an island or atoll. However, microbial communities associated with *Porites lobata* colonies from French Frigate Shoals atoll were more similar to one another than to any other colonies located within the archipelago. These communities also shared some similarities with samples collected from Kaneohe Bay, Oahu, within the main Hawaiian Islands. These observed differences have important management implications, as corals with different assemblages of resident bacteria may respond differently to environmental changes. Seawater samples from sites within the Hawaiian archipelago, Johnston Atoll, and American Samoa were analyzed using similar techniques. Overall, seawater bacterial communities from the Hawaiian Islands were more similar to one another than to the other locales examined. Seawater bacterial communities from American Samoa were quite variable, but distinct from Hawaii, Johnston Atoll shared similarities with both Hawaii and American Samoa, and samples from Kaneohe Bay, Oahu grouped separately from all other locales. Overall, the biogeographic patterns of bacterial communities physically associated with the coral *Porites lobata* differed from those observed in planktonic bacterial communities, indicating that the underlying factors affecting the dispersal and proliferation of bacteria associated with a benthic host versus those within the plankton are different.

## 8-25

**Microbial Profiling For Coral Restoration**

**Camille DANIELS*[1]**, Mya BREITBART[1], Ilze BERZINS[2], Craig WATSON[3]

[1]University of South Florida, College of Marine Science, St. Petersburg, FL, [2]The Florida Aquarium, Tampa, FL, [3]University of Florida, Tropical Aquaculture Laboratory, Ruskin, FL

Coral aquaculture and transplantation are currently being employed to address worldwide decline of coral reefs and promote reef ecosystem recovery. Issues that arise with these restoration strategies include possible introduction of diseases onto natural reefs and the vulnerability of transplanted corals to bleaching and disease. While visual and histological assessments are currently being used to determine if aquacultured coral fragments are suitable for restoration, analyses of coral-associated microbes have yet to be incorporated as a health indicator before transplantation. Before microbial community composition can be incorporated into assessments of coral health, it is necessary to understand the spatial and temporal variability of coral-microbe associations.

This project uses culture-based (TCBS plating and EcoPlate carbon utilization profiling) and culture-independent (ARISA) methods to determine the composition and variability of the microbial community associated with corals used for restoration. Spatial sampling on a large Diploria clivosa parent colony revealed differences in microbial communities found in mucus from different locations on the coral surface. Following fragmentation of this parent colony, individual 2x2 cm fragments were sampled over time, allowing for increasing time intervals between mucus sampling. Rapid changes in the coral-associated microbial community were observed over time, with a significant increase in the number of culturable Vibrio sp. following removal of the coral mucus. Subsequent experiments revealed that the corals (or their associated microbes) adapt to reduce Vibrio numbers upon repeated sampling. The mechanism of this adaptation is currently unknown, but will be a focus of future studies. Results from this project will provide insight into the stability of coral-bacterial associations, and allow us to develop a microbial baseline for coral species used for restoration in the Florida Keys. Understanding microbe-coral interactions is critical for the future incorporation of microbial community profiling into coral health assessments, which has direct implications for coral restoration and conservation.

## 8-26

**Photosynthetic Microorganisms Colonized Within *goniastrea Aspera***

**Seitaro S. YAMAZAKI*[1]**, Takashi NAKAMURA[1,2], Yeong Shyan YUEN[1], Hideo YAMASAKI[1]

[1]Faculty of Science, University of the Ryukyus, Okinawa, Japan, [2]Amakusa Mar. Biol. Lab., Kyushu University, Kumamoto, Japan

Reef building corals have established obligate symbiotic relationship with dinoflagellates commonly known as "Zooxanthella". It is widely known that corals harbor multiple species of microalgae within their endoliths. However, its ecological function as well as impacts on the host corals has remained as a subject to be explored. In addition to the zooxanthella, it has been suggested that the flora of photosynthetic microorganisms colonized within coral endoliths is more complicated than that of described previously. Here, we characterize the photosynthetic microorganisms' flora in the endoliths of corals inhabiting in eutrophic and oligotrophic environments. *Goniastrea aspera* colonies were collected from eutrophic and oligotrophic environments in Okinawa (Japan) and Great Barrier Reef (Australia). We analyzed the species profile of photosynthetic microorganisms with the PCR-DGGE method, extracting total genomic DNA from coral endoliths. The diversity of 16S rDNA of cyanobacteria and chloroplasts in the samples collected from oligotrophic environments was much higher than that of eutrophic environments. The diversity of 18S rDNA of eucaryotic algae was lower than the 16S rDNA, and it was similar in both sites. These results suggest that diversity of cyanobacteria colonized within *G. aspera* in oligotrophic environment is higher compared to eutrophic environment. In contrast with cyanobacteria, fewer species of eucaryotic algae colonized within *G. aspera* and their diversity may not be affected by nutrient conditions. Our findings lead us to conclude that the diversity of cyanobacteria colonizing *G. aspera* endoliths can be altered by nutrient conditions of the environment.

## 8-27

**The Roles Of Viruses in Corals.**

**Rebecca VEGA THURBER*[1]**, Forest ROHWER[2]

[1]Biology, San Diego State University, San Diego, CA, [2]San Diego State University, San Diego, CA

The coral holobiont is a symbiotic community of animal host, zooxanthellae algae, and microbial flora and fauna. Using a combination of manipulation experiments, metagenomic analysis, and real-time PCR, we have found that this diversity of organisms is thus reflected in the viral consortia present within the tissues and mucus of *Porites compressa* corals. We have identified representatives of viruses that infect many protozoan and metazoan phyla, as well as Bacteria and Archaea. We hypothesize that these viruses infect different compartments within the holobiont and therefore affect the coral host in a variety of ways. Of particular interest are three groups of viruses: the herpes-like viruses, single-stranded DNA plant viruses, and Bdellovibrio phages which are elevated in abundance after corals were exposed to increases in temperature, nutrients, and dissolved organic carbon, respectively. To further characterize the role(s) that these viral groups play in coral health and homeostatis, we have conducted analysis on the relative abundance of viral target genes and members of the holobiont. For example, *Symbiodinium* (as measured by a *Symbiodinium* psbA chloroplast gene) abundance was found to be negatively correlated with a putative Geminivirus recently identified in our libraries, suggesting that as this virus is produced, zooxanthellae abundance is reduced, indicative of viral infection and lysis of the zooxanthellae. Also, Bdellovibrio phage (viruses that infect bacterivorous Bacteria) abundance was negatively correlated with groups of heterotrophic bacteria suggesting that Bdellovibrios may play a unique role in regulating bacterial colonization of the holobiont. Lastly, herpes-like virus genes were positively correlated with coral tumor incidence indicating that these viruses may be culprits of coral disease. These and other data suggest that viruses may play important roles in coral biology and coral reef health.

## 8-28

**Microalgae From The Mucus Layer Of Two Massive Corals in The South-Eastern Caribbean, Venezuela**

**Francoise CAVADA*[1]**, Rene AYALA[1], Luis TROCCOLI[2], Juan CRUZ-MOTTA[1]

[1]Departamento de Estudios Ambientales, Universidad SimÃ³n BolÃ-var, Caracas, Venezuela, [2]Departamento de Acuicultura, Universidad de Oriente Nucleo Nueva Esparta, Isla de Margarita, Venezuela

The mucus layer of healthy scleractinian corals contains a variety of eukaryotic and prokaryotic microorganisms. It has been hypothesized that these communities confer some benefits to the coral, specifically the pathogenesis development. However, little is known about the eukaryotic fraction of these communities. This study addresses the description of the patterns of spatial and temporal distribution of microalgae assemblages in the mucus layer of two massive corals in a pristine reef patch in the south-eastern Caribbean, using a sampling design that allowed testing specific hypotheses in relation to: 1) differences between coral species and 2) the generality of the observed patterns. To accomplish this, samples of mucus were haphazardly taken from 72 healthy colonies, 36 *Diploria strigora* and 36 *Colpophyllia natans* plus 3 samples of water and sediment on a monthly basis between January and June 2004. Multivariate analysis, based on similarity matrices, showed that microalgae assemblages present in the mucus samples had no relation with those from the water column or sediment, and that variation in the assemblages of microalgae from the mucus throughout the study period was dependent on the coral species, but changes in both coral species occurred in the same direction through time. The results show that the association observed between corals and the microalgae on the mucus layer may not constitute an opportunistic interaction with the surrounding plankton and/or microphytobenthos. However, it is necessary to carry out further studies to identify the possible factors that affect these assemblages, their relative importance and the way they may interact, as well as the incorporation of other assemblages that inhabit the mucus layer in the sampling design to characterize the mucus microbiota and test specific hypothesis about their role in the coral biology.

## 8-29

**Competition between Caribbean Corals and Macroalgae: Is there a Detrimental Impact on Symbiotic Coral-Bacterial Associations?**

**Kathleen MORROW*[1]**, Mark LILES[1], Nanette CHADWICK[1]

[1]Biological Sciences, Auburn University, Auburn, AL

Long-term studies on Caribbean reefs have revealed declines in live coral cover and increases in algal abundance, resulting in increased physical contact between corals and algae. Macroalgae may gain a competitive edge over scleractinian corals by manipulating coral-associated microorganisms. We used culture-dependent and -independent methods to determine the microbial communities associated with both competing and isolated corals (*Montastraea faveolata*) and macroalgae (*Halimeda* green and *Dictyota* brown algae). Syringe samples were taken from >1 m apart and included: 1) *M. faveolata* not in contact with macroalgae (coral control), 2) *M. faveolata* interacting with macroalgae, at 5cm from the interaction zone, 3) *M. faveolata* surfaces that directly contacted each macroalga, 4) macroalgal thalli interacting with *M. faveolata* and finally, 5) epiphytic *Halimeda* and *Dictyota* not in contact with corals (algal control). Initial plate counts suggest that microbial abundance increases in a step-wise fashion from isolated corals (~500 CFU $ml^{-1}$), to coral-macroalgal interaction zones (~1,500 CFU $ml^{-1}$), to within macroalgal thalli (~3,500 CFU $ml^{-1}$). Microbial community samples were extracted using a bead-beating method to recover DNA, and the 16S-23S rRNA intergenic spacer region was PCR-amplified using universal Eubacteria primers and resolved on a polyacrylamide gel (ARISA method). Bacterial community profiles revealed significant variation in composition between sample types, with considerable intra-sample consistency (n=3). In particular, a dominant bacterial taxon found on the coral controls was observed to decrease dramatically in corals that interacted with macroalgae. We conclude that microbial communities associated with these corals and macroalgae are dynamic and appear strongly impacted by competitive interactions. Coral-algal interactions may directly mediate the stability and function of microbial symbionts on coral surfaces, and have major implications for observed patterns of competitive dominance and disease susceptibility on coral reefs.

## 8-31

**Coral Associated Protists: Additional Partners in The Holobiont**

**Esti KRAMARSKY-WINTER*[1]**, Moshe HAREL[2], Nachshon SIBONI[3], Etan BEN DOV[3], Diana RASOULOUNIRIANA[3], Ariel KUSHMARO[3], Loya YOSSI[1]

[1]Dept. of Zoology, Tel Aviv University, Tel Aviv, Israel, [2]Dept. Plant and Environmental Sciences, The Hebrew University of Jerusalem, Jerusalem, Israel, [3]The Department of Biotechnology Engineering and The National Institute for Biotechnology, Ben Gurion University, Beer Sheva, Israel

Recent investigations on coral associated communities have revealed that microbial communities covering coral surfaces play important roles in colony well-being. A large number of "aggregate" like organisms were recently observed covering the surface of large-polyp corals such as Fungiids and Faviids from a number of geographic locations. These organisms are dispersed in a patchy distribution on the polyp surface, with the highest density occurring in the area of the polyp mouth. They can not be removed from the coral surface by antibiotics, or by bleaching the corals in the dark. To identify these organisms, mucus visibly containing aggregates, was gently scraped or milked from the surface of the solitary Red Sea coral *Fungia granulosa* and examined microscopically, and molecularly (using 18S rRNA gene and 16S mitochondrial rRNA gene sequences). Microscopic investigation revealed that the organisms are embedded in the mucus and in the tissue layers of this coral. They are approximately 5-30 µm in diameter, made up of unique coccoid bodies and contain a nucleus, mitochondria and golgi. Both morphological and molecular data lead us to identify these organisms as stramenopile protists. To further characterize these organisms, samples of aggregate containing mucus were diluted and plated and grown on a variety of media. Some of the resulting colonies of microorganism were similar in gross morphology to those from the coral surface. Pure cultures were grown to follow life cycle attributes, and were identified morphologically and molecularly as belonging to the family Thraustochytridae, a group of protists known for their ability to produce poly-unsaturated fatty acids (PUFA). The presence of this group of microorganisms on the surface of many large polyp coral species from different geographic locations may indicate their importance in coral holobiont health.

## 8-32

**Global Diversity And Distribution Of Coral Associated Archaea And The Possible Role in Coral Nitrogen Cycle**

**Nachshon SIBONI*[1]**, Eitan BEN-DOV[1], Alex SIVAN[1], Ove HOEGH-GULDBERG[2], Ariel KUSHMARO[1]

[1]Biotechnology Engineering, Ben-Gurion University, Be'er-Sheva, Israel, [2]Centre for Marine Studies, University of Queensland, Brisbane, Australia

Corals harbor diverse and abundant prokaryotic communities (bacteria, archaea and protozoa) that may have co-evolved with them. To date, only little attention has been given to studies on the diversity and roles of archea in the coral holobiont. This research focuses on the diversity and distribution of 424 coral-associated Archaeal sequences associated with the surface mucus of three coral genera: *Acantastrea*, *Favia* and *Fungia* sp. from Red Sea, Israel and from Heron Island, Australia. Sequencing of 16S rRNA gene revealed dominance of Crenarchaeota (80% in average) in most of the coral associated sequences. In the Crenarchaeota, 87% were similar (≥97%) to Thermoprotei, of this class 76% were similar (≥97%) to candidatus *Nitrosopumilus maritimus* (DQ085097), an ammonium oxidizer. Most of the Euryarchaeota sequences (73%) were related to marine group II and other clades were related to anaerobic methanotrophic archaea (8%), anaerobic nitrate reducer archaea (16%) and marine group III (3%). Many of the Crenarchaeota and Euryarchaeota corals-associated archaeal sequences from Heron Island GBR Australia (61%) and Gulf of Eilat, Red Sea (71%) were closely (≥97%) related to sequences derived from Virgin Islands corals, Caribbean. This suggests that coral-associated Archaea play an important role in holobiont physiology presumably by acting as a nutritional sink of excess ammonium trapped in the mucus layer, by nitrification and denitrification process.

## 8-33

**Occurrence Of Epidermal Bacteria in The Scleractinian Coral *montastraea Cavernosa***

**D. Abigail RENEGAR*[1]**, Genelle F. HARRISON[2], Patricia L. BLACKWELDER[1,3], Joel E. THURMOND[2], Kimberly B. RITCHIE[2], Bernardo VARGAS-ANGEL[4]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania, FL, [2]Center for Coral Reef Research, Mote Marine Laboratory, Sarasota, FL, [3]RSMAS, University of Miami, Miami, [4]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

*Montastraea cavernosa* is an important scleractinian reef-building coral, found throughout South Florida and the Caribbean. Examination of numerous field-collected and experimental specimens of this coral with transmission electron microscopy (TEM) revealed the presence of bacteria exclusively in the epidermal tissue. To identify these bacteria, DNA was isolated from coenosarc tissue followed by DGGE analysis of the 16S-V3 rDNA genes. Cloning and 16S rRNA sequence analysis identified the predominant bacteria as members of the *Lactobacillus/Lactococcus* bacterial groups. These Gram-positive bacteria are commonly associated with sewage. *Lactobacilli* are anaerobic bacteria, found in the human digestive tract and rotting plant matter that convert lactose and sugars into lactic acid. *Lactococcus* are motile bacteria common in dairy. The occurrence of bacteria within the epidermis of *M. cavernosa* raises the question of the role of bacteria within coral tissue. It is unknown if these bacteria are normal endosymbionts or represent a pathologic condition; in some corals the bacterial population appeared to completely overtake the tissue. Additionally, individual amoebocytes were observed both in the epidermis and in mesoglea adjacent to the epidermis. The amoebocyte cells in the epidermis were often actively engaged in bacterial phagocytosis. The possibility that innocuous bacteria may become pathogenic under stress highlights the importance of understanding and quantifying how environmental stress may affect the nature of the coral/zooxanthellae/bacterial association. This study represents ongoing research directed at the development of monitoring and predictive indices based on TEM and fluorescence in-situ hybridization (FISH) assessment of amoebocyte/bacteria ratios. FISH analyses are also being employed to aid in the identification and localization of these bacteria in other species.

## 8-34

**Bacterial Communities On Healthy And Diseased Corals: Associations With Rapid Tissue Loss (White Plague)**

**Geoffrey M. COOK*[1]**, Masoumeh SIKAROODI[1], Patrick M. GILLEVET[1], Paige ROTHENBERGER[1], Esther C. PETERS[1,2], Robert B. JONAS[1]

[1]Environmental Science and Policy, George Mason University, Fairfax, VA, [2]Tetra Tech, Inc., Fairfax

Although diseases of hermatypic corals, some of proven or suspected bacterial origin, pose a serious global threat to coral reefs, the composition of bacterial communities on healthy corals and those exhibiting signs of disease remains poorly understood. This investigation compared bacterial communities associated with multiple pairs of apparently healthy and diseased *Montastraea annularis* (species complex) colonies from offshore reefs in The Bahamas, U.S. Virgin Islands, Cayman Islands, Bermuda, the Florida Keys National Marine Sanctuary, and the Flower Garden Banks National Marine Sanctuary. Bacterial communities from apparently healthy colonies and nearby colonies exhibiting signs consistent with white plague type II (WPL II) were evaluated using both molecular and culture-dependent methods. Length heterogeneity PCR (LH-PCR) molecular fingerprints were used to interrogate the diversity and relative abundance of both whole and culturable communities. Bacterial communities associated with diseased corals, regardless of geographical location, were more similar to each other than to communities from apparently healthy tissue on either diseased or healthy colonies. A comparison of the whole-bacterial community molecular fingerprint, regardless of tissue type, with the culturable community revealed far greater similarities than expected. Comparison of amplicon lengths and relative abundances suggest that many of the bacterial taxa in coral communities are culturable and that these represent the most abundant bacteria. Dominant microbial taxa include the genera *Vibrio* and *Pseudoalteromonas*. Strains of *Pseudoalteromonas* are known to produce toxins that lyse dinoflagellates and diatoms. These data imply an association between complex bacterial communities and rapid tissue loss diseases.

## 8-35

**Tissue Loss And Tropical Storms: An Investigation Of Bacterial Community Dynamics in *montastraea Annularis* Corals in St. Croix, Usvi**

**Paige ROTHENBERGER*[1,2]**, Masoumeh SIKAROODI[3], Geoffrey COOK[3], Patrick GILLEVET[3], Esther PETERS[3,4], Robert JONAS[3]

[1]Division of Coastal Zone Management, U.S. Virgin Islands Department of Planning and Natural Resources, Frederiksted, Virgin Islands (U.S.), [2]Department of Environmental Science and Policy, George Mason University, Fairfax, [3]Department of Environmental Science and Policy, George Mason University, Fairfax, VA, [4]Tetra Tech, Inc., Fairfax

Tissue loss, consistent with white plague type II (WPII), affects at least 18 species of reef building corals throughout the Caribbean and Western Atlantic. This disease destroys apparently healthy tissue rapidly thus having the potential to dramatically alter coral composition on large reef tracts. This investigation examined bacterial communities on diseased and apparently healthy *Montastraea annularis* (complex) colonies at Sprat Hole in St. Croix, U.S. Virgin Islands. Triplicate core samples from multiple pairs of healthy and diseased colonies were collected in August 2002 and September 2004, immediately following the passage of Tropical Storm Jeanne to the southwest of St. Croix. Tissue loss on colonies exhibiting signs of WPII was at epizootic levels at this site during the summer of 2004. However after the storm only one diseased colony, of five sampled, appeared to be actively losing tissue. Three of the sampled colonies were accumulating sediment at the apparent recent disease margin suggesting no active tissue loss, and one colony had a bleaching margin. Samples were analyzed using microbial culturing, molecular fingerprinting and partial 16S rRNA gene sequencing. Amplicon Length Heterogeneity PCR (LH-PCR) fingerprints indicated that bacterial communities differed significantly between healthy tissue and recently diseased margin samples. There was no evidence that a specific bacterial taxon dominated any of the tissue types sampled. Neither cultures nor the amplicon characteristic of *Aurantimonas coralicida* were found in any samples, although it might have been present at levels below the method's limit of resolution (e.g. 1%). Results of this study highlight the role of local environmental conditions in the WPII disease process and provide an important description of bacterial community composition and dynamics in this reef system.

## 8-36

**Heat-Induced Toxin Production in Vibrio Species Associated With Yellow Band Disease**

James CERVINO[1,2], **Elizabeth LORENCE*[3]**, Fabiano THOMPSON[4], Konrad HUGHEN[5], Jessie KNEELAND[5], Garriet SMITH[6]

[1]Geochemistry, Woods Hole Oceanographic Inst., MA, MA, [2]Biological Sciences, Pace University, NY, [3]Biological Sciences, Pace University, NY, NY, [4]Department of Genetics, Federal University of Rio de Janeiro, Ilha do Fundão, Brazil, [5]Geochemistry, Woods Hole Oceanographic Inst., Woods Hole, MA, [6]Biological Sciences, University of South Carolina, Aiken, SC

The expression of virulence factors induced from heat stressed yellow band *Vibrio* pathogens were investigated by infecting *Symbiodinium* zooxanthellae CLADES A, B1, C1, and D1 subtypes *in vivo*. Heat treatments were performed on both the bacteria and the algae at 33C for three hours. A supernatant was subsequently extracted after centrifugation at 12,000 RPM for 10 minutes. The isolated toxin was then purified using a 2.2 mm millipore filter and re-introduced to non-heat-treated zooxanthellae CLADE subtype cultures at 26C. Exposure times of 8, 24, 48, 72, 96 and 120hrs to the purified supernatant isolated from the *Vibrio* bacteria, indicate that the most severe algal cell necrosis was evident in CLADE subtype C1. However, all heat treated *Symbiodinium* in the presence of *Vibrio* bacteria show severe necrotic cell-death pathways compared to non-heat treated *Symbiodinium.* Supernatant toxin was also inoculated onto *Aptasia pallida* during high temperature exposure of 33C and low temperature exposure of 26C to determine the different cell-death mechanisms during toxin exposure. *Aptasia pallida* death was detected after exposure to purified toxins at ambient temperatures following 96 hr. However, when *Symbiodinium* subtypes were exposed to thermal stress coupled with *Vibrio* toxin, morphological and cellular dysfunction occured at 48hr. Cytological analysis and TEM analysis indicate that the initiation of YBD infection in symbiotic algae may not be exclusively caused by the weakened state of heat-stressed zooxanthellae. To the contrary, infection seems to be independent of environmental stress. Rising temperatures also are associated with lesion advancement that leads to a much faster cell-death in all *Symbiodinium* CLADE subtypes. In addition, we found that instead of *Symbiodinium* being wholly expelled from the gastroderm of *A. pallida*, internal cell-death occurs rather than expulsion from the gastrodermal tissues as seen in thermal coral bleaching.

## 9-1

**Herbivore Diversity And Feeding Complementarity Affect The Structure Of Caribbean Reefs**

**Mark HAY*[1]**, Deron BURKEPILE[2]

[1]School of Biology, Georgia Institute of Technology, Atlanta, GA, [2]Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT

On coral reefs, herbivorous fishes have strong top-down effects on community structure, macroalgal abundance, and coral resilience. However, the longer-term direct and indirect effects of herbivore species richness on reef communities are inadequately understood. To evaluate the effects of herbivore species richness on community structure, we enclosed equivalent densities and masses of either single-species or mixed-species of herbivorous fishes in replicate, 4 m2 cages on a reef in the Florida Keys. The experiment ran for 8-10 months in two separate years. We found strong effects of herbivore richness on seaweed abundance, coral growth and survivorship, and community structure due to feeding complementarity between herbivores. In Year 1, ocean surgeonfish and redband parrotfish synergistically suppressed cover and biomass of upright macroalgae by 54-76% compared to single-species treatments due to complementary feeding on different seaweeds. One herbivore appeared deterred by chemical, the other by structural, seaweed defenses. The mixed-species treatment also increased cover of crustose coralline algae by 23-117%, increased coral cover by 22%, and decreased coral mortality from the 8-24% in single-species treatments to 0%. In Year 2, redband parrotfish and princess parrotfish fed on different algal functional groups with redbands suppressing upright macroalgae and princesses suppressing filamentous algae, again increasing cover of crustose coralline algae. When nonmetric multidimensional scaling was used to compare all treatments across both years, the morphologically and taxonomically dissimilar princess parrotfish and ocean surgeonfish had more similar effects on macroalgal community structure than did the two parrotfishes. Herbivores play functionally diverse roles on reefs, and these differential feeding abilities prevent macrophytes from escaping control and suppressing corals.

## 9-2

**Are Tropical Herbivores More Tolerant Of Chemically-Rich Seaweeds Than Are Temperate Herbivores? A Test Of Seaweed-Herbivore Coevolution.**

**Erik SOTKA*[1]**, Amanda MCCARTY[1]

[1]Grice Marine Laboratory, College of Charleston, Charleston, SC

Lipophilic secondary metabolites produced by seaweeds increase in strength and diversity as one moves toward the tropics. Coevolutionary theory predicts that tropical herbivores should more readily tolerate chemically-rich seaweeds and their metabolites, however, data supporting this prediction are largely correlative and rarely evaluated experimentally. We examined feeding tolerance for chemically-rich seaweeds among populations of a single species, the herbivorous amphipod, *Ampithoe longimana* collected along the eastern coast of North America from New England (41ºN) to southern Florida (26º N). In contrast with coevolutionary predictions, geographic patterns of feeding preference were not correlated with latitude. Rather, populations in North Carolina (34ºN) were far more tolerant of the diterpene-producing seaweed *Dictyota* than were New England or Florida populations. Field-surveys across multiple seasons indicate that *Dictyota* represents an important host to North Carolina populations, but that *Dictyota* is not used as a host by either New England or Florida populations. Thus, geographic patterns of feeding tolerance by *A. longimana* are best explained by the relative importance of *Dictyota* in the ecology of local populations. In spite of prevailing assumptions, our results indicate tropical herbivores will not necessarily be more tolerant than temperate herbivores for lipophilic chemical defenses produced by seaweeds.

## 9-3

**Organic Matter Release By Coral Reef Associated Benthic Algae -Implications For *in-Situ* Oxygen Dynamics**

**Andreas HAAS*[1]**, Malik NAUMANN[1], Florian MAYER[1], Christoph MAYR[2], Mohammed AL-ZIBDAH[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center LMU München, Munich, Germany, [2]Department of Earth and Environmental Science, GeoBio-Center LMU München, Munich, Germany, [3]Marine Science Station, Yarmouk University, Aqaba, Jordan

Recent research indicates that coral reef associated benthic algae may affect important processes in the reef ecosystem via organic matter release, but yet no information is available about the quantity, quality and fate of these exudates. For this reason first fundamental studies were conducted at fringing reefs in the Northern Red Sea during two expeditions in fall 2006 and summer 2007. For the most abundant reef associated benthic algae (representing nearly 100% of total benthic algae coverage), green algae of the genus *Caulerpa*, red algae of the genus *Peyssonnelia* and several typical turf algae consortia, the release of dissolved and particulate organic carbon (DOC and POC) was quantified. All investigated benthic algae exuded high rates of DOC, but also POC in amounts of up to 5430 and 360 mg organic C $m^{-2}$ algae surface area $d^{-1}$, respectively. Release of DOC was highly variable between seasons, with one order of magnitude higher release rates in fall compared to summer. High DOC:POC ratios of up to 22 indicated that most of the exuded algae-derived organic matter immediately dissolved in reef waters, thereby stimulating planktonic microbial oxygen consumption as verified experimentally. In-situ experiments in high spatial resolution using dissolved oxygen loggers confirmed lower daily mean oxygen concentrations in the water close to algae dominated reef areas compared to those dominated by hermatypic corals. Thus, this study supports the hypothesis of microbial involvement in coral-algae interactions, indicates relevance for in-situ processes and also provides a fundamental data set for further required ecosystem studies.

## 9-4

**Nutrient Distribution Across the Insular Shelf of Puerto Rico: Assessment by Algal Tissue Nitrogen**

**Brandi TODD*[1]**, David L. BALLANTINE[1], Ernesto OTERO[1]

[1]Ciencias Marinas, University of Puerto Rico, Mayaguez, Puerto Rico

A survey was conducted to investigate possible presence of an inshore to shelf edge gradient in %N and δ15N tissue content of *Acanthophora spicifera, Lobophora variegata, and Dictyota sp.* in coastal waters of La Parguera, southwest Puerto Rico. Percent N (1.26% ± 0.08 to 3.25% ± 0.10) and δ15N (2.06ppt ± 0.04 to 8.16ppt ±0.14) of *Acanthophora spicifera* was highly variable along the shoreline. The highest inshore values of δ15N occurred at two stations influenced by secondary sewage input and a bird rookery and lower values (0.81ppt ± 0.06) were observed at mid-shelf locations. *Dictyota sp.* and *L. variegata* did not display trends in %N across the insular shelf, however δ15N for *Dictyota sp.* was significantly higher inshore (3.48ppt ± 0.087) versus mid-shelf and shelf edge (0.00ppt ± 0.08) and δ15N for *L. variegata* was significantly higher at mid-shelf (2.13ppt ± 0.25) versus shelf edge locations (0.34ppt ± 0.24). These results indicate that anthropogenic impacts on tissue nutrients are greatest along the shoreline, moderate at mid-shelf, and not evident at the shelf edge.

## 9-5

**Evaluation Of Biotic And Abiotic Factors That Facilitate And Maintain Cyanobacteria Blooms And Phase Shifts in Coral Communities**

**Kathleen SEMON*[1]**, Valerie PAUL[1], Mark CLEMENTZ[2], John Michael TRAPP[3], Karen ARTHUR[1]

[1]Smithsonian Marine Station at Fort Pierce, Smithsonian Institution, Fort Pierce, FL, [2]University of Wyoming, Laramie, WY, [3]Rosenstiel School, University of Miami, Miami, FL

The functional stability of coral communities is currently threatened by recurrent cyanobacteria blooms. Cyanobacteria, such as *Lyngbya* species, are known to displace macroalgae in turf communities, inhibit coral recruitment through allelopathy, smother invertebrates, and alter nutrient and light regimes. Because cyanobacteria blooms impact many physical and biological characteristics of coral communities, damaged coral communities face altered community structure and reduced biodiversity. This study examined both the biotic and abiotic factors that facilitate and maintain cyanobacteria across Florida and Caribbean coral communities. *Lyngbya* spp. tissue and water samples were collected from areas known to be oligotrophic (the Belize Barrier Reef), and from areas adjacent to high human density and under significant anthropogenic influence (throughout south Florida). Stable C and N isotopic signatures reflect different sources contributing to cyanobacteria presence in Belize and Florida, and differences in ambient dissolved and total iron levels were reflected in patterns of cyanobacteria abundance. Correlations of ambient nutrient and temperature regimes and cyanobacteria presence and abundance were also examined from benthic surveys conducted in Belize. Multivariate analyses conducted in PRIMER v.5 revealed that *Lyngbya* spp. presence alone significantly influenced percent cover of stony coral and macroalgae recorded from benthic transects conducted in Belize. Crucial thresholds for coral community phase shifts are suggested based on data collected *in situ* and on preliminary data compiled by experimentally manipulating nutrient regimes in mesocosms known to influence cyanobacteria primary production and biomass accumulation.

## 9-6

**The Role Of Nutrients In *Lyngbya* Growth And Chemical Defense**

**Karen ARTHUR*[1]**, Valerie PAUL[1], Cliff ROSS[2], Hans PAERL[3], Jennifer JOYNER[3], Judith O'NEIL[4]

[1]Smithsonian Marine Station at Fort Pierce, Smithsonian Institute, Fort Pierce, FL, [2]Department of Biology, University of North Florida, Jacksonville, FL, [3]Institute of Marine Sciences, The University of North Carolina at Chapel Hill, Morehead City, NC, [4]Center for Environmental Science, University of Maryland, Cambridge, MD

Benthic cyanobacteria of the genus *Lyngbya* form harmful algal blooms (HABs) that occur on reefs and associated communities. They may be detrimental to other benthic organisms as they can smother corals and seagrass and because they are extremely prolific producers of biologically active secondary metabolites, many of which deter grazing by generalist herbivores. Nuisance blooms of *Lyngbya* may be triggered by terrigenous nutrient inputs and may grow unchecked as grazers avoid consuming the filaments containing secondary metabolites. In this study we examine the ecology of *Lyngbya* blooms in Broward Country, Florida and assess the effects of nutrient additions and light on *Lyngbya* growth and toxin production. We use a bioassay approach to assess the role of nitrogen, phosphorus, iron and low light conditions on the growth and secondary metabolite production of three species of *Lyngbya*. A significant increase in *Lyngbya polychroa* growth resulted from the addition of chelated iron; however, this was not the case for all *Lyngbya* species. *Lyngbya* spp. are also sensitive to light availability, with each species apparently having niche environments with specific light requirements. This study demonstrates the need to manage nutrient inputs into coral reef habitats to ensure that future reefs are not dominated by *Lyngbya* and other benthic cyanobacteria.

## 9-7

**Ecological Consequences Of Cyanobacterial Blooms On Coral Reefs**

**Valerie PAUL*[1]**, Cliff ROSS[2], Raphael RITSON-WILLIAMS[1], Linda WALTERS[3], Karen ARTHUR[1], Sarath GUNASEKERA[1], Theresa MEICKLE[1]

[1]Smithsonian Marine Station, Smithsonian Institution, Fort Pierce, FL, [2]Department of Biology, University of North Florida, Jacksonville, FL, [3]Department of Biology, University of Central Florida, Orlando, FL

A major concern on coral reefs worldwide is massive overgrowth by macroalgae and benthic cyanobacteria (blue-green algae). Benthic cyanobacteria are becoming increasingly abundant on reefs and produce nitrogenous secondary metabolites that can deter feeding by generalist herbivores. Nuisance blooms of *Lyngbya* and *Symploca* occur regularly throughout Florida and on the Belizean barrier reef. Crude extracts from some of these cyanobacteria deter feeding by a natural assemblage of fishes and the sea urchin, *Diadema antillarum*. In addition cyanobacterial secondary metabolites may be important for competition, and the function of allelopathy (chemical inhibition) in mediating the interactions between chemically rich species of cyanobacteria and different life history stages of the coral *Porites astreoides* was tested. Extracts and isolated compounds (microcolins A and B, curacin D) from *Lyngbya* spp. negatively influenced the settlement and metamorphosis of *P. astreoides* larvae. On reefs experiencing increased abundance of chemically defended benthic cyanobacteria, the restocking of adult coral populations may be slowed due to recruitment inhibition caused by cyanobacterial natural products. More research is needed on how to control these harmful algal blooms as they become more common on coral reefs around the world.

## 9-8

**The Good, the Bad, and the Smelly: Positive and Negative Settlement Cues for Coral Larvae**

**Raphael RITSON-WILLIAMS*[1]**, Valerie J. PAUL[1], Suzanne ARNOLD[2], Robert S. STENECK[2], Ilsa B. KUFFNER[3], Linda J. WALTERS[4], Mikel A. BECERRO[1,5]

[1]Smithsonian Marine Station at Fort Pierce, Fort Pierce, FL, [2]Darling Marine Center, University of Maine, Walpole, ME, [3]Florida Integrated Science Center, U.S. Geological Survey, St. Petersburg, FL, [4]Department of Biology, University of Central Florida, Orlando, FL, [5]Center for Advanced Studies, Blanes, Spain

How algal species proliferate in reef habitats and how they maintain "phase shifts" are critical questions to managing coral reef habitats. Some common reef algae (but not all) use chemical defenses to inhibit grazing by Caribbean reef fishes and the sea urchin *Diadema antillarum.* Algal natural products also mediate competitive interactions between algae and scleractinian corals. Some species of *Lyngbya* and *Dictyota,* as well as crude chemical extracts of some of these species, caused either recruitment inhibition or avoidance behavior in coral larvae. Conversely, coralline algae may be important indicators of suitable settlement substrata for coral larvae. The larvae of three spawning coral species, *Acropora palmata*, *A. cervicornis* and *Montastraea faveolata* were tested in the laboratory for their rates of settlement in response to different species of coralline algae. Some species of coralline algae were settlement facilitators, such as *Hydrolithon boergesenii*, *Neogoniolithon affine* and *Titanoderma prototypum*, but every coral species had the highest rates of settlement in response to a different species of coralline algae. Increased herbivory by more generalist consumers may shift the benthic community composition away from coral recruitment-inhibitors towards facilitators such as some species of coralline algae, thus improving the benthos for higher rates of coral recruitment.

## 9-9

**Natural Inducers For Larval Metamorphosis in Three Scleractinian Corals**

**Peter SCHUPP*[1]**, Makoto KITAMURA[2], Daisuke UEMURA[2]

[1]Marine Laboratory, University of Guam, Mangilao, Guam, [2]Department of Chemistry, University of Nagoya, Nagoya, Japan

Many benthic marine invertebrates, including corals, disperse among the plankton before settlement and metamorphosis. Finding a suitable habitat is especially important for larvae of sessile marine invertebrates that upon settlement cannot respond to changes in environmental conditions by moving to a more favorable environment. The ability of larvae to detect habitat-specific cues has been recognized in a range of phyla, but until recently, only a few studies identified the chemical structure of compounds involved in larval settlement and metamorphosis. This study was aimed at identifying compounds involved in the metamorphosis and settlement of three scleractinian corals. Experiments with whole crustose coralline algae (CCA) clearly demonstrated their ability to induce settlement in the scleractinian corals *Pseudosiderastrea tayamai, Acropora surculosa,* and *Leptastrea purpurea*. The previously reported bromotyrosine derivative, 11-deoxyfistularin-3, induced metamorphosis of *P. tayamai* larvae (approx. 28%) and the presence of the carotenoids fucoxanthinol and fucoxanthin increased metamorphosis to approximately 88%. However, experiments with these compounds did neither induce metamorphosis or settlement in *A. surculosa* and *L. purpurea* larvae from Guam. When we tested various chemical extracts of different CCA species from Guam, we only observed high rates of settlement with extracts from CCA of the genus *Hydrolithion* sp. Bioguided fractionation and subsequent structure elucidation of the *Hydrolithion* crude extract indicated a macrolactone as the active compound triggering metamorphosis in *L. purpurea* larvae. Further experiments testing the involvement of CCA biofilms, as well as biofilms from inert surfaces (e.g. tiles, bleached CCA), revealed that biofilms on *Hydrolithion* and biofilms on certain inert surfaces more than a week old repeatedly induced settlement in *L. purpurea* larvae. Experiments to determine the origin of the macrolactone (e.g. *Hydrolithion* itself or the associated biofilms) are ongoing.

## 9-10

**Effects Of Copper Toxicity On Three Species Of Scleractinian Corals**

**Gretchen BIELMYER*[1]**, Philip GILLETTE[2], Martin GROSELL[2], Ranjeet BHAGOOLI[2], Andrew BAKER[2], Chris LANGDON[2], Tom CAPO[2]

[1]Biology, University of North Florida, Jax., FL, [2]University of Miami, Miami, FL

Most corals thrive in a narrow range of water quality and temperature regimes and as such can be considered sentinels of our oceans' health. Globally, coral reefs have been declining at an accelerating rate. Caribbean reefs, in particular, have suffered an estimated 80% loss of reef cover in the last 30 years. Land-based sources of pollution and global warming have been identified as major stressors linked to these declines. Contaminants, such as metals, although noted as a concern have not been closely monitored in these sensitive ecosystems, nor have the potential impacts been characterized. There is a need to develop biomonitoring tools to assess potential effects of metal exposure. In this study, three species of laboratory-reared scleractinian corals, *Acropora cervicornis, Pocillopora damicornis,* and *Montastraea faveolata* were exposed to copper (ranging from 0-25 µg/L) for four weeks. At the end of the exposure period mortality, growth, copper accumulation, carbonic anhydrase activity, zooxanthellae density and electron transport rate were measured. The three coral species exhibited significantly different sensitivities to copper, with effects occurring at copper concentrations as low as 10 µg/L. The relationships between physiological/toxicological endpoints and copper accumulation within and between species will be presented as a means to elucidate the potential mechanism for effects and explain observed differences in sensitivity.

## 9-11

**Chemical Ecology is the Key to Understanding Sponges on Caribbean Coral Reefs**

**Joseph PAWLIK*[1]**

[1]Biology and Marine Biology, UNC Wilmington, Wilmington, NC

Sponges are now the dominant organisms on Caribbean coral reefs. Until recently, it was believed that consumers had little effect on reef sponges, because sponge-eating fishes were thought to spread their predatory activities over all available species to the detriment of none in particular. But research on the chemical ecology of this system has transformed our understanding of it. Laboratory and field experiments have revealed three distinct categories of sponges within the community: (1) defended species that are unpalatable to consumers because they contain secondary metabolites, (2) palatable species that sustain grazing by consumers yet are equally common as defended species on the reef, and (3) preferred species that are rapidly consumed when transplanted to the reef, and are found only in refuge habitats. The secondary metabolites responsible for the chemical defenses of several species have been isolated and identified using bioassay-guided fractionation and field experiments with natural populations of reef consumers. To counter the effects of grazing by fishes, palatable species appear to heal, grow or reproduce faster than defended species. Some sponge species compete with corals for space by producing metabolites that cause coral bleaching or that interfere with photosynthesis of coral symbionts. The predictive value of the foregoing is becoming evident: over-fishing may result in a release from predation of sponge species that are competitively superior to corals, reinforcing the current state of low coral cover on Caribbean reefs.

## 9-12

**Toxic Reef Syndrome: The Sponge-Seaweed Connection And The Consequences Of Allelopathic Impacts Of Sponges And Seaweeds On Degraded Caribbean Coral Reefs**

**Niels LINDQUIST*[1]**, Chris S. MARTENS[2], James L. HENCH[3], Jeremy B. WEISZ[4], Melissa W. SOUTHWELL[5], Brian POPP[6], Nyssa SILBIGER[1], Patrick GIBSON[2]

[1]Institute of Marine Sciences, University of North Carolina Chapel Hill, Morehead City, NC, [2]Department of Marine Sciences, University of North Carolina Chapel Hill, Chapel Hill, NC, [3]Environmental Fluids Mechanics Laboratory, Stanford University, Stanford, CA, [4]Department of Biological Sciences, Old Dominion University, Norfolk, VA, [5]Department of Chemistry and Biochemistry, University of North Carolina Wilmington, Wilmington, NC, [6]Department of Geology and Geochemistry, University of Hawaii, Honolulu, HI

Increasing global, regional and local stresses on coral reefs have resulted in a phase shift on Caribbean reefs from coral to sponge-seaweed dominance, yet little is know about the roles of sponges within the new ecology of degraded reefs. The goal of our sponge research, involving physical oceanographers, marine chemists and coral reef ecologists, is to rigorously determine how sponges alter the composition and abundance of small particles and dissolved chemicals in the seawater they process and how these changes impact reef ecology. On today's reefs, sponges can be exceptionally abundant, and with their high rates of filtration, contribute substantially to nutrient element cycling. We are finding that sponges re-mineralize much of the nitrogen in the particulate and dissolved organic matter they consume to ammonium and nitrate. Simultaneously, their high respiration rates substantially reduce levels of dissolved oxygen in the seawater they filter. The tremendous volumes of seawater many sponges exhale are hypoxic, rich in dissolved inorganic nitrogen, and likely sponge-produced toxins, all of which can harm corals. Sponge inputs of fertilizer to reefs have likely played a role in the proliferation of seaweeds on degraded Caribbean coral reefs, which along with the abrupt die-off of the once ubiquitous urchin *Diadema antillarum* have yielded an abundant algal community dominated by seaweeds and cyanobacteria chemically resistant to fish grazing. Chemicals exuded by these seaweeds and cyanobacteria further reduce benthic boundary layer water quality. While sponges can increase reef stability and provide food and shelter for other organisms, on degraded reefs with little coral cover, sponges likely interact with seaweeds to create an alternative stable state to coral dominated reefs and a chemically hostile environment that diminishes coral health and recruitment.

## 9-13

**Is Allelopathy Involved in Coral Death By Encrusting Excavating Sponges?**

**Andia CHAVES-FONNEGRA*[1]**, Leonardo CASTELLANOS[2], Sven ZEA[1], Carmenza DUQUE[2], Carlos JIMÉNEZ[3], Jaime RODRIGUEZ[3]

[1]Departamento de Biología and Centro de Estudios en Ciencias del Mar -CECIMAR-, Universidad Nacional de Colombia, INVEMAR, Cerro Punta de Betín, Santa Marta, Colombia, Santa Marta, Colombia, [2]Departamento de Química, Universidad Nacional de Colombia, Bogotá, Colombia, Bogotá, Colombia, [3]Departamento de Química Fundamental, Facultad de Ciencias, Universidade da Coruña, A Coruña, España, Coruña, Spain

The Caribbean encrusting and excavating sponges *Cliona delitrix* and *C. tenuis* successfully compete for space with reef corals, killing and displacing live coral tissue at rates of several cm per year. A bioassay guided fractionation of their extracts was carried out to find the compound(s) responsible, and a series of experiments to evaluate whether there is allelopathy involved and its possible mechanism. Ground and polished histological sections of the zone of sponge-coral contact revealed that coral polyp detachment does not seem to occur through erosion of their skeletal support. Healed sponge fragments placed directly over live coral for 1-2 days were killed by coral defenses for *C. tenuis* but not for *C. delitrix*; fragments of both sponges placed in close proximity to corals for 6 months did not have any effect on the adjacent coral tissue. The crude extract and the aqueous partition of both sponge species, and the *C. tenuis* pure compound [(-)-(5S)-2-imino-1-methylpyrrolidine-5-carboxylic acid)] (1), incorporated in gels at close to natural volumetric concentrations, killed coral tissue when brought into contact with live coral for 1-4 days. While compound 1 dissolved in seawater was only mildly toxic against live coral and dissociated coral cells, and killed coral larvae only at high concentration, the aqueous fraction of *C. delitrix* was toxic against live coral tissue, larvae and dissociated coral cells. Bioassay guided fractionation of *C. delitrix* aqueous fraction is under way. Although prolonged contact of compound 1 (and responsible compound(s) in *C. delitrix*) in the enclosed spaces of the coral skeleton may elicit polyp uplift or produce coral tissue death, other alternative mechanisms such as acid or enzyme secretion or histo-incompatibility cannot be ruled out.

## 9-14

**The Association Between The Orange Icing Sponge And Caribbean Corals-More Than A Mutualism?**

**Tse-Lynn LOH*[1]**, Joseph PAWLIK[1]

[1]University of North Carolina Wilmington, Wilmington, NC

Competition is intense on coral reefs due to limited resources, especially space. Contrarily, a mutualism has been reported between the Caribbean reef sponge *Mycale laevis* and scleractinian corals, with a putative advantage for the coral of protection from boring sponges and for the sponge of new substratum provided by the growing coral. Our past research has demonstrated that reef sponges can be categorized on the basis of their chemical defenses into defended, palatable, and preferred species, the last of which are restricted to physical refuges on the reef due to predation. *Mycale laevis* is described as having a semi-cryptic growth form, which predominates on reefs off Key Largo, Florida and the Bahamas. However, off Bocas del Toro, Panama, *M. laevis* is observed to grow with an unusually massive morphology. Crude extracts of both morphs of *M. laevis* are palatable to generalist fish predators, and surveys reveal that sponge-eating fish are very rare at Bocas del Toro compared to sites in the Florida Keys. Caging experiments will be conducted in the Florida Keys to determine the effects of predation on exposed fragments of *M. laevis*. The semi-cryptic habit of *M. laevis* growing under coral colonies or between coral branches could be the result of predation, and not a specific response to a mutualistic relationship.

## 9-15

**Phenotypic Plasticity in Chemical Defense And Growth Across A Depth Gradient in Caribbean Sponges**

**Marc SLATTERY*[1]**, Michael LESSER[2], Sridevi ANKISETTY[1], Deborah GOCHFELD[1]

[1]University of Mississippi, Oxford, MS, [2]University of New Hampshire, Durham, NH

Phenotypic plasticity represents one mechanism by which a species can expand its range across an environmental gradient while maintaining a positive energetic budget. The transition between shallow coral reef communities and deep reef communities in the tropics is characterized by reduced light, and consequently photosynthesis, resulting in potential trade-offs in energetic allocation. While reef-building coral diversity decreases with light, many sponges increase in abundance on reefs from shallow to deep depths. We examined these deep reef sponge communities (to 100m) in the Bahamas and the Cayman Islands over a period of five years using technical mixed gas diving. Biodiversity data from the deep reefs show a rich sponge fauna with approximately 15% endemism and more similarity to one another than to their respective shallow reef sponge communities. Agelas conifera and Plakortis angulospiculatus are two common sponge species that span the depth gradient from shallow to deep reefs. For both species, sponge size and growth rate increased with depth. Growth differences across the depth gradient can be explained by increased food availability at depth, but reduced levels of spongivory on the deep reefs might also result in an energetic trade-off from chemical defenses to growth. Feeding deterrence was higher in shallow water, whereas antimicrobial activity appeared to be greater at depth. Results to date indicate that different selective pressures in these ecosystems result in disparate phenotypes within sponge species that are manifested in plasticity between investments in chemical defense and growth.

## 9-16

**Antioxidant Activity Of Extracts And Secondary Metabolites From Pseudopterogorgia Sps**

**Maia MUKHERJEE*[1]**, Lyndon WEST[2], Howard LASKER[3], Gregory SCHMIDT[4], William FITT[1]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]Pharmaceutical and Biomedical Sciences, University of Georgia College of Pharmacy, Athens, GA, [3]Department of Geology, University at Buffalo, Buffalo, NY, [4]Plant Biology, University of Georgia, Athens, GA

Oxidative stress has been proposed as a mechanism of photoinhibition of photosynthesis in zooxanthellae that could lead to bleaching in symbiotic cnidarians. In a previous study, The addition of exogenous antioxidants to cultured zooxanthellae cells at elevated temperatures, with and without exposure to UV radiation, has resulted in the partial recovery of photosynthetic performance, suggesting that the fluxes of reduced oxygen intermediates were causing damage to the photosynthetic apparatus (Lesser, 1996). Caribbean octocorals, unlike other zooxanthellate cnidarians, seem to possess greater resistance to bleaching. Species of the genus Pseudopterogorgia harbor zooxanthellae of clade B. Previous research (Perez et al, 2000) has shown that in the sea anemone Condylactis gigantea, which also forms a symbiosis with clade B zooxanthellae, elevated temperature was followed by massive algal expulsion. This response is not observed in Pseudopterogorgia elisabethae subjected to similar experimental treatments. Branching octocorals have been the subject of intense investigation by natural product chemists, and have proven to be rich in novel compounds with interesting ecological and pharmacological properties. In this study, we examine the antioxidant potential of semi-purified extracts and purified secondary metabolites isolated from shallow-water Caribbean octocorals of the genus Pseudopterogorgia. We employ both the "Oxygen Radical Absorption Capacity (ORAC)" assay and a qualitative assessment of damage to PS 2 during exposure to elevated temperatures and UV radiation based on measurements of cellular fluorescence capacity with and without the addition of extracts and purified compounds. The ORAC assay depends on the free radical damage to a fluorescent probe through the change in its fluorescence intensity. The inhibition of free radical damage by an antioxidant, which is reflected in the protection against the change of probe fluorescence, is a measure of its antioxidant capacity against the free radical.

## 9-17

**New Hemiketal Steroid From The Introduced Soft Coral *chromonephthea Braziliensis* Ofwegan As Chemical Defense Against Generalist Fishes**

**Beatriz FLEURY*[1]**, Bruno LAGES[1], Jussara BARBOSA[2], Carlos KAISER[2], Angelo C. PINTO[2]

[1]Departamento de Ecologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil, [2]Departamento de Química Orgânica, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

Biological invasions in marine environments are one of the lesser understood aspects of global change (Occhipinti-Ambrogi & Savini, 2003). Recent studies, however, demonstrated that chemical defensive strategies may facilitate the invasion of the exotic soft coral *Chromonephthea braziliensis* Ofwegan (Nephtheidae, Alcyonacea) in the Brazilian Atlantic coast (Lages et al., 2006). We report for the first time, the detailed composition of the monohydroxylated sterol fraction, and a new hemiketal steroid, 23-keto-cladiellin-A, isolated from the unpalatable hexane extract from *C. braziliensis*. Bioassay-guided fractionation of this extract, incorporated into artificial food, revealed that this hemiketal steroid exhibits *in situ* potent feeding deterrent properties against generalist fishes, at the natural concentration. The major sterol fraction, containing the monohydroxylated sterols, was inactive in the bioassay. This result supports the enemy release hypothesis, the most commonly accepted theory to explain the success of invasive species in their new ranges.

## 9-18

**Uv Protective Sunscreen in Coral Reef Fish Mucus**

**Maxi ECKES*[1]**, Sophie DOVE[2], Alexandra GRUTTER[3], Ulrike SIEBECK[4]

[1]SIB, University of Queensland (UQ), St. Lucia, Queensland, Australia, [2]CMS, UQ, St. Lucia, Queensland, Australia, [3]SIB, UQ, St. Lucia, Queensland, Australia, [4]SBMS, UQ, St. Lucia, Queensland, Australia

Coral reefs typically have clear oligotrophic waters with a high UV transmission, which can damage tissues in marine organisms. The Great Barrier Reef (GBR), Australia has experienced a significant increase in the number of cloud-free days over the last 10 years causing an increase in UV-induced DNA damage in reef organisms. Fish were recently discovered to have sunscreen compounds in their external mucus suspected to be mycosporine-like amino acids (MAAs). Using High Performance Liquid Chromatography (HPLC), we examined epithelial mucus from the labrid *Thalassoma lunare* and 13 species of Scaridae. For the first time in fish mucus, MAAs were identified and quantified. In addition, to examine geographical variations, the MAAs from *T. lunare* were compared from three different latitudinal locations (Lizard Island, Heron Island, and North Stradbroke Island, Queensland) and from 13 species of parrotfish along a longitudinal gradient from inshore reefs (Lizard Island) to the outer edge reefs (GBR) to oceanic reefs (Osprey Reef). Depending on the species, different combinations and quantities of the MAAs asterina-330, palythene and mycosporine-N-methylamine serine were present. MAA levels from *T. lunare* decreased with distance from the equator. *Thalassoma lunare* from North Stradbroke Island had lower MAA levels (mycosporine-N-methylamine serine) or absent (palythene) compared with mucus from the more northern locations (Lizard Island and Heron Island). Furthermore, results from our longitudinal comparison showed that the MAA absorbance increased with distance from the mainland landmass to the more oligotrophic outer reefs, where UV penetration is higher. This study shows that the identity and quantity of MAAs in fish mucus not only varies among species but also within a species sampled in different locations. These suggest that the ecological role of MAAs in fishes is varied and complex and that several factors may affect the type and quantity of MAAs found in the mucus of reef fish.

## 9-19

**The Role Of Chemical Signals in The Feeding Behavior Of Crown-Of-Thorns Seastar, *acanthaster Planci***

**Ciemon Frank CABALLES*[1]**, Peter SCHUPP[1]

[1]Marine Laboratory, University of Guam, Mangilao, Guam

The crown-of-thorns seastar, *Acanthaster planci*, is a corallivore known for its capacity to cause large-scale coral mortality at high population densities and continues to be a reef management problem despite previous control efforts. There has been no active control of *A. planci* populations on Guam since the 1970's and manta tow surveys confirmed that *A. planci* continues to damage large areas of reef around Guam. Large aggregations, ranging from 23 to 336 individuals/ha of reef, were observed to feed mainly on Acroporids, especially encrusting *Montipora*. Preferential feeding by *A. planci* causes differential mortality among coral species, which can exert a major influence on community structure. However, the role of chemical signals in *A. planci* prey selectivity is still poorly understood. In this study, we tested the effectiveness of organic extracts from preferred coral species and α-linolenic acid, a previously identified feeding attractant. Feeding assays with *A. planci* were conducted in a Y-maze, using crude extracts incorporated into agar-based feeding plates at natural concentrations. *A. planci* individuals were attracted to crude extracts of *Montipora* sp. ($n=25$; $p<0.05$), *Acropora surculosa* ($n=25$, $p<0.01$), and 1% α-linolenic acid ($n=15$; $p<0.01$). We conclude that with further isolation and characterization, these feeding attractants could be incorporated into the design of traps or bait stations as a new tool for the management of potential *A. planci* population outbreaks.

## 9-20

**A New Role For Dimethylsulfoniopropionate (DMSP) As A Foraging Cue For Coral Reef Fishes**

**Jennifer DEBOSE*[1]**, Sean LEMA[2], Gabrielle NEVITT[1,3]

[1]Neurobiology, Physiology & Behavior, University of California - Davis, Davis, CA, [2]Biology and Marine Biology, University of North Carolina - Wilmington, Wilmington, NC, [3]Bodega Marine Laboratory, University of California - Davis, Bodega Bay

Planktivorous fishes must locate prey patches that can be widely-spaced and highly transient. The sensory cues that fish use to locate prey, however, are not well understood. While it has been speculated that some reef fishes use biogenic chemicals as aggregation or settlement cues, specific chemicals have yet to be identified. Dimethylsulfoniopropionate (DMSP) is a secondary metabolite produced by many species of marine algae. DMSP is released by algal cell lysis and zooplankton grazing, and its distribution in the ocean is commonly associated with areas of high primary productivity and foraging activity. While DMSP has been studied intensively for its role in oceanic sulfur cycles and global climate regulation, here we present the first experimental evidence that planktivorous reef fishes aggregate to controlled deployments of DMSP over coral reef habitat in the wild. We released DMSP (10-7 M) over the fringing coral reefs of Curaçao, Netherlands Antilles. We found that the density of three planktivorous fishes increased significantly over these DMSP release sites. Brown chromis (*Chromis multilineata*) numbers increased to nearly four times background levels ($\chi r2 = 9.66$, $P = 0.002$, $n = 8$). While creole wrasse (*Lepticus parrae;* $\chi r2 = 25.6$, $P < 0.001$, $n = 8$) and boga (*Inermia vitatta*) recruited to the release sites only in response to DMSP. The attraction of schooling planktivorous fishes to this specific, isolated chemical cue suggests that DMSP provides a sensory link between algal production and reef fish aggregations. DMSP is generally released by the natural foraging activity of zooplankton, and our finding that planktivorous fishes aggregated over experimental deployments of DMSP has important implications for our understanding of how fish locate productive patches for foraging and how chemically mediated behaviors may be impacted by changing global temperatures.

## 10-1

**Linking Herbivory To Coral Recruitment And Local Management**

**Suzanne ARNOLD*[1]**, Robert STENECK[1], Peter MUMBY[2], Valerie PAUL[3], Raphael RITSON-WILLIAMS[3]

[1]School of Marine Sciences, University of Maine, Walpole, ME, [2]Marine Spatial Ecology Laboratory, School of BioSciences, University of Exeter, Exeter, United Kingdom, [3]Smithsonian Marine Station at Fort Pierce, Fort Pierce, FL

Coral reefs worldwide have suffered reduced coral cover in response to large scale disturbances. Unfortunately, Caribbean reefs have shown little or no recovery following these disturbances, and while they decline, the debate over how to best manage for reef recovery persists. Coral recruitment is central to the recovery of corals reefs. Several studies (including our own) suggest that scraping herbivores, such as some species of sea urchins and parrotfish, correlate inversely with algal biomass and positively with juvenile coral abundance. This manipulative experiment tests the hypothesis that herbivory facilitates coral recruitment. We focus on herbivorous fishes, particularly parrotfishes, as regulators of fore reef macroalgae and ultimately the recruitment potential for Caribbean reefs. We chose reefs in Bonaire and Belize representing a gradient in parrotfish grazing from high to low, respectively. Within regions, we measured coral recruitment on terracotta tiles with and without stainless steel pegs that impede large parrotfish. The quantitative data on the frequency and intensity of grazing, the settlement of corals, and the algal biomass and community structure that developed surrounding the treatment and control tiles after one year (March 2007-March 2008) will be reported. With these data, we hope to provide further evidence for the link between healthy herbivorous fish populations, algal abundance, and coral recruitment, as well as timely scientific support for the need to protect parrotfish.

## 10-2

**The Effect Of Echinoids On Caribbean Coral Recruitment--A 20 Year Study**

**Harilaos LESSIOS*[1]**

[1]Smithsonian Tropical Research Institute, APO AA

The recruitment and survival of juvenile corals on natural substrates was followed at monthly intervals at the San Blas Islands (Caribbean Panama) on four reefs under four treatments from 1984 to 2004. One treatment consisted of complete removal of all echinoids, one of the presence of *Diadema antillarum* at pre-mass mortality densities, one of the presence of *Echinometra viridis*, and one of the presence of both species. Every 3-5 years, the treatments were rotated between reefs in order to separate treatment and reef effects. The results indicate that in the absence of sea urchins coral recruitment is reduced. *Diadema* (at 1 m-2) or *Echinometra* (at 14 m-2), or both (at these natural densities), have approximately equally positive effects for coral recruitment. *Siderastrea radians,* S. *siderea*, *Agaricia sp.*, *Favia fragum*, and *Porites astreoides* are the most frequently recruiting species, but they also show the highest post-recruitment mortality. *Diploria strigosa*, *Acropora palmata, Isophylastrea rigida, I. sinuosa*, *Montastraea annularis* and *M. cavernosa* recruit at much lower rates, but have higher per capita survival rates. Thus, echinoids play an important role in shaping Caribbean scleractinian communities.

## 10-3

**Coral Reef Resilience: Balancing Production And Herbivory**

**Fiona WEBSTER*[1]**, Russ BABCOCK[2], Mike VAN KEULEN[1], Neil LONERAGAN[1]

[1]School of Biology and Biotechnology, Murdoch University, Perth, Australia, [2]Marine Research, Commonwealth Scientific and Industrial Research Organisation, Floreat, Australia

The Ningaloo Reef provides a unique opportunity to investigate different components of a coral reef ecosystem without the confounding effects of poor water quality and severe overfishing. This research examined a) how macroalgae affects coral recruitment and b) the processes which drive macroalgal abundance. These experiments were conducted in the field using a series of caged, uncaged and partially caged treatments to examine herbivory and control for caging effects. It was identified for the first time, that both the pre- and post- settlement processes of coral recruitment were severely reduced by increased macroalgal biomass. In the presence of macroalgae - for the coral *Acropora millepora*: larval settlement was reduced by up to 93%, post settlement survival was approximately half and those which did survive were around 80% smaller compared to corals in uncaged plots which contained little macroalgae. This demonstrates that macroalgae can inhibit coral reef recovery by reducing coral recruitment.

Bottom up versus top down influences on macroalgal abundance were examined in a multifactorial study using slow release fertilizer and cages to manipulate herbivory. Nubbins of *Cyphastrea microphthalma* were used as a proxy for coral recruits. Nutrients had no effect on macroalgal biomass and coral calcification. Herbivores on the other hand had a strong overriding effect. The volume of macroalgae was up to 40 times greater in caged versus uncaged plots. Over a nine month period the growth of coral nubbins in cages beneath the macroalgae was reduced by approximately 50% compared to uncaged plots. Through video analysis it was identified that the most important herbivores for controlling macroalgal abundance were large parrot fish, in particular *Cholurus sordidus* and *Scarus schlegeli*. These results emphasize the importance of protecting herbivores, in particular larger scarids from overfishing to facilitate coral recruitment and promote coral reef resilience.

## 10-4

**Contrasting Effects of Benthic Algae on Coral Recruits in an Upwelling Reef from the Colombian Caribbean**

**Dagoberto VENERA-PONTON*[1]**, Guillermo DIAZ-PULIDO[2], Laurence MCCOOK[3], Alejandro RANGEL-CAMPO[1]

[1]Instituto de Investigaciones Tropicales-INTROPIC, Universidad del Magdalena, Santa Marta, Colombia, [2]Centre for Marine Studies and ARC Centre of Excellence for Coral Reef Studies, University of Queensland, Brisbane, Australia, [3]Great Barrier Reef Marine Park Authority-GBRMPA, Townsville, Australia

Reef degradation generally involves the replacement of hard corals cover by benthic algae. A successful recovery of coral populations will depend on the competitive ability of corals to settle, recruit, growth and survive on habitats dominated by benthic algae. Most studies on coral-algal interactions and on the impacts of algae on the recovery of coral populations have focused on the roles of algae on coral settlement and adult performance; however, there is very little known about the effects on the survival of coral recruits, a critical step in the resilience of coral reefs. Here we present the results of an experiment investigating 1) whether coral recruits actually compete for space with the surrounding benthic algae; 2) the effects of benthic algae on the growth and survival of coral recruits, and 3) the roles of algae on parrotfish predation on coral recruits. The study used recruits of the coral Porites astreoides and was carried out in the Tayrona National Natural Park in the Colombian Caribbean during two contrasting climatic and oceanographic seasons (upwelling and non-upwelling). We found that the growth of recruits of the coral P. astreoides was significantly increased when the surrounding algae were removed while a weak algal colonization occurred when the coral recruits were damaged. These results were consistent among the upwelling and non-upwelling seasons and constitutes an unequivocal proof for competition between algae and coral recruits. The coral recruits were bitten by parrotfishes only when the surrounding algae were removed and it was also consistent among the two seasons. This suggests that benthic algae may actually protect coral recruits from parrotfish damage. Our results illustrate the complexities of the effects of coral reef algae on the early life history stages of corals.

## 10-5

**The Influence Of Water Quality, Larval Supply And Surrounding Benthos On Coral Recruitment To Nearshore Reefs Of The Great Barrier Reef**

**Stephen J NEALE*[1]**, Damien THOMSON[1], Angus THOMPSON[1], Britta SCHAFFELKE[1]

[1]Australian Institute of Marine Science, Townsville, Australia

Ecological processes on nearshore coral communities of the Great Barrier Reef (GBR) are affected by agricultural and urban runoff. Elevated nutrient and sediment levels in runoff have detrimental impacts on many aspects of coral reproduction and may reduce the ability of nearshore coral communities to recover from other disturbances and hence, their resilience. Few studies have documented recruitment rates in nearshore waters of the GBR and it is unclear how recruitment varies across gradients of water quality and how the surrounding coral community influences spatial and temporal patterns in coral recruitment. As a part of a long-term marine monitoring program under the GBR Water Quality Protection Plan, hard coral recruitment has been monitored for three years (2005, 2006 and 2007). Terracotta settlement tiles were deployed on fringing reefs located along an assumed water quality gradient within each of four inshore regions, to examine the influence of water quality, larval supply and surrounding benthos on the recruitment success of corals. Numbers of hard coral recruits in this study were up to 10 times higher than previously recorded at the same locations, highlighting the large temporal variability of recruitment on GBR nearshore reefs. The influence of water quality on recruitment was variable, but recruitment did not generally increase with increasing distance away from the coast, where turbidity levels and nutrient availability are usually elevated. Characteristics of the surrounding adult hard coral communities, such as the taxonomic composition and the reproductive health (e.g., influenced by disturbance such as bleaching or mechanical damage in the previous year), also played an important role in determining both the quantity of recruits and their taxonomic composition. Sustained local larval supply is vital for the recovery of inshore coral communities from disturbances, and, conversely, large-scale disturbance such as coral bleaching have long-lasting negative effects on these communities.

## 10-6

**Complex Life Histories, Dynamic Populations And Multiple Disturbances: Can A Demographic Approach To Monitoring Help Conserve Coral Reefs?**

**James GILMOUR*[1]**

[1]Australian Institute of Marine Science, Perth, WA, Australia

Global decreases in coral cover resulting from an increasing combination of disturbances are directly related to changes in the rates of transition of life history stages of corals through their life cycle. Quantifying these transition rates for populations (vital rates) therefore provides a way to investigate the past and future consequences of disturbance regimes. However, disturbance regimes affect species and their life history stages differently. The quantification of vital rates in three studies provided evidence of the extent to which the contribution of stage transitions to population growth, and their variability following population decrease, depended on the coral and the disturbance regime. For example, in populations of a fungiid coral exposed to chronic disturbances, survival varied dramatically between sexual and asexual recruits of similar size, whereas survival varied little across all size classes in populations of *Acropora* free of chronic disturbances. Further, the relative importance of sexual recruits or other stages to population maintenance varied along a gradient of water quality in populations of *Acropora*, and for populations of fungiid coral according to whether disturbances were in the form of periodic cyclones or cyclones and chronic sedimentation. In these populations, demographic and temporal variability had implications for the application of their vital rates to projection models. In particular, changes in stage transitions were not independent, so that substituting transition values with those observed in other populations, time-steps, or experimental manipulations, further reduced the accuracy of projections aimed at simulating disturbance regimes. Nevertheless, the quantification of population vital rates and their application to simple matrix models was an effective means of understanding and summarising the impacts of complex regimes of disturbance, and the projection of population structure under a variety of hypothetical scenarios a useful means of illustrating the future consequences of not mitigating certain stressors.

## 10-7

**How Settlement Dynamics Determine The Abundance And Distribution Of Corals**

**Mark VERMEIJ*[1]**, Stuart SANDIN[2]

[1]Botany Department, University of Hawaii, Lahaina, HI, [2]Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, La Jolla, CA

Studying the earliest life-stages of corals (i.e. settled planulae and recently metamorphosed polyps) is problematic due to their small size and cryptic behavior and therefore limited information exists on the earliest demographics of corals. Here we present a combination of field and laboratory studies from the Caribbean and Hawaii aimed at revealing the factors that determine settler abundance and subsequent settlement success. Local densities of heterospecifics (algae and microbes) and conspecifics have profound effects on rates of settlement and early post-settlement survivorship. The early benthic phase of corals represents a severe demographic bottleneck whereby >80% of the initial number of settlers will not survive for more than one year. During this period, density-dependent and density-independent effects of microbes and benthic algae have profound effects on settler survivorship laying a foundation for their future distribution. The effects of algae and microbes can be positive or negative and depended on a settler's developmental stage. Increasing adult cover causes higher local settlement rates but only when total cover is low (<10%). Early post-settlement survivorship decreases with adult cover, revealing structuring density dependence in coral settlers. Survival probabilities increase dramatically after a settler divided for the first time and forms a 2-polyp colony, however, the capability to do so decreases with age. Combined, settlers are interactively affected by the presence of conspecifics, algae and microbes driving local rates of settlement and subsequent settlement success. By the time that a coral settler reaches one year of age, most of the severe and structuring mortality and demographic bottlenecks have passed.

## 10-8

**Survivorship Of Juvenile Corals Depends On Distance From Adult, Microbial Abundance And Water Current Direction**

**Kristen MARHAVER*[1]**

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA

The recovery of Caribbean coral populations will depend largely on successful recruitment of juveniles. In many tropical and temperate tree species, mortality of seeds and seedlings increases with proximity to adults of the same species, a key prediction of the Janzen-Connell model of tropical tree diversity attributed to the action of host-specific predators and/or pathogens. If similar distance-dependent mortality occurs in coral populations, it will affect the rate and pattern of coral recruitment. To test for distance-dependent mortality and its potential causes, I examined the effects of water current direction, distance from adult colony and microbial abundance on the survivorship of *Montrastraea faveolata* juveniles in field and laboratory experiments. In field manipulations, newly settled coral recruits placed up-current from adult *M. faveolata* colonies had significantly higher survivorship than those placed down-current from adult colonies. Within up-current locations, survivorship was highest at 96 cm and 192 cm distances; this was significantly higher than survivorship at 24 cm and 48 cm distances. In laboratory manipulations, swimming coral larvae experienced significantly increased mortality in water collected within 4 cm of an adult colony compared to water collected 2 m up-current from the same colonies. This difference in survivorship was eliminated when water was filter-sterilized to remove microbes and particulate organic matter. The swimming behavior of pre-settlement larvae differed significantly between filtered and unfiltered water treatments. Together, these experiments reveal a distance-dependent pattern of mortality in *M. faveolata* juveniles and suggest that microbes from adult colonies are a likely driver of increases in mortality.

## 10-9

**Importance of Post-Settlement Mortality on Scleractinian Population Maintenance around Moorea, French Polynesia**

**Lucie PENIN*[1,2]**, Francois MICHONNEAU[1,2], Andrew H BAIRD[3], Sean R CONNOLLY[3,4], Morgan S PRATCHETT[3], Mohsen KAYAL[1,2], Mehdi ADJEROUD[1,2]

[1]Université de Perpignan, UMR CNRS EPHE UPVD 5244 Biologie et Ecologie Tropicale et Méditerranéenne, Perpignan, France, [2]UMS CNRS 2978, CRIOBE, Papetoai, French Polynesia, [3]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townville, Australia, [4]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

At a fundamental level, spatial variation in the abundance and community structure of scleractinian corals must be influenced by patterns of larval settlement. However, spatial variation in early post-settlement mortality has the potential to greatly distort patterns established at settlement, and the relative influence of variation in settlement rates and post-settlement processes on spatial dynamics of coral assemblages remains largely unknown.

In this study, spatial variation in mortality of recruits (< 3 months of age) and juvenile corals (< 5 cm in diameter; ~1-4 years of age) was quantified in three depth zones at each of three locations and round Moorea, French Polynesia. Mortality of coral recruits was extremely variable and particularly high (50 % in 7 days), and is associated with the abundance of parrotfishes (Fam. Scaridae). Juvenile mortality was less intense (up to 40 % in 14 months), but also shows strong spatial variability, corresponding with variation in abundance of butterflyfishes (Fam. Chaetodontidae).

Spatial variability in early post-settlement mortality partly accounts for apparent differences in the abundance of coral recruits versus juveniles corals, highlighting the potential importance of post-settlement processes as a driver of spatial variation in the dynamics of coral assemblages. Moreover, variation in early-post settlement mortality of corals appears to be influenced mainly by local densities of Scaridae and Chaetodontidae, which each affect a different stage in the life-cycle (recruits versus juvenile corals, respectively).

## 10-10

**Reproductive Demography Of *siderastrea Radians* in The St. Martins Keys, Florida**

**Katherine LAZAR*[1]**, Thomas FRAZER[1], Charles JACOBY[1], Colette ST. MARY[2]

[1]Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, [2]Department of Zoology, University of Florida, Gainesville, FL

The reproductive demography of corals plays a significant role in their population dynamics by influencing reproductive success. The objectives of this study are to quantify spatial variation in: 1) density, 2) size distribution, 3) fertility, and 4) sex ratio in a population of *Siderastrea radians* in the St. Martins Keys, Florida. Initially, corals were counted and measured in 10 quadrats placed at random points along one randomly oriented, 25-m transect at each of 81 sites arrayed in a 16-km2 grid. Results from the survey indicate that corals were distributed in patches (mean Morisita Index = 5.98; range = 0–20), with densities ranging from 0.0 to 86.0 individuals m–2 (mean = 7.0 individuals m–2). The size-frequency distribution was typical of other scleractinian populations, with the majority of individuals falling within the smallest size classes (positive skew). A statistically significant linear regression showed that numbers of individual polyps, i.e., recruits, increased with numbers of putative adults ($p < 0.001$). To quantify the relationships among density, aggregation, and sex ratio, corals were collected from 10 sites with different combinations of density and aggregation (i.e., high density/low aggregation, medium/low, low/low, low/medium, and low/high). Preliminary histological data corroborates previous reports of a female-biased sex ratio in this species. Overall, results point to the potential importance of small-scale, demographic patterns in determining the reproductive success and population dynamics of *S. radians*.

## 10-11

**Survival Dynamics Of Azooxanthellate Scleractinian Coral Larvae And Implications For Dispersal**

**Erin GRAHAM*[1]**, Andrew BAIRD[2], Sean CONNOLLY[3]

[1]School of Tropical and Marine Biology, James Cook University, Townsville, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]ARC Centre of Excellence for Coral Reef Studies, and School of Tropical and Marine Biology, James Cook University, Townsville, Australia

Survival of pelagic marine larvae is an important determinant of dispersal potential. For scleractinian corals, however, few studies of larval survival are long enough to provide accurate estimates of longevity. Moreover, changes in mortality rates during larval life have implications for connectivity among reefs and have not been quantified for any coral species. This study quantified the survival of larvae from five scleractinian corals (*Acropora latistella*, *Favia pallida*, *Pectinia paeonia*, *Goniastrea aspera*, and *Montastraea magnistellata*) to estimate larval longevity and test for changes in mortality rates as larvae age. Maximum lifespans ranged from 195-244 d, substantially exceeding those documented previously for azooxanthellate corals and predictions based on metabolic rates. In addition, larval mortality rates exhibited strong patterns of variation throughout the larval stage. Three periods were identified in four species: high initial rates of mortality; followed by a low, approximately constant rate of mortality; and finally, increasing mortality after approximately 100 d. The observed lifetimes suggest the potential for long-distance dispersal may be substantially greater than previously thought, probably because larvae regulate their energy use. Indeed, detection of increasing mortality rates late in life suggests that energy reserves do not reach critically low levels until approximately 100 d. Conversely, increased mortality rates early in life decrease the likelihood that larvae transported away from natal reefs will survive to reach nearby reefs, and thus decrease connectivity at regional scales. These results show how variation in larval survivorship with age may help to explain the seeming paradox of high genetic structure at metapopulation scales, coupled with extensive geographic ranges, observed in many coral species.

## 10-12

**The Effect Of Ultraviolet Radiation On Different Stages Of The Life Cycles Of Mass Spawning And Brooding Scleractinian Corals**

**Anastazia BANASZAK*[1]**, Ana Laura GARCÍA LÓPEZ[1], Braulio AVILA RAMÍREZ[1]

[1]Photobiology, Universidad Nacional Autónoma de México, Puerto Morelos, Mexico

Ultraviolet radiation (UVR, 280 to 400 nm) is an important physical factor affecting shallow water reef communities. The effect of ecologically relevant doses of UVR was determined on different stages of the life cycle of the reef-building corals Montastraea faveolata and Acropora palmata, both summer mass-spawning species, as well as on Favia fragum, a species that broods larvae to the planula stage and releases them on a monthly basis. Four different early-development life stages (blastula, gastrula, non-motile planula and motile planule) of Montastraea and Acropora were exposed to artificial solar UVR that was equivalent to a one day dose of natural solar radiation. The gastrula was found to be the most sensitive life cycle stage of Acropora whereas all stages of Montastraea were equally sensitive as determined by mortality during exposure to UVR in comparison to larvae exposed without UVR. Post-exposure mortality rates also differed, with the Acropora planula and Montastraea motile planula being the most sensitive of the four stages. Due to their small size and monthly reproduction, Favia colonies are more amenable to experimental manipulation. Favia colonies were exposed to natural levels of solar radiation over a 13 month period. Colonies in treatments with UVR filtered out produced 9 times as many larvae as colonies exposed to UVR. The larvae that were produced exhibited significantly higher mortalities during exposure to UVR as did juveniles when compared to exposures without UVR. Settlement rates, sites and preferences were also affected in the presence of UVR. Our date show that UVR is an important physical factor in the life cycle of mass spawning and brooding reef corals and should be considered in discussions on reef connectivity and ecology.

## 10-13

**Species Specific Habitat Selectivity Of *Acropora* Larvae In Subtropical Reefs**

**Go SUZUKI*[1,2]**, Takeshi HAYASHIBARA[3], Yoshihisa SHIRAYAMA[2], Hironobu FUKAMI[2]

[1]Division of Applied Biosciences, Graduate School of Agriculture, Kyoto University, Wakayama, Japan, [2]Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto University, Wakayama, Japan, [3]Ishigaki Tropical Station, Seikai National Fisheries Research Institute, Ishigaki, Japan

*Acropora* is one of the most abundant and diverse genera of scleractinian corals in the Indo-Pacific reefs. Distribution of *Acropora* corals often showed a specific pattern of zonation particularly on reef slopes, with corymbose and table colony shapes dominating shallow waters (less than 5 m depth), and branch shaped colonies dominating deeper waters. Environmental factors such as wave action and light intensity have been shown to impact post-settlement survival of *Acropora* corals and play a role in the creation of this pattern. To date the role of larval settlement in establishing *Acropora* zonation has been rarely assessed because of the difficulty in species identification of new recruits. Here, to test the hypothesis that larvae settle selectively on species specific suitable habitat, we identified recruits with two-step molecular sorting process using mitochondrial and nuclear markers to successfully distinguish the seven most dominant species in the study area (Okinawa, Japan). The distribution of the larval settlement of the three dominant species *A. digitifera*, *A. hyacinthus* and *A. tenuis* was significantly related to distribution shown by adult colonies, suggesting that *Acropora* larvae selectively settle on suitable habitats. This is the first *in situ* evidence showing selective settlement of coral larvae. Although yet undocumented, pre-settlement behavior such as species specific swimming abilities may play a role in determining the pattern of reef corals.

## 10-14

**Influence Of Benthic Communities On The Settlement And Post-Settlement Survival Of Two Reef Corals in The Florida Keys**

**Maggy NUGUES*[1,2]**, Alina SZMANT[3]

[1]Dept. of Marine Ecology and Evolution, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands, [2]Center for Marine Science, University of North Carolina Wilmington, Wilmington, [3]Center for Marine Science, University of North Carolina Wilmington, Wilmington, NC

Coral reef recovery depends on the ability of reef corals to recruit successfully to replenish depleted populations. Given the structural and ecological importance of reef-building corals, it is important to understand the factors that determine their ability to achieve successful sexual recruitment. To investigate the role of benthic communities on coral recruitment, we experimentally settled larvae of *Montastraea cavernosa* and *M. annularis* onto settlement plates pre-conditioned at three sites in the Florida Keys. The coral spat were mapped and the composition of the encrusting community characterized on each plate. The plates were then returned to their initial position in the field and retrieved at different time intervals for further monitoring of coral spat and community structure. Results showed that the side of the plates had a much larger effect than location on coral settlement. Although the plates were placed vertically during experimental settlement, the undersides had approximately 1 order of magnitude higher numbers of settlers. 87% of the spat settled directly on microfilm (single cell algae) and only 9% settled on crustose coralline algae, a well known cue for coral settlement. Post-settlement survivorship was 2% after 9 months, with 71% of the spat dying the first 30 days. Survivorship was not associated with the benthic community present on the plates during the first month. However, there was a negative association between survivorship and the cover of overgrowing invertebrates during the second and third months. Thus, biological interactions appear as major factors influencing coral settlement and post-settlement, but other factors must be sought to explain the high mortality of coral spat during the first month of settlement.

## 10-15

**Do Coralline Algae Influence Coral Recruitment On A Reef?**

**Nichole PRICE*[1]**

[1]University of California, Santa Barbara, Santa Barbara, CA

Settlement preferences of sessile invertebrates may be adaptations to local community interactions, particularly if selection of appropriate microhabitat influences early post-settlement survivorship. Laboratory studies indicate that many reef-building corals can be induced to settle by chemical cues in the cell walls of crustose coralline algae (CCA). However, it is unclear if the availability and location of cue-containing CCA on the reef can influence local recruitment patterns of scleractinian corals. This study examines biotic factors influencing the abundance and distribution of CCA and subsequent consequences for coral recruits using the settlement cue. Results of a field coral recruitment experiment indicated that Pocilloporid and Acroporid corals exhibit a hierarchical selection for substrate among five common CCA species. Electivity indices calculated for corals settling to coralline algae species with thin crusts (eg., *Titanoderma prototypum*) were significantly greater than for species with thicker thalli (eg., *Porolithon onkodes* and *Lithophyllum insipidum*). Pair-wise field competition experiments revealed that thick-crusted coralline species were superior space competitors when exposed to transient herbivores, but competitive dominance switched otherwise. CCA producing thin thalli were most susceptible to grazing and were scarred more deeply when exposed to herbivores. Therefore, Pocilliporid corals select to settle upon CCA species exhibiting particular morphological characteristics that may influence the survival and growth of settlers. Coral settlers may even be facilitated by *T. prototypum* as recruits found on this CCA were less likely to be overgrown by other CCA or macroalgae and survivorship was enhanced at least two-fold. *T. prototypum* can also influence coral recruitment indirectly by indicating microhabitat that is protected from incidental mortality by large herbivores. Thus, CCA that cannot withstand biotic disturbances and are competitive dominants in crevices may indicate or even provide spatial refuges that are most suitable for recruitment of reef-building corals.

## 10-16

**Fishing-Induced Changes in Fish And Sea Urchin Abundance Cause Reductions in Crustose Coralline Algae Cover And The Availability Of Coral Settlement Substrate**

**Jennifer O'LEARY*[1]**, Tim MCCLANAHAN[2]

[1]Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]Wildlife Conservation Society, Mombasa, Kenya

Fishing can have cascading effects on trophic structure that influence ecosystem processes such as primary production, calcification and reef stability. Crustose coralline algae (CCA) are a calcifying component of reef ecosystems that comprise the primary settlement substrate for corals. Using a 20-year dataset from coastal Kenya we demonstrate that a fishing-induced change in the dominant grazers can dramatically impact CCA cover. CCA is highest in long-term protected areas (reaching a percent cover similar to that of corals), intermediate in short-term protected areas, and lowest in fished areas. CCA cover is strongly positively correlated with fish biomass and negatively correlated with sea urchin biomass. We use a short-term experiment to investigate the direct impacts of fish and sea urchin grazing on CCA growth rates. While both fish and sea urchins affect CCA growth, the effects are in opposite directions: fish increase CCA cover, but sea urchins reduce CCA growth rates almost to zero. We conclude that on the Kenyan coast, fish have a strong indirect positive effect on CCA (through sea urchin predation) leading to high cover in marine protected areas, while sea urchins have a strong direct negative impact on CCA, greatly reducing CCA cover in fished areas. Fishing can thus lower the amount of settlement substrate available to corals, reducing the ability of reef systems to recover from disturbance. Our results are in contrast with those of previous studies on CCA from temperate systems that show a direct positive association between sea urchin grazing and CCA, and with studies in the Caribbean that show a direct positive association between fish grazing and CCA. Our study demonstrates an ecosystem effect of fishing on an understudied but ecologically critical reef component (CCA), while challenging existing paradigms regarding the relationship between grazers and CCA.

## 10-17

**The Influence Of Macroherbivores On The Macoralgal Dynamics Of A Caribbean Coral Reef**

**Stephen BOX*[1]**, Peter MUMBY[1]

[1]Marine Spatial Ecology Lab, University of Exeter, Exeter, United Kingdom

The spatiotemporal dynamics of macroalgae remain poorly understood despite being the spatial dominant on many Caribbean coral reefs. Whilst herbivores are recognised for their essential role in controlling the abundance and distribution of algae, how they affect macroalgal dynamics and the availability of potential settlement space for corals is less clear. Using transition matrices generated from the occupation states of small permanent quadrats, across successive months, we use generalised linear models to assess the factors controlling the dynamics of available space and those of two dominant macroalgal species, *Lobophora variegata* and *Dictyota pulchella*, on shallow forereefs in Honduras. Using exclusion cages the influence of macro-herbivores on these dynamics were then evaluated. The study found that the rapid occupation and transient dynamics of both macroalgal species across the surfaces of dead coral restrict available space. Unoccupied space was at a minimum in the sheltered microhabitats preferred by coral recruits, resulting in less than 0.06% of the total surface area of dead coral being both in sheltered habitats and free from algal occupation for six months continuously. This spatiotemporal limitation may severely restrict successful coral recruitment. When macro-herbivores were excluded, the availability and persistence of unoccupied space decreased, but the increase in cover by both macroalgal species investigated here were limited by competition from other benthic algae. Herbivory influenced algal dynamics across the surfaces, including the sheltered areas which they could not access. In reducing overall algal cover, herbivores reduce the reoccupation rate and persistence time of algae, affecting their dynamics even in the cryptic areas that cannot be grazed directly. However, the current parrotfish dominated herbivore regime of the study site may actually be beneficial to these two algal species by restricting competition from other algal groups.

## 10-18

**Environmental Stress Drives Seasonal Changes in Top-Down And Bottom-Up Regulation Of Coral Community Structure And Resilience**

**Peggy FONG*[1]**, Matthew WARTIAN[1]

[1]Ecology and Evolutionary Biology, University of California Los Angeles, Los Angeles, CA

Theory predicts that the strength and relative importance of processes structuring communities will vary predictably with changes in environmental stress. In this study, we used a comparative approach by performing two experiments to assess differences in bottom-up (nutrients) and top-down (herbivory) forces on changes in tropical eastern Pacific coral reef community structure and resilience during periods of increasing and decreasing environmental stress due to upwelling. We found that as upwelling intensity increased, herbivores were unable to limit increases in algal cover, which expanded into areas previously dominated by live coral. Additionally, experimental nutrient enrichment reduced coral and enhanced algal cover both in the presence and absence of herbivores at the beginning of the upwelling season. Nutrient additions initially shifted the algal community toward macroalgae, while later it favored turfs. In contrast, in the experiment conducted when upwelling intensity declined, herbivores effectively reduced algal cover and increased live coral cover while experimental nutrient enrichment effects were not significant. However, a combination of herbivory reduction and nutrient enrichment shifted the algal community to dominance by crustose forms. Based on our findings, we conclude that both nutrients and herbivory are important factors in determining coral community structure and resilience, although the relative importance of each was influenced by environmental stress. Large-scale increases in environmental stress decreased the relative importance of top-down forces, increased the dominance of bottom-up forces, and enhanced algal overgrowth of corals. However, once environmental stress was alleviated, herbivores strongly enhanced coral community resilience, reversing phase shifts to greater algal dominance.

## 10-19

**Environmental Stress Changes The Relative Importance Of Top-Down (Herbivorous Fishes) And Bottom-Up (Nutrients) Forces Regulating Community Structure And Resilience Of Coral Reefs**

**Matthew WARTIAN*[1,2]**, Peggy FONG[3]

[1]Weston Solutions, Carlsbad, CA, [2]Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, [3]Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, CA

Understanding the roles of top-down and bottom-up forces in determining community structure and resilience has increasingly become the focus of ecological studies as human influences on ecosystems have intensified, changing the strength of forces, and resulting in phase shifts to alternate states. Recent phase shifts of marine communities are attributed to human impacts, including nutrient enrichment, overfishing of predatory and herbivorous fishes, and increases in environmental stress. For coral reefs, many have hypothesized that herbivores are of primary importance to reef resilience, limiting the proliferation of macroalgae and enhancing coral recovery after stress. However, there have been few experimental studies testing this hypothesis. Here we provide evidence that an intact herbivore community reversed macroalgal overgrowth of coral following a period of environmental stress. Recovery of coral dominance after episodic low-temperature stress was dependent upon the presence of herbivores, a top-down force that removed algal proliferation and prevented further coral mortality. Without environmental stress, no phase shift was initiated indicating that reductions in herbivory alone may not cause community shifts. Rather, without environmental stress both herbivory and bottom-up forcing by nutrients regulated coral/algal dominance, although the magnitude of community changes was relatively modest. We conclude that the ability of coral communities to recover from environmental stress is undermined by overfishing, while maintenance of reef stability is also dependent on nutrients. Our results provide scientific support for the worldwide call for protection of reef fishes as a key management goal, especially in the face of increasing nutrification and environmental stress.

## 10-20

**A Biophysical Perspective Of Grazing in Pacific Parrotfish**

**Sonia BEJARANO*[1]**, Victor TICZON[2], Peter MUMBY[1]

[1]Marine Spatial Ecology Lab, University of Exeter, Exeter, United Kingdom, [2]Marine Science Institute, University of the Philippines, Manila, Philippines

Since grazing by parrotfishes plays a crucial role in processes of reef recovery, this study aimed to understand the way it is affected by important biophysical variables. Data collection took place in the Palau archipelago during May 2006. Individual bite rate within three contrasting reef locations was modelled as a function of time of day, tidal direction and height, species/genus and fish total length (TL). Individual bite area was estimated from jaw dimensions of parrotfish at the fish market. Bite area for each of the most abundant parrotfish genera was modelled as a function of TL. Bite rate and bite area models were combined with local fish census data to predict the grazing impact (m2 hour-1) of individuals of the most abundant species as well as of the whole assemblage of parrotfish. Most species focused their grazing on algal turfs but also included a broad range of substrates including live coral. In general, bite rate was negatively correlated with TL and lower in the morning. In particular, bite rate differences among species were detected in two sites, a different effect of body size depending on the genus in one of these sites and a significant effect of tidal height during midday in another site. Bite rate of initial phase Chlorurus sordidus also seemed to be moderated as tidal height increased in midday. Bite area of all genera was linearly related to TL, similar curves for these relationships were obtained for four genera. Output models identify the relative contribution of some species, species and size classes to overall grazing. We show that the conversion of fish census data to modelled grazing will potentially give a more insightful metric of grazing than using biomass as a simple surrogate.

## 10-21

**The Roles Of Nutrients And Herbivory in Controlling Micro-And Macrobioerosion Patterns in Eastern African Reefs**

**Marina CARREIRO-SILVA*[1,2]**, Timothy MCCLANAHAN[3], Victor KENNEDY[1], Joseph MIHURSKY[1], Marjorie REAKA[4]

[1]Chesapeake Biological Laboratory, Center for Environmental Science, University of Maryland, Solomons, MD, [2]Departamento de Oceanografia e Pescas, Universidade dos Açores, Horta, Portugal, [3]Wildlife Conservation Society, Bronx, NY, [4]Department of Biology, University of Maryland, College Park, MD

The roles of nutrients and sea urchin and fish herbivory in controlling patterns and rates of internal bioerosion by micro- and macroborers were studied on nine reefs along the East African coast. Bioerosion rates by microborers (algae, bacteria, and fungi) were measured at three to six months intervals using herbivore-exclusion cages and experimental substratum made of *Lambis chiragra* mollusk shells. Bierosion rates by macroborers (mainly worms, bivalves and sponges) were measured on branching *Porites* killed during the 1998 bleaching event, four and six years after their death. Hypotheses tested were that (1) rates of micro- and macrobioerosion would be correlated with the spatial variation in nutrient availability; (2) grazing by herbivorous fish and sea urchins would reduce measurable microbioerosion and macrobioerosion rates. In contrast to result of experimental studies in Glovers reef, Belize, no clear relationship was found between nutrient levels and microbioerosion and all reefs experienced high colonization and bioerosion rates by microbial endoliths. Instead, microborers' density of colonization and bioerosion rates were negatively correlated with current speed and cover of encrusting coralline algae. In contrast, macrobioerosion rates were positively correlated with chlorophyll *a* concentrations in reef waters. Microbierosion rates were more influenced by grazing fish whereas macrobioerosion rates were more influenced by sea-urchin biomass. A complex mix of physical, chemical and ecological processes interact in determining rates of bioerosion. Macroborers, which are predominantly suspension and filter feeders, are more influenced by particulate organic material and plankton in the water column. Microborers may be stimulated by inorganic nutrients, but coralline algae may inhibit colonization of microborers by reducing light availability.

## 10-22

**Vegetarians Are Shallow: Declining Herbivore Pressure With Depth**

**Eran BROKOVICH*[1,2]**, Shai EINBINDER[2,3], Inbal AYALON[4], Nitzan SEGEV[4], Yonathan SHAKED[4], Amatzia GENIN[3,4], Moshe KIFLAWI[5,6], Salit KARK[1]

[1]The Biodiversity Research Group, Department of Evolution, Systematics and Ecology, The Hebrew University of Jerusalem, Jerusalem, Israel, [2]Marine Twilight-Zone Research & Exploration (MTRX), The Interuniversity Institute for Marine Sciences at Eilat (IUI), Eilat, Israel, [3]Department of Evolution, Systematics and Ecology, The Hebrew University of Jerusalem, Jerusalem, Israel, [4]The Israel National Monitoring Program, The Interuniversity Institute for Marine Sciences at Eilat (IUI), Eilat, Israel, [5]Department of Life Sciences, Ben-Gurion University, Beer-Sheva, Israel, [6]The Interuniversity Institute for Marine Sciences at Eilat (IUI), Eilat, Israel

Coral reef herbivore fishes play an important role in mediating competition between fast growing benthic algae and relatively slow-growing corals. Herbivore abundance and composition may be affected by primary production levels which will decline with decreasing light levels along the depth gradient. Herbivory studies, even those related to depth gradients, have traditionally concentrated on shallow coral reefs. Hence, the importance of herbivory in deep coral reefs (> 30 m) remains largely unexplored. This study aims to examine herbivore assemblage-structure and potential pressure on turf and macro-algae down to a depth of 65 meters. The study combines visual census of fish assemblages; field measurements of turf algae growth rate; and in-situ evaluations of herbivore pressure using caged vs. exposed settlement plates and bioassays. The number of herbivore species dropped threefold between 5 m and 65 m; along with a decrease in their abundance and algal growth rate. At 65 m most individuals sampled where large roaming Scarids. The rate of macro-algae consumption was 2.25 gr dry algae/hour at one meter depth and dropped rapidly (as a function of the natural log of depth) to almost zero at 65 m. This pattern correlated with fish abundance and biomass. The percent of turf algae consumed increased from 30% in one meter to 60% in 10 m then declined to near zero in 50 m. The lower herbivory pressure in the deep reef suggests that the role of fishes in maintaining suitable algal-free substrate for coral recruitment is less significant than in shallow reefs. Whether or not algae can out-compete corals at these depths due to eutrophication and whether herbivorous fish can mitigate an increase in algal growth remains to be examined.

## 10-23

**The Role of Herbivory in Structuring Benthic Algal Communities on the Great Barrier Reef**

**Andrew HOEY*[1]**, David BELLWOOD[1]

[1]ARC Centre of Excellence for Coral Reef Studies and School of Marine and Tropical Biology, James Cook University, Townsville, Australia

We used a combination of visual census and algal transplants to examine the relationship between herbivore distribution and relative removal rates of macroalgae. The distribution of herbivorous fishes and removal rates of *Sargassum* sp. was quantified on two reefs in each of three cross-shelf regions on the northern Great Barrier Reef. *Sargassum* sp. collected from an inner-shelf reef flat was transplanted to the reef crest and back reef of each reef for a period of 24 hours. The rate of removal of *Sargassum* was greatest on mid-shelf reefs (57.5 – 79.9%.d-1), and decreased markedly on both inner- (10.8 – 16.9%.d-1) and outer-shelf reefs (10.1 – 10.4%.d-1). These relative rates of removal were poorly correlated with the abundance and biomass of macroalgal browsers and all herbivorous fishes, collectively. The biomass of macroalgal browsers on the outer-shelf reef crest was at least double that of any other habitat yet the rate of *Sargassum* removal was the lowest. In contrast, the mid-shelf reef crest displayed the highest rate of *Sargassum* removal yet the biomass of macroalgal browsers was an order of magnitude lower than that of the outer-shelf reef crest. These results highlight the potential difficulties of modeling ecosystem processes on correlative relationships alone.

## 10-24

**Size-Dependent Variation in The Functional Role Of The Parrotfish Scarus Rivulatus On The Great Barrier Reef, Australia**

**Roberta BONALDO*[1]**, David BELLWOOD[1]

[1]Australian Research Council Centre of Excellence for Coral Reef Studies and School of Marine Biology, James Cook University, Townsville, Australia

Biodiversity loss and fishing-induced changes in the size distributions of fishes can impact ecosystem function on coral reefs. These changes have led to an urgent need for studies on the particular roles of species, to underpin effective coral reef management. The present study focuses on the feeding ecology of six size classes (from 2.5 to 30 cm total length) of *Scarus rivulatus* (family Labridae), one of the most abundant parrotfishes on the Great Barrier Reef, Australia. Individuals in all six size classes strongly selected the epilithic algal matrix for foraging and rejected other substratum types, including coral, macroalgae and sand. The six size classes also had similar feeding rates (bites.min-1) and diel feeding patterns, with higher feeding activity during the afternoon. However, the size of grazing scars by *S. rivualtus* differed significantly among the six size classes, with small individuals scraping a greater substratum area per unit biomass and larger individuals taking greater volume of material per unit biomass. Thus, biomass can not be not be viewed as a proxy for ecosystem impact; different sized individuals of *S. rivulatus*, and probably other parrotfish species, have a markedly different impact on the benthic community. Selective harvesting of large individuals will therefore change the functional role of this species. These results emphasize the importance of considering the size of individuals when evaluating the role of reef species in ecosystem process. These intraspecific functional differences will be critical when formulating reef management strategies and evaluating the impact of fishing activity on reef ecosystems.

## 10-25

**Herbivory Under Altered Community States -Is What You See What You Get?**

**Rebecca FOX*[1]**, David BELLWOOD[2]

[1]ARC Centre of Excellence for Coral Reef Studies, School of Marine and Tropical Biology, James Cook University, Fadden, ACT, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, School of Marine and Tropical Biology, James Cook University, Townsville, QLD, Australia

Herbivorous fishes are widely acknowledged as a key element in maintaining the health and resilience of coral reef ecosystems. Quantifying the relative impact of individual species of herbivore is essential if we are to identify systems at risk of undergoing phase-shifts and develop an understanding of how such shifts could be reversed. Traditional approaches have used diver-based observations of herbivore abundance to quantify herbivory. But is what we see in terms of herbivore distribution really representative of all herbivorous activity occurring on coral reefs? We made use of remote underwater video cameras to observe the process of herbivory in the absence of divers under natural and altered community states, the latter being created using macroalgal transplants. Continuous recordings of the diurnal feeding activity of roving herbivores were made across different reef habitat zones and the impact (area of reef grazed per day) of each of the major species was quantified. While the overall pattern of relative grazing intensities across the reef under natural and degraded conditions coincided, the process of herbivory differed dramatically between the two states. Of the three dominant taxa recorded at the location under natural conditions, none played a role in the removal of macroalgae in the altered state. Instead, the agent of macroalgal removal was a species not previously recorded at the location. Our findings highlight that species critical to the healthy functioning and resilience of reef systems may have gone unnoticed in previous observations of natural foraging patterns. The implications of the differences in grazing activity among community states will be discussed in the context of herbivory as an agent of disturbance, and the potential roles of individual species in the resilience and recovery of coral reef ecosystems will be highlighted.

## 10-26

**Herbivory On Coral Reefs: The Challenge Of Change**

**David BELLWOOD*[1,2]**

[1]Marine Biology, James Cook University, Townsville, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, Townsville, Australia

This presentation will examine our understanding of the role of herbivorous fishes on coral reefs. Herbivory is widely accepted as one of the most important processes on coral reefs. Yet, despite over four decades of research on herbivory we are still at the stage of identifying the players and their respective roles. This apparent lack of progress reflects rapid changes in our understanding of the potential role of herbivorous fishes in ecosystem processes and the emergence of new challenges. Global warming and direct human activity are rapidly changing coral reef ecosystems. Herbivorous fishes have switched from animals that eat algae to critical functional groups with important roles in supporting reef resilience, preventing coral-algal phase shifts and underpinning reef regeneration. The key question now is: which of the herbivorous fishes are important for the future of coral reefs and why? In this presentation I will: a) provide an historical overview of research on fish based herbivory, with an emphasis on the Great Barrier Reef; b) examine the implications of recent methodological advances in the application of remote underwater video techniques; and c) explore our ability to critically evaluate the status of today's coral reefs.

## 10-27

**Continuing Decline Of *montastraea* Populations On Protected And Unprotected Reefs in The Florida Keys National Marine Sanctuary.**

**Struan SMITH*[1]**, Richard ARONSON[2], John OGDEN[3]

[1]Georgia State University, Atlanta, GA, [2]Dauphin Island Sea Lab, Dauphin Island, AL, [3]Florida Institute of Oceanography, St. Petersburg, FL

Coral populations in Fully Protected Zones and on adjacent unprotected reefs in the Upper and Lower Florida Keys were assessed in terms of percent cover, recruitment, and juvenile and adult colony survival rates from 1998 to 2005. Analysis of random video transects showed that, overall, percent coral cover has declined by 50% on both protected and unprotected reefs during this period. The framework-building corals *Montastraea* spp. have declined in absolute cover from 5% to 2% in the Lower Keys and from 2% to 1% absolute cover in the Upper Keys on both protected and unprotected reefs. Censuses of corals in permanent quadrats revealed that three coral genera recruited successfully every year: *Siderastrea* spp. (5-10 m-2 yr-1), *Porites* spp. (1-2 m-2 yr-1), and *Agaricia* spp. (0.5-1 m-2 yr-1). However, the *Montastraea annularis* species complex have shown very low recruitment rates (<0.02 m-2 yr-1), and high rates of colony shrinkage and mortality (5-40% per year, across different size classes). *Montastraea cavernosa* has recruited slightly more successfully (0.2-0.5 m-2 yr-1) but still suffered high mortality rates (2-26% per year, across different size classes). Transition-matrix population models based on these rates of change in different size classes predict a 50% decline in existing *Montastraea* populations in the next 7-10 years. The Fully Protected Zones thus have not improved the status of resident *Montastraea* populations.

## 10-28

**Relative Strengths Of Factors Affecting Community Structure in The Main Hawaiian Islands**

**Danielle JAYEWARDENE*[1]**

[1]Zoology, University of Hawaii at Manoa, Honolulu, HI

While Marine Protected Areas (MPAs) are an increasingly advocated tool for managing coral reefs, they represent manipulation of only one of several factors that influences the coral community, the level of predation. Beyond this factor, coral reef communities are structured by; 1) the dispersal of larvae to the reef; 2) physical conditions such as temperature, salinity, currents, wave energy; 3) resources such as space, light, habitat and food; 4) other biological interactions such as competition and mutualisms; and 4) disturbance regimes. The objective of this study was to determine which of these factors are primary influences on the structure of reef communities in the Main Hawaiian Islands. Principal Component Analyses were applied to analyze the relationships between the abundance of herbivorous fishes, the cover of macro-, filamentous- and crustose coralline algal, the composition of the coral community, and the relative difference in abundance of grazing versus boring urchins across 9 coral reef sites in the Islands. Results indicate that the principal component structuring the coral community is wave energy. Thus while MPAs across the globe and in Hawaii have been shown to promote the size and abundance of fish populations, the coral community seems to be strongly influenced by physical processes beyond that of the control of marine protection. Establishing MPAs will thus not necessarily protect these reef communities in the face of large scale threats such as global warming that increases the intensity of storms and thus wave energy which in turn suppresses coral cover and thus growth of the reef calcium carbonate framework.

## 10-29

**Coral Reef Assemblages and Diversity in the Volcanic Northern Mariana Islands**

**Peter HOUK*[1]**, John STARMER[1]

[1]CNMI Marine Monitoring Program, Saipan, Northern Mariana Islands

The volcanic Northern Mariana Islands (NMI) provide a unique opportunity to examine patterns in coral-reef assemblages, diversity, and reef growth due to varying island size, volcanic activity, and environmental regime. Initially, this study explores why patchy, inconsistent reef growth is evident throughout the archipelago by examining if there are linkages between 'reef types' and the modern assemblages growing upon them. The 'reef types' examined were: 1) volcanic boulders, 2) colonized boulders, 3) low-slope Holocene and sand, 4) complex, colonized Holocene, 5) complex, uncolonized Holocene, and 6) high-slope, sheltered Holocene. Replicated, quadrat-based surveys were conducted at 41 sites to gather coral colony size and taxon occurrence data. The initial results showed that 'reef type' acts as a good predictor of modern coral assemblages, however, taxon occurrence data showed less affiliation with 'reef type', rather an 'island effect' emerged. Most islands supported distinct populations of algae and invertebrate species. Building from this base, regressions between island size, volcanic disturbance, salinity, and species richness are interpreted to approach existing theories that explain diversity patterns. Notably, island size had a positive, log-log relationship with species richness across many phyla, including corals. The differing z-values, or rates of increase, suggest different levels of connectivity may exist between the local and regional populations for different phyla. Deviations from the expected species-area relationship for corals (e.g. residuals) were positively related to the number of years since volcanic activity has occurred. At a minimum, the presence of a favorable foundation is required for sustained coral growth, while coral populations and reef diversity rise on large islands that are less influenced by freshwater and volcanic disturbances. For the NMI specifically, the results provide a desirable context for developing management strategies to maintain and enhance the biological integrity of these remote islands.

## 10-30

**The Rise And Fall Of A Coral Reef Ascidian**

**Noa SHENKAR*[1]**, Omri BRONSTEIN[2], Yossi LOYA[1]

[1]Zoology Department, Tel Aviv University, Tel Aviv, Israel, [2]Tel Aviv University, Tel Aviv, Israel

Although ascidians constitute a minor benthic component on exposed surfaces on natural coral reefs they play an important role in the carbon and nutrients cycles in coral reef ecosystems. Eutrophication of these ecosystems may result in vast changes in the densities and distribution of colonial ascidians and their interaction with benthic biota. In the coral reefs of Eilat, a new colonial ascidian, *Botryllus eilatensis*, has been observed rapidly colonizing artificial substrates and overgrowing dead coral skeletons. Monthly monitoring of 50 - 70 tagged coral colonies interacting with *B. eilatensis* was conducted in order to study overgrowth dynamics and the relationship between coral morphology, size, and orientation and ascidian overgrowth. Results show that the rate of *B. eilatensis* overgrowth was influenced by the coral's morphology and orientation combined with a seasonal appearance of the ascidian. During spring (April - June) the average ascidian cover percentage was 27 ± 4.6 %; decreasing rapidly during summer months. This seasonality is linked to the vertical mixing phenomenon that occurs in Eilat every winter. This was corroborated when *B. eilatensis* fragments translocated to a nutrient rich site were observed to increase three fold in size and exhibited higher survivorship rates in comparison to the intact fragments remained in a reference site. Increased anthropogenic activity, particularly the eutrophication occurring along the Israeli coasts, creates favorable conditions for filter-feeding organisms such as ascidians, providing them with an advantage in competition for space with reef-building corals and other organisms.

## 10-31

**Population Dynamics Of The Corkscrew Anemone Bartholomea Annulata On Caribbean Coral Reefs: Implications For Anemoneshrimp Symbionts And Fish Cleaning Stations**

**Michael NELSEN*[1]**, Stephen RATCHFORD[2], Nanette E. CHADWICK[1]

[1]Auburn University, Auburn, AL, [2]University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Large sea anemones are conspicuous components of coral reef communities, yet little is known concerning their population dynamics. On Caribbean coral reefs, the corkscrew anemone Bartholomea annulata hosts an assemblage of obligate shrimp symbionts, some of which are important cleaners of parasites from large reef fish. Thus, the stability and recovery from disturbance of anemone host populations may impact the coral reef community at several trophic levels. During 2006-2008, we monitored the dynamics of populations of B. annulata at 2 coral reef sites near St. Thomas, US Virgin Islands. The abundance and body size of individuals both were significantly higher at an inshore than an offshore reef site. At both sites, recruitment was rapid and populations were extremely dynamic. Rates of growth and mortality decreased with body size; small individuals tended to either grow rapidly or die, while large individuals either shrank or did not change in size, and rarely died. Some individuals in all size classes reproduced asexually to produce small buds (clonal replicates), resulting in a rapid potential expansion of populations. We applied matrix modeling and sensitivity analyses to determine which life stage most impacted change in these populations. Based on these demographic characteristics, we also provide recommendations for the support of a sustainable fishery on these anemones, which are heavily collected for the ornamental aquarium trade. We conclude that rapid population turnover in this sea anemone leads to radiating effects on the stability of obligate anemoneshrimps and the location of fish cleaning stations on Caribbean reefs.

## 10-32

**What Is The Future Of The Threatened *acropora Palmata*? Population Projections And Management Recommendations**

**Tali VARDI*[1]**, Dana E. WILLIAMS[2,3], K. Lindsey KRAMER[4]

[1]Scripps Institution of Oceanography, La Jolla, CA, [2]Cooperative Institute for Marine and Atmospheric Studies, University of Miami RSMAS, Miami, FL, [3]Southeast Fisheries Science Center, NOAA Fisheries, Miami, [4]Pacific Island Network Inventory and Monitoring Program, National Park Service, Kailua-Kona, HI

*Acropora palmata* was once the dominant hermatypic coral in shallow reef environments throughout the Caribbean, Florida, and Bahamas. Since the 1980s it has suffered a 97% decline in abundance throughout its range and was included on the US Endangered Species List in 2006. Despite the dramatic nature of this decline, and the loss of habitat that would be caused by an extinction, neither abundance nor rates of decline have been documented systematically throughout the Caribbean. In Autumn 2007, abundance of *Acropora palmata* was estimated in Florida, Puerto Rico, Jamaica, Virgin Gorda, and Curaçao. Abundance in Florida was dramatically lower than in other sites. The scarcity of *Acropora palmata* in Florida is explained by increased hurricanes and disease, problems that are difficult to manage. To explore population changes in more detail and to help identify life history stages most affected, a size-based population model was developed. Based on *Acropora palmata*'s population trajectory since 2004, as measured by a standardized, size-based demographic monitoring protocol in the Florida Keys, the local population will reach a stable distribution in 20 years. At that time, the current population structure, in which 35% are pre-reproductive and 45% are reproductive, will have become dominated by pre-reproductive individuals and only 20% of colonies will reproduce sexually. This loss of large individuals would also reduce the number of asexually derived fragments, leading to an overall decrease in abundance of colonies in Florida. Parallel data from the island of Curaçao from 2006-7, show both a greater overall abundance of *Acropora palmata* and no significant change in the relative abundance of larger individuals. Significant changes in size distribution can warn of impending phase shifts. These results suggest that determining and eliminating the causes of mortality in large adults are key conservation priorities for Florida reefs.

## 10-33

**Testing A Novel Functional Group Approach For Caribbean Hard Corals By Comparing Their Rank Abundances Across The Florida Reef Tract Also Refutes The Unified Neutral Theory**

**Thaddeus MURDOCH*[1,2]**, Richard ARONSON[3,4]

[1]BREAM: Bermuda Reef Ecosystem Assessment and Mapping Programme, Bermuda Zoological Society, Flatts Village, Bermuda, [2]Murdoch Marine Environmental Consultant Services Ltd., Paget, Bermuda, [3]Marine Science, Dauphin Island Sea Lab, Dauphin Island, AL, [4]Marine Science, University of South Alabama, Mobile, Alabama

A functional group approach can be used to categorize organisms by adaptive traits instead of phylogeny. One such approach, the "Adaptive Strategies Theory" (AST), originally developed for terrestrial plants, was modified to apply to reef corals. The coral AST predicts the assemblage structure of Caribbean reef corals from fundamental habitat characteristics. Accordingly, species and functional groups of coral differ in dominance in a predictable manner, depending upon the levels of resource and disturbance of the habitat they are in. Alternatively, the unified neutral theory (UNT) proposes that all coral species are functionally equivalent, and the ranking of any species will be random from site to site, regardless of the environmental conditions of the reef habitat.

Examination of patterns of rank abundance across 10 transects on each of 20 sites located across the Florida Reef Tract, encompassing a quantified gradient of disturbance, determined that eleven species out of a pool of at least 36 species were highly significantly more abundant than the rest. These 11 abundant species belonged to three different functional groups, and, for these species, the species members of each functional group were statistically more similar in rank and site affinity than were species belonging to other functional groups. The rarer species, alternately, showed rank-abundances and distributions across transects that were without apparent pattern. The functional-group differences in rank-abundance were also highly non-random. The dominance patterns of each functional group relative to the level of disturbance measured on each of the 200 transects fit the predictions of the newly proposed coral AST. These results indicate certain traits indicate functional responses in corals, that all coral species are not equivalent in their functional responses. As a consequence, the fundamental hypothesis of the UNT that all species of coral are functionally identical is also refuted.

## 10-34

**Spatial Dynamics Of Scleractinian Coral Populations in The Florida Keys**

**Dione SWANSON*[1]**, Mark CHIAPPONE[2], Steven MILLER[2], Leanne RUTTEN[2], Steven G. SMITH[1], Jerald AULT[1]

[1]Marine Biology and Fisheries, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [2]Center for Marine Science, University of North Carolina-Wilmington, Key Largo, FL

Natural and anthropogenic disturbances have caused major changes in reef species composition worldwide during the past few decades resulting in significant decreases in coral cover and abundance. Traditional monitoring metrics such as percent coral cover and species richness have not provided an avenue to address the processes that contribute to these changes. Knowledge of population dynamics of corals is required to address questions concerning the sustainability of coral reefs. Colony density and size structure provide information on fundamental demographic rate processes (colony recruitment, growth, mortality, and survivorship) as well as the net outcome of these processes. To address coral population structure and recruitment in the Florida Keys, adult (colonies >4 cm in diameter) and juvenile (colonies < 4 cm diameter) abundance were estimated using a two-stage stratified random sampling survey design. Primary sample units (sites) were allocated among thirteen reef-types (habitat strata) within the Florida Keys reef tract (survey domain). Design features included strategic sampling that produced relatively precise population estimates and the ability to statistically compare multiple sites within and among benthic habitats over relatively broad spatial scales. From 1999-2006, surveys of coral colonies were conducted at sites which spanned the range of habitats along Florida Keys reef tract through the Dry Tortugas. Quantitative analyses addressed coral population structure in three categories: descriptive and species size analysis, coral-habitat regression analysis, and habitat use analysis. These results help to discern the influence of habitat type and location on demographic processes that regulate coral population size structure and facilitate inferences concerning the consequences of the current coral population distributions in the Florida Keys.

## 10-35

**Partial Mortality Of Caribbean Corals: Modes, Trends, And Consequences**

**Jessica GILNER*[1]**, Robert VAN WOESIK[2]

[1]Biological Sciences, Florida Institute of Technology, Melbourne Beach, FL, [2]Biological Sciences, Florida Institute of Technology, Melbourne, FL

Partial mortality leads to changes in life-history strategies and energetics, which can jeopardize colony fitness and survival. Increases in partial mortality of coral colonies are arguably the primary mechanism of declines in coral cover in the Caribbean. In 2005, an intense coral bleaching event was recorded on reefs at Puerto-Morelos, Mexico. We applied a hierarchical sampling design, using randomly selected 75 x 25 m stations as our effective sampling units nested within five sites spaced 1-2 km apart. Re-randomized 50 x 1 m belt transects were used to sample partial morality of coral colonies during and after the bleaching event. In 2006, three 4 x 4 m permanent quadrats were established at each station to track colony changes through time. In 2005, bleaching was recorded on 88% of surveyed colonies. Using the re-randomized sampling, there was an increase in the frequency of partial mortality from September 2005 to August 2007 in some species, while other species were less affected. The permanent quadrats detected different trends because of the manner in which corals undergo partial mortality. For example, *Diploria strigosa* and *Agaricia agaricites* are more likely to die at peripheral edges, while other species, such as *Porites astreoides* and *Siderastrea siderea* undergo patchy mortality within the colony. The former mortality process is more difficult to detect with one-off surveys, but are detectable when plots are examined over time; both processes lead to changes in size-frequency distributions. Partial–mortality trends do not appear to depend on reproductive strategies but rather the degree of colony integrity. Some species appear more vulnerable at the colony periphery, while others loose integration and are vulnerable throughout. While species-specific partial mortality serves as a reliable indicator of coral stress, there are clearly two different modes, and both are useful proxies of population dynamics.

## 10-36

**Spatial Aggregation Promotes Species Coexistence Of Reef-Building Corals**

**Joshua IDJADI*[1]**, Ronald KARLSON[1]

[1]Biological Sciences, University of Delaware, Newark, DE

Scleractinian coral species with varying competitive abilities often occur in communities where shared resources are limited. Despite this, these communities can be very diverse, without dominance by the best competitors. We experimentally tested the role of spatial heterogeneity, specifically the spatial arrangement of competitors, in promoting species coexistence among corals. Using a strong competitor (*Porites rus*) and a weaker one (*P. lobata*) we addressed the hypothesis that when corals are intraspecifically aggregated, coexistence is increased. When these corals were placed into artificial competitive neighborhoods, weaker competitors grew at almost twice the rate when they were grown in aggregated versus non-aggregated patterns. Further experimental work suggested that aggregation is most important when there is no refuge from competition for weaker competitors. The results of these experiments were extrapolated to larger spatial and temporal scales by a discrete space model. The persistence of weaker competitors was increased substantially when the beneficial effect of aggregation was applied to this model system. This research adds to evidence from other work in plant systems that spatial arrangement can promote species coexistence in competitive, resource limited communities.

## 10-37

**Fish Demography in The Large**

**Richard VANCE*[1]**, Mark STEELE[2], Graham FORRESTER[3]

[1]Ecology & Evolutionary Biology, UCLA, Los Angeles, CA, [2]Biology, California State University Northridge, Northridge, CA, [3]Natural Resources, University of Rhode Island, Kingston, RI

Effective management of commercial coral reef fish metapopulations will require creation of marine protected areas. Informed design of MPA's must employ demographic rate functions that drive fish metapopulation dynamics. Unfortunately, practical constraints usually force measurement of demographic rates on small portions of individual reefs, a spatial scale far too small to apply directly to metapopulations. Using these measurements therefore requires some way of "expanding" them to the spatial scale of entire large coral reefs.

This talk will describe a practical scaling-up procedure. We will show, for the bridled goby *Coryphopterus glaucofraenum* (a convenient non-commercially fished species) how a whole-reef density-dependent death rate function can be constructed from an empirically measured death rate function that applies at the local scale. The procedure employs a computer simulation model that follows the fates of individual gobies in all 2m x 2m cells of a large reef. The reef habitat varies spatially both in its local density of crevices that provide refuge from predators to goby adults and in the substrate's attractiveness to goby settlers. From simulated cell-level demographic data is calculated a whole-reef per capita death rate, and this rate is then statistically fitted to a function of whole-reef goby and refuge densities using maximum likelihood methods.

Density dependence at the whole-reef scale is highly statistically significant and can be described by a function whose form resembles that of the local-scale function. However, reef spatial heterogeneity forces some adjustment in parameters. Indeed, density dependence at the whole-reef scale actually proves stronger than at the local scale. We shall display how scaling up the death rate function is influenced by variability in local refuge density and in local settler attraction, by the correlation of these reef attributes, and by the spatial scale on which this habitat heterogeneity occurs.

## 10-38

**Large-Scale Experiment Reveals Effects Of Habitat Structure On Coral Reef Fish Assemblages**

**Mark STEELE*[1]**, Graham FORRESTER[2], Jameal SAMHOURI[3], Clare WORMALD[2]

[1]Department of Biology, California State University Northridge, Northridge, CA, [2]Department of Natural Resources Science, University of Rhode Island, Kingston, RI, [3]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA

The structure of coral reef fish assemblages is usually strongly correlated with attributes of reef structure. Experimental studies on small patch reefs have improved our understanding of how certain attributes of reef structure (e.g., shelter hole size) influence these assemblages, but it is not clear if these results from small-scale experiments extrapolate to larger spatial and temporal scales. We manipulated the abundance of rubble habitat to evaluate how this shelter-providing habitat affected the structure of coral reef fish assemblages at large scales. We added several tons of limestone rubble and conch shells to one half of each of 5 large (3,000-15,000 $m^2$), isolated reefs near Lee Stocking Island, Bahamas. We tracked changes in the reef fish assemblage with underwater visual censuses over 4 years. On rubble addition halves of reefs, several species of small fishes (damselfishes, wrasses, and gobies) became more abundant, whereas several similar species in the same families were unaffected. Small-scale habitat associations and results of previous small-scale habitat manipulations generally did a good job of predicting which species would be affected by the habitat manipulation and which were not. Larger species (e.g., snappers, grouper, and squirrelfishes) were unaffected by the manipulation, presumably because they are not dependent on small crevices for shelter and their abundance is not influenced by the abundance of smaller potential prey species that increased as a result of the rubble addition. There was no strong evidence that any species was negatively affected by the habitat manipulation. Thus, our results indicate that assemblage structure can by altered by large-scale habitat manipulations, which increase the abundance of some habitat-dependent species, without unintended negative effects on other species.

## 10-39

**Extrapolating From Small-Scale Experiments: Predation And Refuge-Shortage in Coral Reef Fishes**

**Graham FORRESTER*[1]**, Mark STEELE[2], Jameal SAMHOURI[3], Richard VANCE[4]

[1]University of Rhode Island, Kingston, RI, [2]Biology, California State University Northridge, Northridge, CA, [3]NOAA Fisheries, Seattle, WA, [4]University of California Los Angeles, Los Angeles, CA

Although field experiments allow rigorous tests of ecological hypotheses, they are usually limited to small spatial scales. We often want to know if their findings extrapolate to larger scales, especially when seeking to apply their results to conservation and management. Experiments on small coral reef fishes (bridled gobies) occupying small habitat patches reveal that locally density-dependent mortality is inflicted by predators. As prey become crowded, they suffer a progressively increasing shortage of structural refuges. Consequently, goby mortality at small-scales is well described by a model in which vulnerability is proportional to the ratio of gobies to refuges. A manipulation of refuge abundance on entire reefs, which are the size of small marine reserves and approach the scale at which some reef fisheries operate, suggests that a similar interaction occurs at this much larger spatial scale. This result is in accord with a scaling model which indicates that the effects of refuge shortage on entire reefs can be extrapolated from the model describing goby vulnerability as proportional to the ratio of fish to refuges. In simple terms, the biological interactions causing density dependence scale up. Careful extrapolation from small-scale experiments identifying species-interactions may thus be possible, and so should improve our ability to predict the outcomes of alternate management strategies for coral reef fishes.

## 10-40

**Musical chairs: competition for unguarded refuges and density-dependent mortality**

**Jameal SAMHOURI*[1,2]**, Richard VANCE[3], Graham FORRESTER[4], Mark STEELE[5]

[1]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, [2]Department of Ecology and Evolutionary Biology, UC Los Angeles, Los Angeles, [3]Department of Ecology and Evolutionary Biology, UC Los Angeles, Los Angeles, CA, [4]Department of Natural Resources Science, University of Rhode Island, Kiingston, RI, [5]Department of Biology, California State University Northridge, Northridge, CA

Predation is widely recognized as a dominant structuring force in marine populations and communities. As a result, refuges that reduce predation risk can be an important limiting resource in prey populations, ultimately mediating the occurrence and strength of density-dependent mortality. On coral reefs, many fishes retreat to unguarded structural refuges, such as crevices under coral or other hard substrate, only in response to a predator strike. This behavior leads to a type of competition for refuges that resembles conceptually the childhood game of musical chairs: prey scramble to find a safe place to hide when threatened or attacked, and only when refuges are abundant relative to the number of retreating prey is it likely that individuals will successfully evade predation. We introduce a new mathematical function to describe the relationship between structural refuges, population density, and per capita mortality in bridled gobies (*Coryphopterus glaucofraenum*) under this form of competition. In this model, we assume that the proximate cause of all goby deaths is predation, a fixed fraction of individuals do not respond to predator strikes by retreating to structural refuges, and the remaining individuals are capable of seeking shelter in a fixed number of unguarded refuges when threatened or attacked. Therefore, the likelihood of an individual dying during a predation event is either constant and density-independent or directly proportional to refuge availability, and these two components of mortality are not additive. In comparison to conventional density-dependent mortality functions, our musical chairs function provides a much improved fit to available empirical data for bridled gobies. We suggest that the musical chairs function may have broad applicability to other coral reef fishes, and more generally, for species in which refuges from predation are a limiting resource but territorial refuge-guarding does not occur.

## 10-41

**Substrate Effects On Reef Fish Distribution**

**Karen NEELY*[1]**

[1]Ecology, Duke University, Beaufort, NC

Western Atlantic coral reefs host up to 750 species of fish. It has been hypothesized that substrate characteristics control the abundance and distribution of these fish, but this has traditionally been examined at a community level. I conducted a correlational study in Curacao, Netherlands Antilles, that addressed fish abundances at the level of species and age class. I also experimentally tested habitat preferences in two ways. Choice experiments on adults of common species determined the influence of live coral and rugosity in an isolated environment, while habitat preferences of adults and juveniles in a multi-species environment were tested using *in situ* artificial reefs that differed in live coral cover. As a whole, these studies showed rugosity to greatly affect total abundance and diversity, while live coral cover had a slight effect on these community parameters. However, this small effect of live coral masks large differences at the species and age class level. For coral cover and other measures of substrate, both positive and negative selections were seen among species, but these preferences did not follow a readily identifiable taxonomic or niche classification. Algae-feeding species within the genus *Stegastes*, for example, showed both positive and negative preferences for live coral. Ontogenetic changes in habitat preferences were also documented. These results suggest that changes in live coral cover on a reef would affect fish communities in ways not observable using the standard community measures of fish distribution.

## 10-42

**Competitive Displacement Vs. Habitat Structure: The Selection Agents That Shape Microhabitat Recognition Of A Damselfish Over Time**

**Mati HALPERIN*[1]**, Yehuda BENAYAHU[1]

[1]Department of Zoology, The George S. Wise Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel

The three-spot dascyllus, *Dascyllus trimaculatus* Rüppell, has generally been described as recruiting to sea-anemones. However, in a preliminary survey in Eilat, northern Red Sea, we recorded *D. trimaculatus* individuals mainly in branching coral colonies. Intrigued by the lack of *D. trimaculatus* juveniles in their typical microhabitat, we studied the fish abundance and distribution there through a survey of types of microhabitat and their structural features, in addition to a fish census, aimed at developing and experimentally testing a hypothesis regarding microhabitat preferences. We addressed the question of whether the distribution of *D. trimaculatus* is regulated by the presence of competitor fish species through mechanisms of displacement, or whether it is microhabitat-dependent, taking into account specific microhabitat recognition by damselfish at their various life stages. A distinct pattern of distribution of corals and damselfish was revealed, in which the marine lab site constituted the major habitat for *D. marginatus* while the jetty site hosted *D. trimaculatus.* We also found that it is the abundance of *Pocillopora* coral microhabitats that determines the population distribution of *D. trimaculatus* in Eilat. Consequently, it is suggested that the abundance and distribution of both *Dascyllus* species may follow the general pattern of the competition model, emphasizing their apparent need for specific microhabitats. In addition to the competitive displacement, which excludes *D. trimaculatus* individuals from their congeners' microhabitat (i.e. *Stylophora* colonies), and determines the population distribution at the microhabitat level, we also suggest that the specific recognition of a microhabitat by juvenile *D. trimaculatus* may play a major role in determining the distribution of its population at the macrohabitat level. The demographics of *Dascyllus* fish in Eilat may reflect a unique situation in which the selection forces of microhabitat recognition by *D. trimaculatus* have undergone alteration over time.

## 10-43

**Fish Grazers As Gatekeepers Of The Species Composition Of Coral Reefs**

**Paul YOSHIOKA*[1]**

[1]Marine Sciences, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico

In this report I propose that intermediate-sized (about 15 cm long) fish mesograzers play a critical role in determining the species composition of sessile coral reef communities. Fish mesograzers include parrotfishes (Scaridae), wrasses (Labridae) and surgeonfish (Acanthuridae) that feed on small prey. I describe these fish as gatekeepers in the sense that they control the entry of small (newly recruited) prey individuals into coral reefs. In contrast, keystone grazers control the 'post entry' abundances of larger sized prey. The gatekeeper scenario is based on several well-recognized features of coral reef ecology: (1) Fish grazing has major impacts on overall abundances of benthic organisms; (2) Artificial substrates in tropical open coast habitats are often colonized by fouling communities characterized by species such as the octocoral Carijoa (Telesto) riisei, the sponge Tedania ignis, the tunicate Ascidea nigra and the anemone Aiptasia tagetes; and (3) Many prey species in coral reefs enjoy a refuge in size from grazers due to structural/chemical defenses. Differences between keystone and gatekeeper effects probably arise from features (2) and (3) because many fouling (and typical coral reef) species are vulnerable to gatekeepers when small and inconspicuous, but enjoy a refuge in size from keystone species when large. Due to these size-specific effects, assemblages of prey species controlled by gatekeepers and keystone predators will differ to some degree. Escape from gatekeeper grazing will also have indirect effects on community structure because of interactions (e.g., competition) among prey populations. From a more general perspective, both the gatekeeper and keystone concepts emphasize species-specific effects on prey populations. In addition, the gatekeeper scenario posits that the size of prey individuals also plays a key role in the ecological structure of coral reef communities.

## 10-44

**Coral Morphology Modulates The Benefits Of Resident Fishes To Coral Growth?**

**Andrew BROOKS*[1]**, Sally HOLBROOK[2], Russell SCHMITT[2], Hannah STEWART[3]

[1]Marine Science Institute, University of California, Santa Barbara, Santa Barbara, CA, [2]Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA, [3]Friday Harbor Labs, University of Washington, Friday Harbor, WA

Hermatypic corals are functional mixotrophs that rely on water flow for the delivery of dissolved nutrients and prey. As the external morphology of individual colonies affects the rate of water flow through the colony, coral morphology may exert a strong influence on the flux of materials within the interior spaces of the colony itself. We explored the relationships between local water flow, abundance of resident fishes, external coral morphology and coral growth rates for a common species of branching coral, *Pocillopora eydouxi*, in lagoons of Moorea, French Polynesia. Colonies of *P. eydouxi* provide structural habitat and refuge space for a variety of reef fishes. In turn, these fishes may augment nutrient supply to their host coral while sheltering through the natural excretion of ammonia. To measure coral growth rates, we outplanted small coral nubbins into colonies of *P. eydouxi*. Mesh cages were used to exclude resident fishes from half of these colonies. Flow rates within host corals were measured using fluorescent dye and external morphology was quantified using digital photographs. Our experiments revealed that colonies of *P. eydouxi* containing resident fishes grew substantially faster than neighbors that did not. Coral growth rates were significantly correlated with within colony concentrations of ammonia. Our estimates of water flow within coral colonies indicated that this flow varied considerably among experimental colonies experiencing the same general flow regime, suggesting that coral morphology may modulate the effects of resident fishes on coral growth rates by influencing the overall flux of nutrients within a coral colony.

## 10-45

**Interactions Among Inhabitants Of Branching Coral: Multiple Predator Or Competitor Effects?**

**Russell SCHMITT*[1]**, Sally HOLBROOK[1], Andrew BROOKS[2], Jennifer LAPE[1]

[1]Ecology, Evolution & Marine Biology, University of California Santa Barbara, Santa Barbara, CA, [2]Marine Science Institute, University of California Santa Barbara, Santa Barbara, CA

The ability to forecast change in coral reef communities requires sufficient understanding of how multiple factors operate together, yet the complexity of real systems often is simplified by lumping species into such functional groups as predators or competitors. Oversimplification can obscure important influences on the strength of interactions, such as non-additive effects of multiple predators (MPEs) on shared prey that can either reduce or enhance their mortality risk. In French Polynesia, we explored interactions involving two putative predators (arc-eye hawkfish *Paracirrhites arcatus*, red-spotted coral crab *Trapezia rufopunctata*) and several damselfishes (*Dascyllus flavicaudus*, *D. aruanus*, *Chromis viridis*). Field and laboratory observations revealed that both hawkfish and coral crabs were capable of capturing and consuming recently settled damselfish. Because these species all use the branches of the coral *Pocillopora eydouxi* as shelter from 'external' predators, the hawkfish, coral crabs and damselfishes also may be competitors for enemy-free space. A survey suggested that the density of damselfish on *P. eydouxi* was reduced in the presence of either an arc-eye hawkfish or red-spotted coral crab. A field experiment confirmed that both hawkfish and coral crabs reduced survivorship of recently settled damselfish, and that their combined per capita effects were additive. Additivity occurred because the strongest effect of these species on damselfish was from competition for enemy-free space that increased their vulnerability to external predators; only 25% of damselfish mortality attributable to hawkfish resulted from consumption by hawkfish, while none of the mortality caused by crabs resulted from predation by crabs. Hence, in this case, there were no emergent effects of multiple predators. These results underscore the need to understand the particular mechanisms by which species exert their influence on others.

## 10-46

**Indirect Effects On Coral Dynamics From Interactions Between Resident Fishes**

**Sally HOLBROOK*[1]**, Russell SCHMITT[1], Andrew BROOKS[2]

[1]Ecology, Evolution and Marine Biology, UCSB, Santa Barbara, CA, [2]Marine Science Institute, UCSB, Santa Barbara, CA

Mortality rates of coral often scale inversely with colony size, and hence factors that enhance the growth of smaller, more vulnerable size classes can be important to the dynamics of coral populations. In a field experiment, we found that branching coral in the genus *Pocillopora* grew a third faster when a colony was occupied by a group of damselfishes; the amount of growth enhancement varied positively with the number (biomass) of resident damselfish. We undertook field studies to determine what influences the occurrence of damselfish groups on *Pocillopora* in Moorea, French Polynesia. Field surveys revealed three distinct fish occupancy patterns that were related to coral size: (1) no coral <40 cm in circumference was occupied, (2) intermediate-sized corals (40–75 cm) hosted either a group of damselfish or a single arc-eye hawkfish (*Paracirrhites arcatus*, a predator of small damselfish), and (3) >80% of large corals (>75 cm circumference) hosted a group of damselfish, more than half of which also had co-occurring hawkfish. Field experiments and observations revealed that arc-eye hawkfish could prevent the establishment of a damselfish group on intermediate-sized corals by suppressing recruitment of young damselfish (reducing settlement rates, increasing early mortality rates). By contrast, hawkfish could not stop groups of damselfish from colonizing larger corals because they could not prevent immigration of older (larger) damselfish and they appeared less efficient at reducing larval recruitment in large corals. Thus the growth - and perhaps survival - rates of intermediate-sized *Pocillopora* can be influenced substantially by a small piscivore. These results indicate that biotic interactions among species of fish that use corals as habitat can have substantial but non-obvious indirect effects on the dynamics of corals.

## 10-47

**Recruitment And Population Dynamics Of A Coral-Reef Fish: A Large-Scale Long-Term Field Experiment**

**Mark HIXON*[1]**, Todd ANDERSON[2], Kevin BUCH[3], Darren JOHNSON[4], Christopher STALLINGS[5]

[1]Department of Zoology, Oregon State University, Corvallis, OR, [2]San Diego State University, San Diego, CA, [3]Texas A&M University at Galveston, Galveston, TX, [4]Oregon State University, Corvallis, OR, [5]Florida State University, St Teresa, FL

The relationship between the input of newly settled recruits and post-settlement demographic rates in populations of coral-reef fishes is complex, and has thus been controversial. To examine this relationship at the spatial scale of entire local populations and the temporal scale of entire generations, we conducted an 8-year field experiment in the Bahamas. First, from 1998 to 2002, we monitored demographic rates (recruitment, survival, growth, and egg production) in four populations of the bicolor damselfish (*Stegastes partitus*). During this 4-year baseline period, two "near sites" adjacent to the Exuma Sound source of larvae exhibited relatively high recruitment rates and largely density-dependent dynamics. In contrast, two "far sites" located some 20 km from the Sound on the Great Bahamas Bank exhibited low recruitment and density-independent dynamics, in accordance with the "recruitment limitation" hypothesis. Second, during four consecutive recruitment seasons (2002-2005), we reduced recruitment 10-fold at one near site by removing new recruits as they settled, and bolstered recruitment 10-fold at one far site by transplanting new recruits. We continued demographic monitoring at all four sites into 2006. Examining all 8 years, population dynamics remained mostly density-dependent (compensatory) at the near sites, yet became inversely density-dependent (depensatory) at the far sites. The cause of depensation appears to have been a combination of relatively low habitat complexity and high physical (including hurricane) disturbance at the far sites, such that new recruits suffered higher mortality rates at lower densities. We conclude that a combination of factors, rather than larval supply alone, determines the level and kind of dependence on population density exhibited by demographic rates.

## 10-48

**Habitat Competes For Fish Larvae: Increased Fish Production Despite Settlement Redirection**

**Adrian STIER*[1]**, Craig OSENBERG[2]

[1]Zoology, University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL

Declines in the quality and quantify of coral reefs can decrease the abundance and diversity of the organisms that dependent on the reef habitat. As a result, coral reef restoration (e.g., via deployment of artificial reefs or coral fragments) has been proposed to reverse long-term degradation. The effect of new habitat remains unclear, primarily because added habitat may simply redistribute individuals, rather than increasing the regional size of a population. This uncertainty has led to the "attraction-production" controversy. Redirection alone does not increase production; it just redistributes it. However, if fish compete, then redistribution of larvae can enhance regional populations by lowering densities on existing reefs and thereby reducing the effect of density on post-settlement survival. Settlement redirection has never been previously tested in a field experiment. Thus, we designed a field experiment to quantify the degree to which new habitat increases settlement (or redirects it). Addition of new habitat increased total settlement, but decreased density. However the effect on settlement was much less than expected based on the increase in reef habitat: habitat increased 6-fold, but settlement increased less then two-fold. Thus, settlers are redirected to new habitat, but total settlement increases, and local density decreases. Based on the observed strength of density-dependence in these systems, we demonstrate how habitat addition should lead to a reduction in density, an increase in regional density, and a significant increase in fish production by ameliorating negative effects of density.

## 10-49

**Interactive Effects Of Competition And Microhabitat On Juvenile Survival in A Coral Reef Fish**

**Mary BONIN*[1,2]**, Glenn ALMANY[1,2], Maya SRINIVASAN[2], Geoffrey JONES[1,2]

[1]ARC Centre of Excellence for Coral Reef Studies, Townsville, Australia, [2]Marine and Tropical Biology, James Cook University, Townsville, Australia

Microhabitat type and competition for preferred microhabitats can influence patterns of abundance and mortality in coral reef fish communities, however the relative influence and interaction between these two factors is not well understood. In Kimbe Bay, Papua New Guinea, we used surveys to quantify microhabitat use in two live-coral specialist damselfishes (Pomacentridae), *Chrysiptera parasema* and *Dascyllus melanurus*. We then used a patch reef experiment to test how intra- and interspecific competition interacts with two types of microhabitat to influence survival of juvenile *C. parasema*. Surveys demonstrated that *C. parasema* and *D. melanurus* utilize similar coral microhabitats; 72% of *C. parasema* and 85% of *D. melanurus* used corymbose and bottlebrush growth forms of *Acropora*. One microhabitat type, *Pocillopora* spp. coral, was used by *D. melanurus* but not *C. parasema*. The patch reef experiment revealed that microhabitat type had the strongest influence on survival of *C. parasema*. In the absence of interspecific competitors, approximately 90% of *C. parasema* survived for 5 days after transplantation to bottlebrush *Acropora* compared to only 30% survival on *Pocillopora*. In both microhabitats, interspecific competition with *D. melanurus*, but not intraspecific competition, decreased survival of *C. parasema*. The interspecific effect of *D. melanurus* was greater in the more structurally-complex microhabitat; on *Acropora* reefs, interspecific competition resulted in a 34% decrease in *C. parasema* survival compared to 19% on *Pocillopora* reefs. This study demonstrates that interspecific competition and microhabitat type can interact to influence survival in coral reef fishes, though whether and how these factors influence survival will depend on the behavioural attributes and strength of habitat associations among potential competitors.

## 10-50

**Differential Effect Of Early Post-Settlement Processes On The Abundance Of Two Concurrently Settling Coral Reef Fishes**

**Henri VALLES*[1]**, Donald KRAMER[1], Wayne HUNTE[2]

[1]Biology, McGill University, Montreal, QC, Canada, [2]Biology, University of the West Indies, Cave Hill, Barbados

To examine the magnitude, spatial variability and causes of early density-independent (DI) and density-dependent (DD) post-settlement losses in coral reef fishes, we monitored density of *Sparisoma* (Scaridae) and *Stegastes partitus* (Pomacentridae) on three reefs in Barbados (West Indies) for 3-3.5 months following a period of high recruitment and fitted the data to a modified Beverton-Holt model. To assess whether surveys missed early DD mortality, we compared recruitment on reefs to that on standard monitoring units (SMURFs) that excluded predators. Recruitment was >11x (*Sparisoma*) and >3x (*S. partitus*) greater than the initial number of large juveniles/ adults. Mortality was very high (*Sparisoma* 97%; *S. partitus* 91%), indicating that post-settlement processes were more important than settlement in determining local density. Mortality did not vary significantly across sites. After 3-3.5 months, *Sparisoma* densities were similar to those before recruitment. *S. partitus* densities increased, but increases did not match among-site differences in recruitment, indicating that post-settlement processes differed spatially. DI effects did not vary significantly between taxa or sites. DD effects were one order of magnitude higher for *Sparisoma* than for *S. partitus*, possibly due to lower availability of refuge microhabitat for *Sparisoma*. DD effects varied significantly across sites for *S. partitus*, but not *Sparisoma*, perhaps because of lower precision in density estimates for *Sparisoma*. Among-site differences in DD effects for *S. partitus* were associated with differences in recruitment rates and substrate. Predator density was similar across sites. Recruit density on the reefs mirrored captures in SMURFs, indicating that surveys did not miss important DD predation. Our findings suggest that substrate influences rates of DD mortality and therefore local population dynamics, but with markedly different strength for different taxa.

## 10-51

**Living in a Washing Machine: Differing Capacities to Capture Prey Under Divergent Velocity/Turbulence Conditions Reflect Microhabitat Differences of Two Chaenopsid Blennies**

**Raymond CLARKE*[1]**, Christopher FINELLI[2], Edward BUSKEY[3]

[1]Department of Biology, Sarah Lawrence College, Bronxville, NY, [2]Department of Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC, [3]The University of Texas at Austin Marine Science Institute, Port Aransas, TX

Wave-generated oscillating water flow on coral reefs creates a challenge for the fishes that live there, but it also creates opportunities. Roughhead blennies (*Acanthemblemaria aspera*) and spinyhead blennies (*A. spinosa*) live in holes in dead coral skeletons from which they make rapid forays to capture passing prey, primarily copepods. On coral reefs throughout the Caribbean, spinyheads occupy locations in tall corals while roughheads reside close to the reef surface. Spinyheads have metabolic rates 1.5 times higher than those of roughheads. Our study involves (1) measuring water speeds and flow patterns both generally and within blenny feeding volumes, (2) videotaping blennies feeding in the field and (3) studying blenny feeding patterns and success in flumes. The flume studies include wild-caught calanoids (*Acartia tonsa*) as prey and water flow regimes that replicate those measured in the field. Spinyheads experience greater velocity and turbulence and possess a more fixed attack pattern, focusing primarily on planktonic prey whereas roughheads feed primarily on benthic prey but periodically shift to planktonic prey under low flow conditions. Spinyheads attack at greater distances and at greater rates under all conditions. Both species attack more frequently during the slack stage of the wave cycle, but spinyheads attack over a greater proportion of the wave cycle than do roughheads. Spinyheads also have greater capture success than roughheads under fast smooth flow and all turbulent water conditions. These data reveal in some detail the ways in which these blennies are adapted to different microhabitats thus facilitating coexistence in the same reef zones.

## 10-52

**Micropredator Gnathiid Isopods Reduce Larval Damselfish Persistence By Affecting Performance**

**Alexandra GRUTTER*[1]**, Angela CREAN[1], Lynda M CURTIS[1], Armand M KURIS[2], Robert R WARNER[2], Mark I MCCORMICK[3]

[1]School of Integrative Biology, The University of Queesland, St. Lucia Queesland, Australia, [2]Ecology, Evolution, and Marine Biology, Univeristy of California Santa Barbara, Santa Barbara, CA, [3]ARC Centre of Excellence for Coral Reef Studies and School of Marine and Tropical Biology, James Cook University, Townsville Queensland, Australia

Traditional hypothesis for the pelagic phase of demersal coral reef fishes are not strongly supported by the data. An alternative hypothesis is that they migrate to the pelagic environment to disrupt or avoid transmission of infectious agents. On the Great Barrier Reef, gnathiid isopods (mobile micropredators) are one of the most common ectoparasites of fish. Gnathiid effects on small fishes were used as a model for the consequences of keeping larvae on the reef. Nothing is known of how gnathiids affect the performance and survival of juveniles in the wild. We therefore tested the effect of gnathiids on the swimming performance, oxygen consumption, and survival of the common damselfish *Pomacentrus amboinensis* in nature. Of juvenile fish sampled at dawn and during the day, 3.5% and 0% had a gnathiid respectively, however, this difference was not significant. In the laboratory, most gnathiids (79%) remained attached to juvenile fish for up to 6 h and all fish survived exposure to the gnathiids. When tested in pairs in a double-laned swim chamber, settlement-stage fish that had previously been fed on by a gnathiid ceased swimming first in 77% of the trials. They also had a 14% lower critical swimming speed compared to fish not exposed to a gnathiid. Previously parasitized settlement-stage fish had a 32% higher oxygen consumption rate than did unexposed fish. When tagged settlement-stage fish were placed in pairs on dead coral patches in the wild and monitored, the previously parasitized fish disappeared from the reef first in 67% of the trials. Our analysis indicates that gnathiid isopods significantly decrease the performance of young *P. amboinensis*. This may affect their survival and successful establishment on the reef. Micropredation by gnathiids may therefore contribute to selection pressure for a pelagic stage.

## 10-53

**Does Behaviour Mediate The Costs And Benefits Of Fast Growth? An Example in A Marine Fish, *pomacentrus Amboinensis***

Corinna VON KUERTHY[1], **Mark MEEKAN*[2]**, Mark MCCORMICK[3]

[1]University of Kiel, Kiel, Germany, [2]Darwin Office, Australian Institute of Marine Science, Brinkin, Australia, [3]School Marine and Tropical Biology, James Cook University, Townsville, Australia

Body size is a central determinant of survival, fecundity and competitive ability. Fast growth, resulting in large body size, can be beneficial so we might expect that individuals that are capable of maximising growth to attain the greatest body size will be favoured by selection. However, in the field, maximal growth is found only rarely. It has been suggested that trade-offs between the costs and benefits of growth are mediated by behaviour, whereby rapid growth is associated with greater predation mortality due to increased foraging effort. Here, test this hypothesis by examining the behaviour, growth and survivorship of a common reef fish, *Pomacentrus amboinensis* at Lizard Island on the Great Barrier Reef (GBR) during the first month of settlement on the reef. We collected young fish using light traps settled them onto small artificial reefs where their behaviour and survivorship was monitored for 24 hrs. One month later individuals of the same cohort were collected from shallow reefs and distributed on the same artificial reefs. Their behaviour and survivorship was monitored for 6 d. Size-at-age and growth rates of surviving fish in both experiments were reconstructed using the records stored within the otoliths or earbones of the juvenile fish. At settlement young fish suffered high mortality that preferentially removed larger, faster-growing individuals. However, we could not find any evidence that the foraging behaviour of these larger fish contributed to this pattern of selective mortality. In contrast, one month after settlement the same cohort of fish underwent negative size selective mortality where the smallest, slower-growing fish were preferentially removed by predators. Larger fish spent more time foraging and were more aggressive than smaller individuals. These results are discussed in the context of current views of the role of behaviour in mediating patterns of selective mortality in prey species.

## 10-54

**Microhabitat Specialisation, Recruitment And Coral Decline: Population Responses in Two Coral Reef Fish Families**

**Maya SRINIVASAN*[1]**, Geoffrey JONES[1], Mark MCCORMICK[1]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

Many marine species are undergoing long-term changes in abundance in response to habitat degradation. While recruitment is known to be a primary driver of the temporal and spatial dynamics of coral reef fish populations, its role in determining responses to habitat change is poorly understood. Here we examined microhabitat use of recently settled reef fishes in Kimbe Bay (PNG), focussing on family-level patterns for the two most common reef-associated taxa, the damselfishes (Pomacentridae) and wrasses (Labridae). We also investigated the influence of microhabitat specialisation at settlement on temporal patterns in adult abundance following a decline in coral cover. The majority of species were strongly associated with a narrow range of microhabitats. Both live branching corals (particularly Acropora and Pocillopora spp.) and dead substrata were preferred recruitment microhabitats for different species. A decline in coral cover between 1997 and 2002 resulted in population declines of 75% of the common reef fish species. Wrasses exhibited the greatest range of responses, including increases, declines and stable populations, while the majority of damselfish species declined. The magnitude and direction of the long-term change in fish abundance was inversely correlated with the degree of association between recruits and live branching corals. For a given level of live coral dependence, the magnitude of decline was greater among the damselfishes than the wrasses. This may be explained by a comparison of recruit-adult relationships among species and between the two families, which established that a given average density of recruits resulted in greater average densities of adult damselfishes, compared with wrasses. The family-level differences between damselfish and wrasses may reflect fundamental differences in their life history traits, reliance on living corals and the carrying capacities of the habitat.

## 10-55

**Is Bigger Really Better? Investigating The Size Selectivity Of Predation On Newly Settled Coral Reef Fishes**

**Thomas HOLMES*[1,2]**, Mark MCCORMICK[1,2]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]Australian Research Council Centre of Excellence for Coral Reef Studies, Townsville, Australia

Recent evidence suggests that the early post-settlement period of coral reef fishes may be critical in determining the size and structure of adult fish populations. Predation by small site associated predators has been shown to be responsible for a majority of mortality during this period, and the relative body size of predator and prey is generally regarded as one of the most important characteristics influencing the outcome of such events. This study investigated the size selectivity of four predator species known to be responsible for a majority of predation on early post-settlement reef fishes at Lizard Island, northern Great Barrier Reef, Australia. Additionally, it examined how size selectivity changed with predator ontogeny. Using aquarium based predator trials, selectivity was examined for both the size range of prey at the time of settlement, and for the size range over the early juvenile period immediately following settlement. The intensity and direction of size-selection was found to differ greatly between the predator species. During the 'settlement stage' trials, distinctive preferences towards either large or small prey size classes were observed for some predator species, whilst others were more 'generalist' in their prey choice. During 'early juvenile' trials all predator species generally chose smaller size classes, although the intensity of this selection varied. Selectivity was not found to differ with changing predator body size. This research shows that larger size at the time of settlement does not necessarily convey a survival advantage during predatory interactions. However, larger size does become a clear advantage as an individual passes into the early juvenile stage. These selective patterns are thought to be driven by a combination of prey behaviour, and species specific predator behaviours, predation modes and gape size.

## 10-56

**Carry-Over Effects – The Importance Of A Good Start**

**Mark MCCORMICK*[1]**, Monica GAGLIANO[1]

[1]Marine and Tropical Biology, James Cook University, Townsville, Australia

Complex life cycles are common in marine organisms and success at each life stage depends upon individuals exhibiting the best series of performance traits to meet the challenges of their current environment. High performance in one stage does not guarantee success in another. Despite the potential for conflicting selective forces on sequential life stages, recent evidence emphasizes the importance of interconnections between survival traits among life stages. This presentation reviews recent studies of carry-over effects for marine fishes and emphasizes the overwhelming importance of previous growth history in biasing later survival and reproductive success. Research also stresses the importance of non-genetic maternal effects in affecting offspring success.

## 10-57

**A Comparison Of Rates And Structure Of Social Foraging Interactions in Coral Reef Fishes**

Kimberly BARBER[1], **Peter AUSTER*[1]**

[1]University of Connecticut, Groton, CT

We compared the rates and structure of social foraging groups at reef sites in the Gulf of California, off Bonaire in the Caribbean Sea, and on the Great Barrier Reef. Data were collected on number and composition of social foraging groups and background community composition. While on a regional scale species richness varied (i.e., Coral Sea > Caribbean > Gulf of California), comparisons of local community diversity and diversity of species participating in social foraging groups were not statistically different. Approximately 50% of species in local communities participated in social foraging. Sixteen to 30% of species participated in single species groups while 31%-46% of species participated in mixed species groups. Most groups, whether single or mixed-species, were composed of 2-9 individuals. Rates of social foraging varied with a mean of approximately 7 bouts per survey at Gulf of California and Caribbean sites, while only 4 bouts per survey were observed at Coral Sea sites. Interaction strengths between social foragers were "mapped" using cluster analysis and similarity levels were indicative of the consistency of such interactions. Mixed-species foraging groups observed at Gulf of California and Caribbean sites had highly mixed trophic guild composition while those at Coral Sea sites were composed primarily of species within single trophic guilds. Our results demonstrate the extent of social foraging interactions across a wide geographic range and infer a level of importance yet to be defined for the role such positive species interactions play in mediating local community structure and diversity.

## 10-58

**Short-term effects of the invasive Indo-Pacific lionfish (*Pterois volitans/miles* complex) on Bahamian coral-reef fish abundance and diversity**

**Mark A. ALBINS*[1]**

[1]Department of Zoology, Oregon State University, Corvallis, OR

Caribbean coral-reef communities have been substantially degraded over the last several centuries by numerous natural and anthropogenic disturbances. These communities now face a new threat: the invasive Indo-Pacific lionfish. Lionfish are voracious predators with defensive venomous spines. Using oversized, ornate pectoral fins, they herd and ambush small reef fishes and crustaceans, a novel strategy in the invaded system. Since 2005, we have observed increasing densities of lionfish at multiple study sites within Exuma Sound, Bahamas. During the summer of 2007, we initiated a combination of observational and experimental investigations to determine the effects of this invasive predator on native coral-reef fish communities. We observed a high rate of lionfish recruitment (*ca.*16 fish ha-1day-1) to a matrix of artificial (concrete-block) and translocated (live-coral) patch reefs over the summer recruitment period. Stomach-content analysis in combination with aquarium feeding observations confirmed that lionfish prey on a wide variety of native animals, including bony fishes and crustaceans, and that lionfish are capable of consuming large numbers of prey, as well as large prey relative to their body size. We ran a controlled experiment (lionfish present *vs*. absent) using a matrix of artificial and translocated patch reefs to examine the effects of lionfish on the survival of small reef-fishes. Reefs were censused at one-week intervals for a period of five weeks during the height of the summer recruitment season. Although lionfish affected the abundance of species differentially, the mean abundance and species diversity of small reef-fishes (<5 cm TL) was significantly reduced on lionfish reefs relative to control reefs over the experimental period. We conclude that invasive lionfish have substantial negative effects on the local abundance and species diversity of small, native, coral-reef fishes over short time scales.

## 10-59

**Mutualism, Aggregation And Predation Result in Behaviorally-Mediated Indirect Interactions On A Coral Reef**

**Thomas ADAM*[1]**

[1]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

Indirect interactions (eg., trophic cascades) are ubiquitous on coral reefs and can be transmitted through changes in behavior as well as changes in density. Here, I explore possible behaviorally-mediated indirect interactions resulting from a common mutualism on coral reefs where cleaner fish are visited by client fish for the removal of ectoparasites. Because client fishes include predators and herbivores that can alter the demographic rates of reef residents, cleaners are likely to have indirect effects on these residents by attracting and concentrating clients that may browse or graze nearby when visiting cleaner stations. I present results from field observations and experiments conducted in Moorea, French Polynesia, demonstrating that bluestreak cleaner wrasse (*Labroides dimidiatus*) are attracting corallivorous butterflyfishes (Chaetodontidae) to cleaner stations, and by doing so have a negative indirect effect on the growth rate of a common branching coral (*Porites rus*). In addition, herbivorous surgeonfishes (Acanthuridae) aggregate near cleaner stations, and consequently more algae are grazed in these areas. However, unlike butterflyfish, the greater abundance of surgeonfish at cleaner stations appears to result largely from overlapping habitat preferences between surgeonfish and cleaners. Thus, while cleaners are indirectly responsible for decreased growth rates of *Porites rus* at cleaner stations, morphological characteristics of coral colonies, rather than cleaners, result in an indirect effect on algae. These results highlight the potential for cleaners (and coral colonies) to create spatial heterogeneity in predation pressure and emphasize the need to incorporate knowledge about reef fish behavior into our understanding of community processes on coral reefs.

## 10-60

**Partitioning of coral defense by exosymbiotic crustaceans**

**Seabird MCKEON*[1]**, Adrian STIER[2], Shelby BOYER[3]

[1]Florida Museum of Natural History/Deparment of Zoology, University of Florida, Gainesville, FL, [2]Zoology, University of Florida, Gainesville, FL, [3]Moss Landing Marine Laboratories, Moss Landing, CA

Much of early ecological research focused on the role of negative interactions among organisms (e.g. competition and predation); more recently ecologists have become aware of the importance of positive interactions such as facilitation and mutualism. As diverse ecosystems, coral reefs serve as models for understanding the complexities of symbiosis; mutualisms in this system have previously been oversimplified and viewed as interactions between pairs of species, instead of guild-guild interactions. Studies of the obligate crustacean exosymbionts of the branching corals Pocillopora have previously identified these symbionts as mutualists, identifying their defensive and sediment-clearing capabilities on a species level, but ignoring the interactions among resident crustaceans. This type of simplified approach is present in many systems and has hindered our understanding of the importance of mutualism in many systems including the coral reef environment. Here we experimented on the role of the exosymbiotic crustacean guild, quantifying the defensive efficacy of both crab (Trapezia sereni), and shrimp symbionts (Alpheus lottini) in response to a common corallivorous seastar predator (Culcita novaeguineae). Our trials tested the effectiveness of these crustaceans both independently and in combination in a series of choice, no-choice, and behavioral experiments. The presence of any of the symbionts (T.serenei, A.lottini or both) consistently lowered the frequency of attack, but only the presence of both exosymbionts significantly reduced the amount of coral consumed by a corallivorous seastar. Defense of the coral host by both the shrimp and the crab increased coral survivorship - a result likely to have far reaching effects on the demography of host Pocillopora. These results demonstrate that the benefits provided to the host by the guild of crustacean exosymbionts are additive in nature- and provide more effective protection than one species alone.

## 10-61

**Sediment Removal By Crabs Maintains Health Of Young Corals**

**Hannah L. STEWART*[1]**, Nichole N. PRICE[2], Sally J. HOLBROOK[2], Russell J. SCHMITT[2], Andrew J. BROOKS[3]

[1]Friday Harbor Labs, University of Washington, Friday Harbor, WA, [2]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA, [3]Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, Santa Barbara, CA

Increasing threats to tropical reefs from long-term climate change and human land use render it critical to understand how stony corals, the foundational species of reef ecosystems, respond to such perturbations. Corals form habitat for other species, so it is necessary to understand the influence of associated organisms in mediating responses to perturbation. We show the importance of an association with trapeziid crabs (genus *Tetralia*) in reducing adverse effects of sediments deposited on coral for small (<12cm diameter) and juvenile (<3cm diameter) branching corals. In field experiments, mortality rates of both sizes of corals were significantly lowered by the presence of crabs. All outplanted corals with crabs survived whereas 45 - 80% of small corals without crabs died within a month, and 80% of juvenile corals were dead after 1 year. For surviving corals that lacked crabs, growth was slower and tissue bleaching and sediment load were higher. Laboratory experiments revealed that corals with crabs shed substantially more of the sediments deposited on coral surfaces, but also that crabs were most effective at removing grain sizes that were most damaging to coral tissues. The proportion of juvenile corals with crabs increased as a function of coral volume and branch number, indicating that certain morphological criteria must be met before a crab will associate with a coral, and that the presence of a crab in turn results in increased volume and growth of host corals. Field surveys indicated crab-coral associations are ubiquitous (>90% of corals harbor crabs) and this work shows they are important to the early life stages of corals, particularly in areas of high sediment and low flow. The mechanism underlying this symbiotic relationship has not been recognized previously, and its role in maintaining coral health is likely to become even more critical as reefs worldwide experience increasing sedimentation.

## 10-62

**Direct, Species-Specific Impacts Of Sea Urchins On Live Corals**

**Wendy COVER*[1]**, Donald POTTS[1]

[1]Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA

Interactions between species can shape major processes and influence community structure on coral reefs. Sea urchins and corals are usually thought to interact through indirect processes, mediated either through herbivory on macroalgae or excavations beneath corals. Although bioerosional capabilities of urchins on dead carbonate substrates are well documented, direct impacts of urchins on live coral tissue are rarely reported. We investigated the potential for direct urchin predation on live coral, and whether such interactions vary by species of urchin and coral. We conducted experiments in the backreef of Midway Atoll (NW Hawaiian Islands) during 2006-2007 using three coral species (*Pocillopora ligulata*, *Montipora* c.f *turgescens*, and *Porites lobata*) and two urchin species (*Echinometra mathaei* and *Heterocentrotus mammillatus*), both with broad Indo-Pacific distributions. We epoxied coral fragments of each species inside channels created by bioerosional activities of the two urchin species. In half the plots we removed urchins, and in the other half they remained; we found impacts on corals in plots with urchins present that varied by urchin and coral species. Most fragments of all coral species placed in plots with *E. mathaei* present were grazed down increasingly over a period of several weeks, often resulting in a complete removal of coral tissue and skeleton. Fragments of *M*. c.f. *turgescens* were grazed down more quickly than those of *P. lobata*. Fragments in plots with *E. mathaei* removed and fragments in all *H. mammillatus* plots were unaffected over the course of the experiment. The influence of E. mathaei is spatially patchy, limited mainly to their bioeroded channels. We conclude that E. mathaei can exert a clear direct negative impact on live corals, and the rate and relative impact can vary by coral species, with implications for coral recruitment and community structure.

.

## 10-63

**Context-Dependency Of Growth And Predator Deterrence Of Caribbean Coral Reef Sponges**

**Janie WULFF*[1]**

[1]Department of Biological Science, Florida State University, Tallahassee, FL

Sponges play key roles on coral reefs, including filtering the water column, gluing live corals to the reef frame, protecting exposed carbonate skeletons from excavating organisms, and facilitating regeneration of damaged reefs. Concerns that these roles could be lost due to declines in sponges, or, conversely, that sponges could overgrow reef surfaces with detrimental effect, impel understanding of factors that control sponge distribution and abundance. Relative importance of top down versus bottom up trophic factors was evaluated by comparing size changes of 12 common species of Caribbean coral reef sponges in three linked habitats that differ in spongivore abundance and taxa and in water column productivity. Small pieces were cut from parent sponges and protected in cages until cut edges healed. Sponge pieces of the same size and genotype were attached to stable solid substrata inside cages and next to, but outside of, cages on the reef and in the seagrass, and on PVC pipes suspended among mangrove roots. Growth and survival were monitored at intervals for 1-3 years. On the coral reef, growth and survival were indistinguishable for sponges inside and outside of cages, but in the seagrass most species did not survive outside of cages. Growth and survival of the reef sponges were highest among the mangrove prop roots.

## 10-64

**How Hydrodynamics And Corallivory Interact To Influence The Performance Of Juvenile Corals**

**Hunter LENIHAN*[1]**, Jim HENCH[2], Alice ALLDREDGE[3]

[1]Bren School of Environmental Science and Management, UC Santa Barbara, Santa Barbara, CA, [2]Environmental Fluids Laboratory, Stanford University, Pall Alto, CA, [3]Dept. of Ecology, Evolution, and Marine Biology, UC Santa Barbara, Santa Barbara, CA

Decades of research indicate that natural catastrophes have a major influence on coral reef community dynamics. Examining ecological processes that regulate reef recovery following major disturbances provides a means of testing whether and how reef communities are changing through time and space. Data suggests that reef composition in some areas of the IndoPacific and elsewhere is changing through the relative loss of acroporid and gain of pocilloporid corals. Whether such change is due to species replacement or represents a stage within the recovery process is unclear. We tested whether the individual performance of acoporid and pocilloporid coral colonies in Moorea, FP varied in response to chronic, low-level disturbances, and whether differences in the relative performance of two taxa help explain population and community dynamics. Using population surveys, demographic studies, and manipulative experiments, we found that growth and survival of juvenile *Acropora* spp. and *Pocillopora* spp. varied with habitat structure, hydrodynamic conditions (current speed, turbulence, sedimentation, and food delivery rates), corallivory by fishes, and their interaction. Results a multi-year demographic study indicated that coral recruitment is relatively high for both taxa, but that the growth and survival of juvenile colonies varies greatly with substrate type, hydrodynamics, and the abundance of corallivores (puffer-, butterfly-, and parrot fishes). Results from manipulative experiments indicate that corallivory has strong influence on juvenile growth and survival; that predation intensity is tightly controlled by turbulence, and thus seasonal variation in physical forcing; and that coral growth, in the absence of corallivory, is regulated in large part by the flux of zooplankton. Overall, rates of predation on *Acropora* and *Pocillopora* were similar, but had a greater negative effect on *Acorpora*. Variation in the response of the two taxa to abiotic and biotic stressors help explain present-day patterns of community composition, and are used to predict future change.

## 10-65

**Plasticity of the Corallivorous gastropod *Coralliophila abbreviata*: Implications for Imperiled Caribbean Coral**

**Lyza JOHNSTON*[1]**, Iliana BAUMS[2], Margaret MILLER[3]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Department of Biology, The Pennsylvania State University, University Park, PA, [3]Southeast Fisheries Science Center, NOAA, Miami, FL

*Coralliophila abbreviata* is a corallivorous gastropod that lives and feeds on several species of scleractinian coral in the tropical Western Atlantic and the Caribbean. Throughout the region, gastropod populations found on branching acroporid corals display different morphological, behavioral, and life-history characteristics than those found on massive and plating corals, prompting hypotheses about host-associated genetic differentiation within *C. abbreviata*. Although damage to massive and plating corals appears minimal, these gastropods cause substantial and chronic mortality of *Acropora palmata* and *Acropora cervicornis*, two species recently listed as Threatened under the U.S. Endangered Species Act. Under the premise of one plastic species of *C. abbreviata*, massive and plating corals may serve as reservoir hosts, producing a continuous supply of predators even as acroporid populations continue to dwindle. The species status and population dynamics of *C. abbreviata* thus have important conservation and management implications for Caribbean coral reefs. To address this issue, we used mitochondrial and microsatellite markers to assess the genetic structure of *C. abbreviata* populations from two coral host taxa (*A. palmata* and *Montastraea* spp.) and three locations spanning the species range (Florida Keys, Navassa Is., and St. Vincent and the Grenadines). We found no significant genetic structure between hosts or among geographic locations, indicating that *C. abbreviata* is one plastic species with unrestricted gene flow throughout the range sampled. Based on these results, it seems pertinent that strategies be implemented to mitigate the impact of *C. abbreviata* on vulnerable acroporid coral populations.

## 10-66

**Strong Interactions From Hidden Species: Vermetid Snails Have Large Deleterious Effects On Corals**

**Craig OSENBERG*[1]**, Jeffrey SHIMA[2], Adrian STIER[1]

[1]Department of Zoology, University of Florida, Gainesville, FL, [2]School of Biological Sciences, Victoria University Wellington, Wellington, New Zealand

The dynamics and restoration of coral reefs is of critical concern given their ecological importance and the deleterious impacts caused by disease and anthropogenic activities. Previous research has demonstrated important potential effects of nutrients, algae, disease, and disturbance, but may have overlooked other key factors. Vermetid gastropods, which are sessile and feed via an extensive mucus net, are poorly studied members of the coral reef community, yet also may interact strongly with corals. We examined the possible effects of vermetids on coral growth and survival in a field study in a lagoon of Moorea, French Polynesia. Vermetids were either left at ambient densities or removed from small (~3m2) patch reefs. Coral nubbins were collected, weighed (using the buoyant mass technique), and outplanted to these patch reefs. Growth was assessed after ~7 weeks and survival after ~8 months. Eight experiments were conducted using four different species of coral (*Pocillopora*, *Montipora*, *Porites lobata*, and *Porites rus*). Growth and survival were both greater offshore than inshore, although effects of vermetids were similar in both regions. Effects of vermetids were strongly deleterious but varied among coral taxa. Vermetids reduced the growth of coral by as much as 90% (*Pocillopora*) and by as little as 30% (*Montipora*). Survival was reduced from >98% in the "removals" to 79% (*P. rus*), 70% (*P. lobata*), and 45% (*Pocillopora*). These large short-term effects can have dramatic consequences for coral regeneration and dynamics. We projected changes in coral community composition resulting from observed effects of vermetids and found that the effects rival those documented from other factors.

## 10-67

**Cultivation Mutualisms Between Territorial Damselfish And Algae in The Indo-West Pacific**

**Hiroki HATA*[1]**

[1]Graduate School of Science, Kyoto University, Sakyo, Kyoto, Japan

This research aims to understand the origin and evolution of cultivation mutualisms on coral reefs in the Indo-West Pacific. Territorial damselfishes defend territories individually against intruding herbivores and manage algal farms on which they exclusively feed in the territories. We revealed that some territorial damselfish farm species-specific *Polysiphonia* algae in Okinawa, Japan. Molecular genetics enabled us to detect four cryptic species of *Polysiphonia* algae, each of which were collected from territories of four different damselfish species. Notably, one *Polysiphonia* algal species dominated the farms of a damselfish *Stegastes nigricans* and was found nowhere else. *S. nigricans* feeds on this highly digestible alga as a staple food, whereas *Polysiphonia* sp. is exclusively protected and grown by the damselfish. In this way, the two species rely on each other; this situation is described as an obligate cultivation mutualism.

I studied damselfish territories in the Indo-West Pacific (Mauritius, Kenya, Egypt, Maldives, Thailand, Malaysia, and Australia) and revealed that the general pattern of species-specificity between *Stegastes* damselfishes and *Polysiphonia* algae was relatively stable throughout the Indo-West Pacific, but the dependency on the specific partner varied remarkably. *Polysiphonia* sp. 1, which is dominant in algal farms of *S. nigricans* in Okinawa, was also found in territories of the same fish species in Mauritius, Egypt, and Australia. However, *Polysiphonia* sp. 1 did not always dominate the farms in those areas, and therefore the fish did not always depend on the alga as a staple food. In addition, a new sibling *Polysiphonia* species was found. The farms of *S. nigricans* in Kenya, Maldives, and a part of Mauritius were inhabited by other *Polysiphonia* species, instead of *Polysiphonia* sp.1. These results imply that the cultivation mutualisms between damselfish and *Polysiphonia* algae have coevolved under geographic selection mosaics with host shifts across regions.

## 10-68

**Effects Of Farmerfish On Coral Community Structure**

**Jada-Simone WHITE*[1]**

[1]Department of Zoology, University of Florida, Gainesville, FL

Complex ecological interactions, coupled with abiotic processes, underlie the structure of diverse communities. In Moorea, French Polynesia, an abundant algal-farming fish, the dusky farmerfish *Stegastes nigricans*, alters the coral reef community by farming algal turf and exerting resource control through territorial defense. These behaviors affect coral indirectly by modifying their interactions with two guilds of community members: 1) increased interactions with farmed algal turf; and 2) decreased interactions with mobile grazers and predators due to reduced reef access. Small scale experiments involving farmerfish and / or turf removals indicated dominant massive *Porites* were more vulnerable to competition with turf than branching *Acropora, Pocillopora,* or encrusting *Montipora.* In contrast, delicate branching corals were more vulnerable to predation by mobile corallivores and grow and survive better in the presence of *S. nigricans* defense. I assessed these indirect effects in a demographic context using a combination of recruitment tiles and size specific population monitoring in the presence and removal of *S. nigricans.* Experimental parameter estimates were tested by comparing projected size distributions with spatially explicit size distributions of corals in the presence and absence of this abundant farmerfish. The disturbance history has played a pivotal role in the types of community changes observed. While *S. nigricans* usually colonizes *Acropora* thickets, a series of disturbances on the north shore virtually eliminated these habitats and farmerfish subsequently colonized disturbance tolerant, but turf sensitive, abundant massive *Porites*. The relative resistance to competition with turf allowed recovering, disturbance sensitive, species to utilize the dead portions of massive coral. This increase in substrate availability, when coupled with lower predation rates, has led to enhanced recovery of rare and branching corals within territories relative to outside.

## 10-69

**Ecological Processes in *halimeda Kanaloana* Meadows in Hawaii From 10 To 90 M Depths**

**Heather SPALDING*[1]**

[1]Botany Department, University of Hawaii at Manoa, Honolulu, HI

Hawaii's coral reef ecosystem includes expansive *Halimeda kanaloana* meadows, forming a continuous assemblage over soft sediments to 90 m. These meadows form habitat for cryptic organisms, and are a hunting ground for large, predatory fish. We used technical diving, ROV surveys, and submersibles to describe spatial and temporal variation in distribution, abundance, demography, and growth of *Halimeda kanaloana*, and to determine the role of herbivory, competition, and recruitment in structuring these meadows across a depth gradient. Sexual reproduction occurred intermittently throughout the year; 0.02 – 0.76% of the population was reproductive at any given time. Fragmentation and clonal propagation allowed large portions of the meadow to recover from wave induced burial and sand scour. Clearing experiments showed *Halimeda* could quickly regrow from the intact holdfast, but was slow (> 20 months) to recolonize areas cleared of both holdfast and thallus. Individuals were long-lived (> 27 months), but fluctuated greatly in segment number and height over time, suggesting plant size is not an appropriate age indicator. Densities peaked at 20 m (342 ± 13 SE individuals per m2), but varied seasonally and between locations at similar depths. *Halimeda* growth was rapid (9.8% ± 1.4% SE new growth per plant per week) and generally decreased with increasing depth. Herbivores (*e.g.*, *Tripneustes gratilla*) did not appear to significantly influence *Halimeda* densities. Episodic blooms of green algae (*e.g.*, *Caulerpa filicoides*, *Cladophora sericea*) and cyanobacteria (*Lyngbya majuscula*) overgrew *Halimeda*, and most likely competed for light and nutrients with increasing depths. The perennial nature, rapid growth rates, and asexual reproduction of *Halimeda kanaloana* appear to contribute toward the success and persistence of this species in Hawaii. Disturbance removing entire individuals over a large area, e.g. repeated cruise ship anchoring, would require years for recovery.

## 10-70

**Space Competition Between *acropora* Coral And Algae -Different Reaction Of Coral To Two Types Of Algae With Different Growth Form**

**Reiko TAMAI*[1]**, Kazuhiko SAKAI[1]

[1]Tropical Biosphere Research Center Sesoko Station, University of the Ryukyus, Okinawa, Japan

Dominance of reef-building corals on coral reefs is achieved by herbivory and oligotrophic sea water which restricts algal blooms. Since algae are superior space competitor to corals, reduced herbivory and increased nutrient may result in phase shift from dominance by corals to dominance by algae. Although some previous studies reported interplay among herbivory, algae and corals, studies that focused on the genus *Acropora*, which is dominant in coral communities of Indo-Western Pacific, are limited. We examined the effect of herbivory on algal biomass, and the effect of algae on survival and growth of *Acropora tenuis* by conducting field experiments at Iriomote Island, where human population density is low and land development is localized.

We set up grazer-exclusion cages and transplanted small (≈2 cm in length) coral fragments of *A. tenuis* inside and outside the cages. Algal biomass, and survival and growth of the coral fragments were monthly monitored.

Herbivorous fishes were excluded effectively by the cages, and algal biomass was significantly higher inside than outside the cages. Although growth rate of the fragments was significantly lower inside the cages as predicted, the growth rate changed drastically after algal species composition changed inside the cages at the middle of the experimental period. Before seasonal change, turf algae dominated inside the cages and the fragments could not enlarge the attachment area on substrata. Frondose algae increased after disappearance of turf algae in autumn, and the fragments grew rapidly afterward.

We conclude that the effects of algae on survival and growth of small corals may be variable depending not only on algal biomass but also on their growth form.

## 11-1

**Sex Change In Fungiid Corals**

**Yossi LOYA*[1]**, Kazuhiko SAKAI[2]

[1]Zoology, Tel Aviv University, Tel Aviv, Israel, [2]Sesoko Station, University of the Ryukyus, Okinawa, Sesoko, Motobu-Cho, Japan

Sex change in animals has been the subject of a variety of theoretical and empirical evolutionary studies. The direction of sex change in animals has been reported occurring mainly from M to F (males to females; protandry) and visa versa (protogyny) and in some cases as bidirectional. Our knowledge of the various modes of sexual reproduction in scleractinian corals has increased greatly during the last two decades, but is far from encompassing the wide plasticity of reproductive strategies exhibited by this group. Here we report on novel observations of sex change in two coral species, where tagged individuals have been monitored during 3 years in the field and experimental aquaria at Sesoko, Okinawa: Fungia repanda (exhibiting protandry), and Ctenactis echinata, revealing novel bidirectional mode of sex change: (M-F-M and F-M-F). Our study exemplifies the view that models that can be applied on the scale of individuals may provide important insights to the factors underlying the evolution of sex change in animals.

## 11-2

**Behavioural Endocrinology Of Bi-Directional Sex Change in Coral-Dwelling Gobies**

**Frederieke KROON*[1]**, Philip MUNDAY[2], David WESTCOTT[1], Luke GARDNER[3], Abigail ELIZUR[4,5]

[1]CSIRO Sustainable Ecosystems, Atherton, Australia, [2]James Cook University, School of Marine and Tropical Biology, Townsville, Australia, [3]Queensland Department of Primary Industries & Fisheries, Woorim, Bribie Island, Australia, [4]University of the Sunshine Coast, School of Science and Education, Maroochydore DC, Australia, [5]Queensland Department of Primary Industries & Fisheries, Woorim, Australia

The discovery of bi-directional sex change (i.e. the ability to change sex repeatedly in both directions) in various fish species provides a unique opportunity to study the endocrine mechanisms underlying female and male sex differentiation. We examined a potential causal relationship between behaviour, endocrine pathways, and natural sex change in coral-dwelling gobies of the genus *Gobiodon*. These species generally live in heterosexual pairs and natural sex change occurs as a result of changes in social conditions. If adult sex change in coral-dwelling gobies is a result of changes in behavioural interactions perceived by an individual fish, then we predict the following:

that in heterosexual pairs males are behaviourally dominant;

that in heterosexual pairs cortisol levels are higher in females than in males;

that in heterosexual pairs aromatase expression is higher in females than in males;

that in heterosexual pairs estradiol levels are higher in females than in males;

that an increase in cortisol levels results in protandrous sex change, and a decrease in cortisol levels results in protogynous sex change.

To test these predictions, we observed behavioural interactions in existing heterosexual pairs in the laboratory, and conducted field experiments under natural social conditions. The results suggest that, in coral dwelling gobies, behavioural interactions mediates sex change in each direction via the aromatase pathway.

## 11-3

**Light Sensing And The Coordination Of Coral Broadcast Spawning Behavior**

Dan HILTON[1], **Peter VIZE*[2]**

[1]Biological Sciences, University of Calgary, Calgary, AB, Canada, [2]Biological Sceinces, University of Calgary, Calgary, AB, Canada

While lunar cycles establish the day of spawning in corals, sunlight driven systems control the hour and minute of spawning. The two lines of evidence supporting this contention are: 1. coral spawning times change from year to year corresponding to changes in sunset time 2. artificially changing sunset time results in a corresponding change to spawn time. This later point also indicates that the solar control is not an entrained circadian system or it would not respond in this manner. Our research is exploring the cellular pathways by which solar light regulates spawning behavior through a combination of proteomics and candidate pathway analysis. We are mapping coral protein phosphorylation oscillations in response to different levels of illumination. As most light transduction systems result in changes in such patterns this approach will identify phosphoprotein signatures that can be used as markers of signal perception. Such signatures can then be used to test the role of different signaling pathways in the response to light, to compare responses in species with different spawning times, to measure the importance of zooxanthellae in the response etc. A second approach is identifying coral orthologs of genes involved in regulating either circadian cycles or light responses. These candidates are then tested for responsiveness to lunar and solar light at both the transcriptional and post-transcriptional level. Through a combination of these two approaches we hope to map the pathways by which lunar and solar light independently regulate coral spawning behavior. We are particularly interested in how these two different systems intersect to select the exact moment of gamete release and how changes in the dynamics of the molecular sensing systems generates distinct species-specific spawning windows.

## 11-4

**Light-Responsive Cryptochromes From A Simple Multicellular Animal, The Coral Acropora Millepora**

**Oren LEVY*[1]**, Lior APPELBAUM[2], William LEGGAT[3], Yoav GOTHILF[4], David HAYWARD[5], David MILLER[6], Ove HOEGH-GULDBERG[7]

[1]Department of Environmental Sciences, The Weizmann Institute of Science, Rehovot, Israel, [2]Center For Narcolepsy, Stanford University, Palo Alto, CA, [3]Biochemistry and Molecular Biology, James Cook University, Townsville, Australia, [4]Department of Neurobiochemistry, Tel Aviv University, Tel Aviv, Israel, [5]Molecular Genetics and Evolution Group, Australian National University, Canberra ACT, Australia, [6]Comparative Genomics Centre, James Cook University, Townsville, Australia, [7]Centre for Marine Studies, The University of Queensland, Brisbane, Australia

Hundreds of species of reef-building corals spawn synchronously over a few nights each year, and moonlight regulates this spawning event. However, the molecular elements underpinning the detection of moonlight remain unknown. Here we report the presence of an ancient family of blue-light–sensing photoreceptors, cryptochromes, in the reef-building coral Acropora millepora. In addition to being cryptochrome genes from one of the earliest-diverging eumetazoan phyla, cry1 and cry2 were expressed preferentially in light. Consistent with potential roles in the synchronization of fundamentally important behaviors such as mass spawning, cry2 expression increased on full moon nights versus new moon nights. Our results demonstrate phylogenetically broad roles of these ancient circadian clock–related molecules in the animal kingdom.

## 11-5

**Evidence For Opsin-Regulated Long-Wavelength Photosensitivity in Coral Larvae**

**Benjamin MASON*[1]**, Matthew BEARD[2], Margaret MILLER[3], Jonathan COHEN[4], Valery SHESTOPALOV[5], Vladlen SLEPAK[6]

[1]RSMAS, University of Miami, Miami, FL, [2]Biological Sciences, Florida State University, Tallahassee, FL, [3]NOAA - Southeast Fisheries Science Center, Miami, FL, [4]Marine Science, Eckerd College, St. Petersburg, FL, [5]BascomPalmer Eye Institute, McKnight Vision Center, Leonard M. Miller School of Medicine, University of Miami, Miami, FL, [6]Molecular and Cellular Pharmacology, Leonard M. Miller School of Medicine, University of Miami, Miami, FL

Research has demonstrated that light influences the swimming behavior and settlement of coral larvae, yet a physiological and molecular basis for photosensitivity has not been described in corals. Here we provide evidence for long-wavelength photosensitivity in several species of scleractinian coral larvae and demonstrate the presence of an opsin–like protein, localized in solitary, sensory epithelial cells. Settlement experiments with *Porites astreoides* and *Acropora palmata* demonstrated that these larvae are attracted to and preferentially settle on red substrates. Larvae settled and metamorphosed on red fluorescent plastic substrate but not on plastic substrates of other colors. Preference for red was not observed when larvae were maintained in the dark, suggesting that phototaxis, rather than a chemical cue, was responsible for the observed preference. Electrophysiology (electroretinographic traces) confirmed sensitivity to long-wavelength light in larvae of *P. astreoides*. Immunoblots, using a rabbit polyclonal antibody directed against squid opsin, indicated the presence of a ~50 kDa, opsin-like protein in larvae of *A. palmata*, and *Diploria strigosa*. Immunofluorescence and confocal imaging of sectioned larvae demonstrated this opsin-like protein is localized in solitary, ciliary epithelial cells in *P. astreoides*, *D. strigosa*, *Montastraea faveolata,* and *Favia fragum*. Protein blasts of *M. faveolata* larval contig ESTs with *Nematostella vectensis* and squid opsin sequences, revealed the expression of two 7-transmembrane receptors with significant similarity (2e^-9 to 2e^-18) to the query sequences. Efforts to determine the remaining sequence and confirm the identity of these proteins are currently in progress.

## 11-6

**Bleaching Has No Short-term Effect on Reproduction in the Scleractinian Coral *Montipora capitata***

**Evelyn COX*[1]**

[1]University of Hawaii West Oahu, Pearl City, HI

Bleaching is generally expected to produce detrimental impacts on coral reproduction. This study compared the fecundity of bleached and unbleached colonies of the Hawaiian coral *Montipora capitata*. It was hypothesized that bleaching would have no effect on reproduction because previous studies have shown that *Montipora capitata* can increase heterotrophic feeding following bleaching. Reproductive parameters, total reproductive output (bundles released ml-1 coral colony), number of eggs bundle-1, and egg size, measured in the summer of 2005 did not differ between colonies that bleached or did not bleach during 2004. These data were collected following a single bleaching event and cannot be used to predict the outcome should bleaching episodes become more frequent or severe.

## 11-7

**Reproduction in The Coral Reef Herbivore Scarus Ferrugineus (Scaridae): Its Timing And Seasonality**

**Yohannes AFEWORKI*[1,2]**, John VIDELER[2], Henrich BRUGGEMANN[3]

[1]Applied Marine Science, College of Marine Science, Massawa, Eritrea, [2]Marine Biology, University of Groningen, Haren, Netherlands, [3]Laboratoire ECOMAR, Université de La Réunion, La Réunion, France

Reproductive behavior of the rusty parrotfish *Scarus ferrugineus* was studied in a fringing reef in the Southern Red Sea (Eritrea). Observations on territory holding Terminal Phase Males (TTP) were conducted to record the following parameters: the location of the territory, timing and duration of territory holding, territory size, size of the TTP, number of Initial Phase females (IP) and non-territorial Terminal Phase males (TP) arriving at the territory, frequency of spawning and streaking. The mating system of *S.ferrugineus* is lek-based where large TTPs occupy a temporary breeding territory in the deep fore reef (6 – 10 m depth). Territory holding and spawning occurred daily year-round. But the timing was different for the cold (November – April) and warm (May – October). During the warm months (July – September) breeding territories were kept at around high tide time. The timing of spawning shifted with the peak high-tide-time as it progressed through the consecutive days. Only when the day high tide occurred after 3:00 pm the fish switched to the early hours of the morning just after the night high tide. Duration of the breeding ranged between 1 – 3.5 hours with the longest periods occurring during the morning. In the colder months (December – March) territory holding invariably took place during the morning hours between 7:30 and 11:00 irrespective of the period of the tide. Intensity of reproductive behavior was highest during the cold months. During that period 70 % of females that were striped had hydrated eggs compared to 40 % during the warm months. A tradeoff between reproduction and growth is evident in the cold months as reflected in the low body condition of all the social categories. This tradeoff appears to be caused by lost feeding opportunities while spawning, high energetic costs of spawning and territory keeping and low primary production during that period.

## 11-8

**Patterns of Egg Predation at Reef Fish Spawning Aggregation Sites and the Role of Target Egg Predators**

**Matthew FRASER*[1]**, Mark MCCORMICK[1]

[1]Marine and Tropical Biology, James Cook University, Townsville, Australia

Predator-prey interactions at reef fish spawning aggregations are poorly understood yet form the foundation of hypotheses explaining spawning site selection and temporal patterns of spawning aggregations. The current study examined egg predation by reef based obligate and facultative planktivores at reef fish spawning aggregation sites at Kimbe Bay, Papua New Guinea. The objective of this study was to quantify egg predation levels among spawning aggregation sites and among three reef fish species, and examine characteristics of both the spawners and spawning sites in order to explain the patterns of egg predation. Spawning activity was monitored daily at seven spawning aggregation sites across three reefs over a two month period. During each spawning event the number of spawning rushes released, the number of rushes preyed upon and the species of egg predators that fed on each rush. Attributes of each spawning aggregation site measured were density of egg predators during a spawning event and substratum topographic complexity. Egg predation was greatest for the surgeonfish, *Ctenochaetus striatus*, and differed significantly among sites. Levels of egg predation for *C. striatus* correlated significantly with egg predator density while egg predation levels for the parrotfish, *Chlorurus bleekeri*, and wrasse, *Thalassoma hardwicke*, did not. Similarly, levels of egg predation for *C. striatus* correlated significantly with substrate topographic complexity while egg predation levels for *C. bleekeri* and *T. hardwicke* did not. This study shows the immediate predation of eggs by target egg predators is an important source of mortality and directly influences the number of propagules being effectively liberated from spawning sites used by *C. striatus*. The differences in the levels of egg predation between spawning species suggests that the intensity of target egg predation may not be an important determinant in the choice of spawning aggregation sites.

## 11-9

**Reproductive Pattern Of The Polychaete Sabellastarte Spectabilis in Hawaii.**

**David R. BYBEE*[1]**, Julie H. BAILEY-BROCK[2], Clyde S. TAMARU[3]

[1]Department of Biology, Brigham Young University-Hawaii, Laie, HI, [2]Department of Zoology, University of Hawaii, Honolulu, HI, [3]Sea Grant College Program, University of Hawaii, Honolulu, HI

The objective of this study was to determine the timing of reproduction in the Sabellid polychaete *Sabellastarte spectabilis* (Grube 1878) and to correlate reproductive activity with water temperature and day length. Worms were collected at approximately monthly intervals from Jan. 2002 to Dec. 2003 from intertidal and subtidal reefs in Kaneohe Bay, Hawaii, USA (21° N, 157 ° W). Reproductive activity was investigated qualitatively using histological techniques and quantitatively with induction of spawning trials. Worms were characterized into four discrete reproductive stages based on histological evidence: 1) No evidence of reproductive activity in the coelom 2) Only coelomocytes present in the coelom 3) Some gametes present in the coelom and 4) Coelom densely packed with gametes. Stage 4 worms were present over an extended period of time (females, March-December and males, March-November) indicating a potentially broad reproductive season. No correlation between day length and maturation stages in *S. spectabilis* was detected. However, there was a correlation between water temperature and % frequency of Stage 4 worms. Maturation appeared to coincide with water temperatures of 24 to 25 ºC (March – September) after which there was a reduction in the % frequency of stage 4 individuals. Induction of spawning trials conducted between May – January showed the month of October with a significantly higher percent success than any other month investigated. According to all available information (e. g., natural spawning in water tables, histological data, induction of spawning trials, correlation of maturation stages with observed changes in average monthly water temperature.), there is an apparent peak in reproductive activity (spawning) within a broad maturational season, which may be influenced by water temperature.

## 11-10

**The Effects Of Temperature And Light On The Gametogenesis And Spawning Of Four Sea Urchin And Five Sea Cucumber Species On Coral Reefs in Kenya And La Reunion**

**Nyawira MUTHIGA*[1]**, Chantal CONAND[2], Joan KAWAKA[3], Sophie KOHLER[4]

[1]Marine Program, Wildlife Conservation Society, Bronx, NY, [2]Laboratoire de biologie marine, Université de La Réunion, Saint Denis, France, [3]Wildlife Conservation Society, Mombasa, Kenya, [4]University de La Reunion, Saint Denis, France

This paper reviews studies of the reproductive cycles of 4 species of sea urchins (*Echinometra mathaei, Diadema savignyi, D. setosum, Tripneustes gratilla*) and 5 species of sea cucumbers (*Actinopyga echinites, Holothuria atra, H. leucospilota, H. scabra* and *Stichopus chloronatus*). Measurements of gonad index and macro and microscopic observations of gonads were used to evaluate changes during gametogenesis in individuals collected on Kenyan and Reunion reefs. The effects of temperature, light and lunar period were also assessed. *Echinometra mathaei*, *H. arenacava*, *H. leucospilota* in Kenya and *H. atra* in Reunion showed an annual pattern while *A. echinites*, *H. leucospilota* and *S. chloronatus* in Reunion and *H. scabra* in Kenya showed a biannual pattern of reproduction. A particularly pronounced seasonal pattern occurred in *E. mathaei*, *H. arenacava* and *H. leucospilota* on Kenyan reefs where gametogenesis started in July when temperatures and light were at their lowest and spawning peaked between March-April just after peak levels of temperature and light. These species showed higher correlations between light and gonad index than between temperature and gonad index indicating that light had a stronger influence than temperature on the onset of gametogenesis on these species on the Kenyan coast. In the species without pronounced annual reproductive patterns, gonad indices were high during one (*D. setosum*, *D. savignyi, T. gratilla* in Kenya) or two (*A. echinites*, *H. leucospilota* and *S. chloronatus* in Reunion and *H. scabra* in Kenya) periods of 1 - 2 and up to 6 months but the reproductive season often coincided with periods of high temperature and light. Only three of the sea urchin species (*D. savignyi*, *D. setosum* and *T. gratilla*) showed lunar periodicity.

## 11-11

**Gametogenic and reproductive cycles of a sea anemone that provides essential habitat for anemonefish**

**Anna SCOTT*[1,2]**, Peter HARRISON[3]

[1]Coral Reef Research Centre, Southern Cross University, Lismore, Australia, Coffs Harbour, Australia, [2]National Marine Science Centre, Coffs Harbour, Australia, Coffs Harbour, Australia, [3]Coral Reef Research Centre, Southern Cross University, Lismore, Australia, Lismore, Australia

Sea anemones that host obligate symbiotic anemonefish are ecologically important throughout many reefs of the Indo-Pacific. Despite their importance there is very little information available on their sexual reproductive biology. This study aimed to address this lack of knowledge by determining the gametogenic cycles of the sea anemone, *Entacmaea quadricolor*. Gonad samples were taken in the field using a specially developed biopsy sampling technique from January 2003 to February 2005 at North Solitary Island, Solitary Islands Marine Park, Australia. On each sampling occasion, 15 to 20 individuals were sampled, with the depth, colour and pedal disc diameter of each anemone being recorded. Samples were fixed and histological sections were prepared to determine the state of reproductive activity for each individual. All oocytes sectioned through the nucleus were measured and assigned to size classes of 150 µm. Males were classified into one of five stages based on assessment of spermary maturity. Spawning was inferred by the disappearance of the largest size class of oocytes in the females, and the disappearance of mature spermaries and the appearance of the ruptured or spawned mesenteries in the males. *E. quadricolor* had separate sexes at the study location, with female anemones being significantly more abundant than male anemones. Female anemones displayed asynchronous oocyte development, both within and among individuals, whereas male anemones showed a single cycle of spermary growth, development and spawning. Six spawnings, which occurred between January and April, were inferred over the study period. On all but one occasion both female and male anemones were inferred to have spawned during the same period. Due to ease of interpretation, the developmental pattern of the spermaries may therefore provide a better indicator of spawning times in this species.

## 11-12

**Mass Coral Spawning Events At Reunion Island (21°s) From 1991 To 2007**

**Mireille M.M. GUILLAUME*[1,2]**, Maurice PARMANTIER[2], J. Henrich BRUGGEMANN[2]

[1]Milieux et Peuplements Aquatiques, UMR 5178 CNRS-UPMC-MNHN, Muséum National d'Histoire Naturelle, Paris, France, [2]ECOMAR, Université de la Réunion, Saint-Denis, Reunion

The occurrence of mass coral spawning has been checked intermittently at Reunion Island since 1985. In 1991, M. Parmantier discovered the timing of mass spawning in A. muricata and surveyed one coral patch annually until 2003. While correlation to full moon was confirmed, the month and exact timing varied between years.

The objectives of the present study are to inventory the species involved and analyze the timing of mass spawning in relation to environmental parameters susceptible to trigger these events. Mass spawning events were surveyed from 2004 to 2007 on three coral reefs (Saint-Gilles, la Saline and Saint-Leu) during the four nights following full moon in August to December, involving each night ~20 observers from the University of Reunion. Temperature was recorded in situ at each reef, while solar insolation is available by Météo France. Few species contributed to mass spawning on the shallow reef flats, the dominant species Acropora muricata, both ecomorphs of A. digitifera, A. vaughani and sometimes A. gemmifera. The long-term spawning record (1991-2007) of A. muricata is analyzed with environmental data. Mass spawning occurred when SST was the lowest, in October or November, once in September. Coral spawning was clearly related to the lunar cycle, occurring from the 1st to the 4th day after full moon, 1 to 2.5 hours after the night-time low tide, but not later than midnight. Gamete release coincides with the incoming flow by night, following the tidal wave that sweeps the West coast of Reunion Island from South to North. Synchrony is high between reef flats, but A. muricata at one site at la Saline, may be one month in advance. Corals on outer reef slopes spawn together with those on reef flats, but not yearly.

## 11-13

**Biannual Multi-Specific Coral Spawning On North-West Australian Reefs**

**Natalie ROSSER*[1]**, James GILMOUR[2], Andrew BAIRD[3]

[1]RPS, Perth, Australia, [2]Australian Institute of Marine Science, Perth, Australia, [3]ARC Centre of Excellence for Coral Reef Studies, Townsville, Australia

Observations of multi-specific synchronous coral spawning periods in Australia have lead to the recent realisation that on the west coast of Australia there is a primary multi-specific spawning in the austral autumn (March/April), and on some northern reefs, a secondary multi-specific spawning in spring (October). Here we present data of species participating in the secondary spring spawning from three locations in north Western Australia: the Bonaparte Archipelago (Kimberley), Scott Reef and the Dampier Archipelago, indicating that the spring spawning occurs across a wide latitudinal range. In all three locations all species that spawned in spring also spawned in autumn. However some species that spawned in spring in one location did not necessarily spawn in spring in another, e.g. A. hyacinthus spawned in spring at Scott Reef, but not at Dampier. Other species spawned in spring at all three locations e.g. A. humilis and yet others never spawned in spring at any location e.g. A. millepora. These results suggest that there is a physiological element driving a species ability to be able to spawn during both spring and autumn, as some species consistently spawned in both seasons while others consistently did not. Furthermore, that some species spawned in both seasons in one location but not in another, would also suggest that it may be a combination of both physiology and environmental conditions that allows a species to spawn in both seasons, and that these environmental parameters are highly localised.

## 11-14

**Sexual Reproduction Of Hermatypic Corals Along The Mexican Pacific Coast**

**Eugenio CARPIZO-ITUARTE*[1]**, Hector REYES-BONILLA[2], Amilcar CUPUL MAGAÑA[3], Andrés LÓPEZ-PÉREZ[4], Pedro MEDINA-ROSAS[3], Hector Efraïn CHÁVEZ-ROMO[1], Paola RODRÍGUEZ-TRONCOSO[1], Verónica VIZCAINO-OCHOA[1], Miriam MORA-PÉREZ[2], Gerardo LEYTE-MORALES[4], Luis E. CALDERÓN-AGUILERA[5], Guillermina CHI-BARRAGÁN[1], Olivia TAPIA-VÁZQUEZ[6]

[1]Oc. Biológica, Isnt. Inv. Ocean. UABC, Ensenada, B.C., Mexico, [2]Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico, [3]Ciencias Médicas y Biológicas, Universitario de la Costa, Univ. De Guadalajara, Pto. Vallarta, Mexico, [4]Instituto de Recursos, Universidad del Mar, Pto Angel, Mexico, [5]Ecología, Centro de Investigación Científica y Educación Superior de Ensenada, Ensenada, Mexico, [6]Comité Estatal de Sanidad Acuícola e Inocuidad de Baja California, Ensenada, Mexico

In contrast to the equatorial eastern Pacific (EEP), where the sexual reproductive activities of several zooxanthellate coral species have been described, only recently have similar studies been initiated in the Mexican Pacific (MP) region. During the last eight years, the reproductive patterns of three of the most common MP species have been investigated: *Pocillopora damicornis*, *Porites panamensis* and *Pavona gigantea*. The study areas range from La Paz, Baja California Sur (24o 19' 02" N; 110o 19' 57" O) to Bahia de Banderas, Jalisco-Nayarit (20o 42' 03" N; 105o 33' 52" O), and along the Huatulco coast, Oaxaca (15o 44' 40" N; 96o 07' 35" O). Initial surveys have shown the three species produce mature gametes, and that seasonality, frequency and extent of the reproductive period are highly influenced by local oceanographic conditions (upwelling centers, thermocline shoaling, marked seasonal temperature variation). Compared to extended reproductive activity in Panama, Costa Rica and Ecuador in the EEP, the same species in the MP exhibit a higher degree of seasonality. Continuing studies of the three species in different areas, and other less abundant species, will allow a more critical comparison of the reproductive activities of corals along the entire latitudinal range of the eastern Pacific. Regional comparisons of asexual reproduction and recruitment are also planned to better understand the relative importance of these life history traits in relation to MP coral community dynamics. We are hopeful these studies will provide information that can be used to promote better management and conservation strategies for the preservation of coral communities and reefs along the MP coast.

## 11-15

**Reproduction of Reef Corals from the Southwestern Atlantic (Brazil)**

**Débora PIRES*[1]**, Clovis CASTRO[1]

[1]Departamento de Invertebrados, Museu Nacional/Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

Brazil has the only true coral reefs known in the South Atlantic, with most builder corals endemic. Based on histological data, we investigated sexual patterns, mode and seasonal patterns of reproduction, and spawning periods of 10 scleractinians (five endemic: Mussismilia braziliensis, M. harttii, M. hispida, Favia gravida, and Siderastrea stellata; and five also occurring in the Caribbean: Scolymia wellsi, Porites astreoides, Madracis decactis, Agaricia humilis, and Montastraea cavernosa). Our results indicated that half of the species are brooders and half are spawners. Two species are gonochoric. In Brazil, the release of gametes/planula occurs in different times of the year. A few simultaneous spawning days of M. hispida and M. harttii were observed in Porto Seguro (16ºS). Histological data from Abrolhos specimens (18ºS) suggested that M. hispida can present simultaneous spawning with M. braziliensis in this area. More studies are necessary to understand the variation in time of spawning of M. hispida in different areas. Mussismilia spp. are hermaphroditic and present at least two consecutive monthly periods of spawning a year, dictated by the new moon. Most of the brooder corals present several annual periods of planula release. Favia gravida and Agaricia humilis release planula monthly, while Scolymia wellsi and Porites astreoides release only in some consecutive months of the year. Siderastrea stellata has a period of planula release restricted to the summer, and in Madracis decactis it happens in the beginning of the autumn. Mussismilia harttii presents synchronic spawning in different places (08ºS, 16ºS, 18ºS). There is assynchrony in the spawning period of S. stellata and M. hispida, when populations of Búzios (23ºS) and other places are compared. Upwelling events, that happen in Búzios during the summer, may be influencing the gametogenesis of these species.

## 11-16

**Planulation Near Dawn Results in Increased Survivability Of *favia Fragum***

**Gretchen GOODBODY-GRINGLEY*[1,2]**

[1]Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, [2]Bermuda Institute of Ocean Sciences, St. George's, Bermuda

Numerous studies have addressed annual timing of planulation in scleractinians, documenting a tightly synchronized process that coincides with lunar periodicity. In contrast, diel variation has received little attention yet may have important implications for post-metamorphic success. In summer 2007, I examined hourly release of planulae by *Favia fragum* in Bermuda. Planulation occurred throughout the night with a significant peak between 4 and 5 am. Release near dawn may be advantageous for *F. fragum* as a means of maximizing time for utilization of light cues in larval behavior and increasing availability of symbiont-derived photosynthetic products. Such benefits to pre-dawn release may be manifested in life history traits such as competency, settlement, mortality and growth. To compare competency and metamorphic success of larvae released at night versus pre-dawn, planulae were collected over two-hour intervals, from 10 pm to 12 am (night) and 4 to 6 am (pre-dawn), in July and August 2007. Percent larvae competent for settlement was significantly higher for those released pre-dawn than those released at night. Despite the 6-hour difference in release time, settlement in both groups coincided with daylight hours, suggesting that environmental factors govern this process. Additionally, percent metamorphic success was significantly higher for larvae released pre-dawn. Following settlement, terra-cotta tiles with new spat were placed on an inshore patch reef and monitored for growth and mortality over the succeeding 40 days. Growth rates for pre-dawn planulae were initially significantly higher than night released planulae, however this difference did not persist over time. Benefits accrued to larvae released near dawn, compared to those released 6 hours earlier, may be explained by a combination of increased energy reserves provided through immediate exposure of photoautotrophic symbionts to light, coupled with decreased total respiration from time of planulation to settlement.

## 11-17

**The Annual Timing Of Coral Spawning: A Role For Rainfall?**

**Judith MENDES*[1,2]**

[1]Department of Life Sciences, University of the West Indies, Kingston, Jamaica, [2]Bellairs Research Insititute of McGill University, St James, Barbados

Sea surface temperature (and the solar insulation responsible for temperature) is the most frequently cited trigger for the annual timing of coral spawning. We conducted a meta-analysis of spawning time at 42 sites worldwide in relation to sea surface temperature and rainfall. The data on temperature, rainfall and spawning time were examined by log-linear analysis. The log-linear model of best fit included al 2-way interactions (temperature x rainfall, spawning x temperature, and spawning x rainfall; chi-squared = 41.06, df = 39, p = 0.38). The chi-squared test is not significant indicating that the values predicted by the model are not significantly different from the observed values. One can thus conclude that the model is sufficient to explain the time of spawning. Tests of partial association show that the magnitude of the temperature effect was greater than that for rainfall, however, on its own, temperature was insufficient to explain the time of spawning. Only when the interaction between rainfall and spawning was incorporated in the model could the time of spawning be adequately explained. According to our model, temperature and rainfall have opposite effects on the time of spawning with the likelihood of spawning increasing with increasing temperature and decreasing with increasing rainfall. Two possible roles underlying the contribution of rainfall to spawning time are, firstly, that spawning during period of low rainfall reduces the risk of catastrophic reproductive failure caused by gametes coming into contact with rain diluted surface water. Secondly, spawning prior to the peak of heavy rainfall, may also increase the food available for newly-settled, azooxanthellate coral polyps and the chance of such polyps acquiring zooxanthellae. A similar association of spawning to heavy rainfall (typhoons) has recently been described for the abalone *Haliotis diversicolor* (Onitsuka et al, 2007)

## 11-18

**Global Patterns And Environmental Controls Of Sexual Reproduction in Scleractinian Reef Corals**

**Peter HARRISON*[1]**

[1]Coral Reef Research Centre, School of Environmental Science and Management, Southern Cross University, Lismore, NSW, Australia

Research on sexual reproductive patterns of scleractinian reef corals continues to expand rapidly, providing important insights into proximate environmental controls and evolutionary constraints on coral reproductive success. An updated global review of scleractinian coral reproductive patterns confirms that hermaphroditic broadcast spawning remains the dominant pattern among scleractinian corals studied to date, with fewer gonochoric broadcast spawning or brooding species known. In a few species, mixed patterns of sex allocation and both brooding and broadcast spawning occur. Sea temperature and light in various forms are key environmental factors that interact to control reproductive cycles, lunar periodicity and spawning periods in reef corals. These proximate cues also strongly influence breeding periods and reproductive synchrony among coral species, with mass spawning (involving many species) or multispecific spawning (with fewer species) prevalent on many tropical and subtropical reefs. Protracted breeding periods and less synchronous reproduction are evident among reef corals on some equatorial reefs. A new model is developed that integrates thermal and light energy optima as primary determinants of coral reproductive patterns, with suboptimal conditions resulting in impaired reproduction and reduced reproductive success. Sea temperature also significantly influences coral larval development, competency and settlement success, with more rapid larval attachment and increased likelihood of localised settlement, but lower post-settlement survival, under elevated temperature. This has very important implications for reef connectivity and gene flow among coral populations in a rapidly warming global climate, and the future viability of some isolated reef systems.

## 11-19

**Solar Insolation Drives Reproductive Schedules Of Reef Corals: A Long Road in The Search For Proximate And Ultimate Cues**

**Robert VAN WOESIK*[1]**

[1]Biological Sciences, Florida Institute of Technology, Melbourne, FL

Coral populations depend on the formation of sex cells (gametes) for survival and adjustment to climatic shifts. Since adaptation involves differential-reproductive rates of individuals in populations, it is critical to understand global reproductive schedules of corals. This study tested the hypothesis that annual rising Sea Surface Temperatures (SSTs) and solar insolation are related to gamete maturation and synchronous gamete release in the Atlantic and Indo-Pacific Oceans. Reproductive schedules of corals were positively related to solar insolation cycles, and SSTs were poor predictors of coral spawning schedules. Near the equator coral spawning coincided with the equinoxes, showing two annual events. While proximate cues may explain how spawning synchronicity develops, there is a need to identify ultimate cues to ask why questions, including: 1) Why do such patterns exist? and 2) What is the long-term advantage (or adaptive significance) of such synchronized patterns? There is a strong positive relationship between the derivative of solar insolation and mean-wind speed, suggesting that rates of solar insolation change are strong predictors of mean-wind speed. This infers that corals appear to synchronize mass spawning during seasonally calm periods; which clearly agrees with recent genetic evidence of local dispersal and high local retention. Synchronization during calm periods would have rapidly evolved through selection outside the seasonally calm periods, because gametes and larvae would have been lost from the local species pool. Therefore, while solar insolation may be the proximate cue, the strong evolutionary filter (the ultimate cue) may have been the calm periods when insolation was not changing rapidly, which in turn facilitated local larval retention. This research demonstrates that solar insolation strongly influences coral reproductive schedules worldwide, and synchronization enhances time-varying differences in reproductive output and fitness because it occurs at times of low regional wind speeds that facilitate high local larval retention.

## 11-20

**Predicting patterns of coral spawning at multiple scales**

**Andrew BAIRD*[1]**, James GUEST[2]

[1]ARC CoE Reef Studies, James Cook University, Townsville, Australia, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom

Early theoretical work predicted that the reproductive season of widespread organisms should be more extended near the equator than at high latitudes because conditions favourable for gametogenesis persist year round. Similarly, it was believed that synchrony among both populations and species would be lower at the equator because there are fewer good cues in the tropics where annual fluctuations in environmental variables are lower. Here, we present data from numerous locations within the Indo-Pacific which indicates that multi-specific synchronous spawning is a characteristic feature of all Acropora assemblages and further, at large scales, spawning episodes are highly predictable. In the central Indo-Pacific, for example, the majority of reproductive output is concentrated in brief periods following full moons at the beginning and end of the monsoon. Above approximately 28-30 degrees latitude, and possibly at some sites in the cental Pacific, this pattern breaks down and the spawning episode is progressively one month later in the season for every 2-400 km further from the equator. At smaller scales the patterns are far less predictable. For example, in the central GBR peak spawning times within sub-populations of a single species can vary dramatically over very small scales. In conclusion, while large scale patterns in coral spawning seasonality may be relatively predictable, detailed studies at the local scale are required to determine precisely when a given sub-population will spawn.

## 11-21

**Spatial Patterns Of Reproductive Synchrony By Four Genera Of Tropical Green Seaweed Across A Latitudinal Gradient in The Caribbean.**

**Kenneth CLIFTON*[1]**

[1]Biology, Lewis and Clark College, Portland, OR

Spatial and temporal patterns of reproductive effort are an especially significant feature of fertilization success for virtually all broadcast spawning organisms. While most research efforts on this topic have focused on varying temporal scales of reproductive synchrony (i.e., diel, lunar, and seasonal scales), patterns of reproductive synchrony on varying spatial scales (i.e. from meters to hundreds of kilometers) are less well studied. Simultaneous investigations of sexual reproduction by tropical green seaweeds (e.g., *Caulerpa, Halimeda, Penicillus, Udotea*) across a latitudinal gradient in the Caribbean (Panama, U.S. Virgin Islands, Florida) reveal patterns of reproductive synchrony on different spatial scales. Within a region, spatial synchrony often extends beyond local populations (meters to tens of meters) to at least scales of tens of kilometers, however, such synchrony is not maintained across larger (hundreds of kilometer) spatial scales. Relative synchrony within and between genera is maintained across this larger latitudinal gradient, however. Reproductive seasonality also shows an interaction with latitude for these seaweeds, with shorter, temporally delayed seasons of reproductive activity occurring at higher latitudes.

## 11-22

**Genetic, Spatial And Temporal Patterns Of Spawning in The Caribbean Montastraea Annularis Species Complex**

**Don LEVITAN*[1]**, Nancy KNOWLTON[2]

[1]Biological Science, Florida State University, Tallahassee, FL, [2]Department of Invertebrate Zoology, Smithsonian Institution, Washington, DC

Members of the *Montastraea annularis* species complex all spawn on the same few evenings each year. *Montastraea franksi* spawns approximately 100 minutes after sunset and *M. faveolata* and *M. annularis* overlap in spawning approximately 200 minutes after sunset. These latter two species have incompatible gametes, whereas *M.franksi* and *M. annularis* gametes are compatible when corals are manipulated to spawn simultaneously. Here we investigate patterns and consequences in spawning times within a species. What factors influence spawning times and what are the consequences of spawning early or late within a conspecific spawning event? We have mapped and genotyped over 350 individual corals on a reef off of Bocas del Toro, Panama. These tagged corals have been monitored for spawning over the past six years. The results indicate that (1) putative clone-mates produced via fragmentation have more similar spawn times than unrelated genotypes, (2) corals in deeper water tend to spawn earlier, and (3) there is a genotype by depth interaction in spawning times (clone-mates have significant differences in the way they respond to depth in spawn time). In addition although the species tends to spawn over a period of approximately 40 minutes, (4) individuals corals tend to spawn within a few minutes of when they spawned in previous years; individuals have a high degree of fidelity to a particular spawn time. Overall these results suggest a large genetic component to precise spawn times. Data on reproductive success of corals that spawn at different times indicate that (5) corals spawning during the mid-point of the event have higher reproductive success compared to individuals spawning at the tails of the event. The genetic control over spawning time coupled with the fitness consequences of variation in spawning times provide the evolutionary mechanism by which reproductive synchrony is achieved.

## 11-23

**Correlated Evolution Of Life-History Traits in Scleractinian Corals**

**Alexander KERR*[1,2]**, Andrew BAIRD[2], Terry HUGHES[2]

[1]Marine Laboratory, University of Guam, Mangilao, Guam, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

The population and quantitative genetic aspects of life-history traits receive considerable theoretical and empirical attention, yet far less is known about the macroevolutionary relationships among such characters, particularly in a phylogenetic context. In this study, we examine the evolution of two important life-history features, sexuality and reproductive mode, on a composite or "supertree" phylogeny of 242 species of scleractinian corals in order to address the following questions: (1) How rapidly do reproductive traits evolve? (2) Are the evolutionary rates of reproductive characters correlated? (3) How does trait evolution generate large-scale taxonomic patterns in reproductive traits? Both maximum likelihood-based model selection and maximum-parsimony mapping of state transitions done over a sample of optimal trees to incorporate phylogenetic uncertainty indicate that the evolution of sexuality (gonochorism versus hermaphroditism) and reproductive mode (brooding versus spawning) were unambiguously correlated across Scleractinia. Transition rates between states differed significantly and by as much as two orders of magnitude among, as well as within, characters. Reproductive mode evolves at twice the rate of sexuality, while the evolution of sexuality was heavily biased: Gonochorism is over 100 times more likely to be lost than gained and then only among brooders, such that gonochoric spawners seldom evolve hermaphroditism. Gonochoric spawners preferentially shift to brooding and then, or jointly, become hermaphroditic before reacquiring spawning to attain the dominant scleractinian reproductive condition. Thus, we conclude that large-scale taxonomic and phylogenetic patterns in a fundamental life-history character may be accentuated by correlated evolution with other life-history traits when coupled by state bias in at least one character. Further, phylogenetic and taxonomic patterns of joint character states can be generated through unanticipated and extended pathways of state change if traits are under intense natural selection.

## 11-24

**The Reproductive Biology Of Pacific Island Corals: Patterns And Permutations**

**Robert RICHMOND*[1]**

[1]Kewalo Marine Laboratory, University of Hawaii at Manoa, Honolulu, HI

Data and observations on reproductive characteristics are available for approximately 220 species of scleractinian corals world wide. Only 10 coral species have been identified as having year round production of gametes and larvae, and all of these are brooders. The remaining 200+ species have been identified as having limited periods of reproductive activity each year, from a few nights or days per year, to several periods over several months. Two decades of data on coral reproduction in the Pacific Islands of Hawaii and Micronesia have revealed annual, lunar and diel patterns in timing as well as reproductive responses to both natural and anthropogenic disturbances. Many of the mass spawning species including those in the genera *Acropora*, *Goniastrea*, *Favia*, *Porites* and *Leptoria* have distinct temporal patterns during the days or nights on which they spawn. Repeated sampling has demonstrated species will release gametes consistently at specific times of day, evening or night year after year. Variability in annual reproductive cycles has been found in response to climatic conditions and events. Recent research on the effects of multiple stressors on corals has found reproduction is affected by both exogenous and endogenous factors and that reproductive patterns can be interrupted or otherwise affected by pollution and other sources of stress. Reproduction and subsequent recruitment are the two processes responsible for the persistence of coral reefs, and as such, are important processes for addressing the future of these precious ecosystems in the face of mounting levels of anthropogenic disturbances including global climate change.

## 11-25

**Survival Of Brooding And Broadcasting Reef Corals Following Large-Scale Disturbances: Is There Any Hope For Broadcasting Species During Global Warming?**

**Peter GLYNN*[1]**, Susan COLLEY[2]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]PBS&J, Ft. Lauderdale, FL

This study examines the reproductive ecology of extant equatorial eastern Pacific (EEP) zooxanthellate scleractinian corals relative to projected global warming conditions. Reproductive characteristics (e.g. sexuality, fecundity, timing of spawning, seasonality, larval type, asexual propagation), colony morphology, growth, survivorship, and patterns of abundance and distribution of 12 recently studied species in Costa Rica, Panamá, and the Galápagos Islands are considered. All but one of these 12 EEP species are broadcast spawners. The broadcasting species, which make up 44% of the known zooxanthellate species occurring in the EEP (25 species), are numerically abundant, widely distributed, and the principal reef builders in this region. *Porites panamensis*, which broods and releases planulae, is a small nodular coral with a restricted distribution; it does not contribute importantly to contemporary reef building. The majority of the broadcasting species are highly fecund, active sexually during large parts of the year, with sexual recruits that appear to disperse relatively far to a variety of habitats. Asexual fragmentation is also common in broadcasting species compared with brooding species in the EEP region. We hypothesize that diverse habitats and varying environmental conditions (e.g., upwelling/nonupwelling centers, carbonate/basalt substrates, wet/dry seasons, high/low turbidity, high/low productivity, El Nino/La Nina activity) would increase the probability of survival of sexual recruits and the asexual fragments of broadcasting species. Such refuge populations could serve as sources of larvae or fragments to repopulate coral communities in disturbed areas. The EEP reef coral fauna, consisting dominantly of broadcasting species, may appear to be poised to resist extinction during global warming.

## 11-26

**To Eat or Not To Eat? Trophic Biology of Stylophora pistillata Larvae - A Stable Isotope Approach**

**Ada ALAMARU*[1,2]**, Ruth YAM[3], Aldo SHEMESH[3], Yossi LOYA[4]

[1]Department of Zoology, George S. Wise Faculty of Life Sciences, Tel-Aviv University, Eilat, Israel, [2]Interuniversity Institute for Marine Sciences of Eilat, Eilat, Israel, [3]Department of Environmental Sciences and Energy Research, Weizmann Institute of Sciences, Rehovot, Israel, [4]Department of Zoology, George S. Wise Faculty of Life Sciences, Tel-Aviv University, Tel-Aviv, Israel

Recruitment success of planktonic larvae to coral reefs is essential for the continued survival of these highly diverse ecosystems. Feeding strategies may affect recruitment success and potentially determine species distribution. The aim of this study was to ascertain the feeding strategies of *Stylophora pistillata* larvae (planulae) using stable isotopes, a powerful method utilized in dietary studies. Planulae and fragments of parental colonies were collected from 2m and 20m depth at the coral reef of Eilat, Israel (Gulf of Aqaba) during 2007. Carbon and Nitrogen stable isotope compositions and C/N ratios of planulae were compared with those of parental colonies. Results showed that δ13C of planulae was significantly lower than that of the parental colonies, but that C/N ratio was two times higher regardless of depth. Following lipid extraction, we found no significant difference in δ13C and in C/N values between planulae and parental colonies. Therefore, the differences in δ13C originate in the lipid content of the planulae and not from an isotopic fractionation during embryological development. In order to determine if released planulae feed heterotrophically, I conducted controlled feeding experiments using dissolved organic matter, phytoplankton and zooplankton comparing the isotopic ratios of planulae and the food sources. To evaluate the contribution of photosynthates translocated from the algal symbionts to the planulae, experiments were carried out under light and dark conditions. Despite the presence of an oral opening, the planulae did not feed. Moreover, following two weeks of "starvation" in the dark, planulae started utilizing their lipid reservoirs, indicating the importance of photosynthesis to the planulae. Our findings stress the importance of the physiological state of parental colonies in producing viable planulae, capable of going through metamorphosis and successful recruitment to coral reefs.

## 11-27

**Sexual Reproduction And Early Life History Of Acropora Reef Corals At Moorea, French Polynesia**

**Andrew CARROLL*[1,2]**, Peter HARRISON[3,4], Mehdi ADJEROUD[5,6]

[1]Coral Reef Research Centre, Southern Cross University, Lismore, Australia, Coffs Harbour, Australia, [2]National Marine Science Centre, Coffs Harbour, Australia, Coffs Harbour, Australia, Australia, [3]Coral Reef Research Centre, Southern Cross University, Lismore, Australia, Lismore, Australia, [4]National Marine Science Centre, Coffs Harbour, Australia, Coffs Harbour, Australia, [5]Ecole Pratique des Hautes Etudes, Perpignan, France, Perpignan, France, [6]Centres de Recherches Insulaires et Observatoire de l'Environnement, Moorea, French Polynesia, Papetoai, Moorea, French Polynesia, French Polynesia

This study provides the first detailed quantitative data on the sexual reproduction, larval development and settlement competency periods of broadcast spawning *Acropora* reef corals at Moorea, French Polynesia. From 2002 to 2004 the timing and mode of sexual reproduction for *Acropora* reef corals was examined at four sites on the outer reef slope and reef lagoon. To determine extent of spawning synchrony within and among species, colonies of *Acropora* spp. were tagged and repeatedly sampled, or collected for spawning in flow through outdoor aquaria, during September through November. Spawning was observed in aquaria and inferred in the field from the disappearance of mature gametes for 13 species of *Acropora*, between 6-9 nights after the full moon in September, October and November. Following spawning in November 2004, post fertilisation samples were taken from *A. nasuta*, *A. striata* and *A. lutkeni* to compare the morphological stages of embryo and larval development from early cleavage to ciliated planula larvae. Larval development and settlement competency periods were studied using *A. retusa* and *A. striata* planulae. Larval attachment onto settlement tiles occurred within 3-4 DAS (days after spawning) in both species. Peak periods of larval metamorphosis and permanent settlement occurred between 4-10 DAS for *A. retusa* and 5-10 DAS for *A. striata*. The early development and initial rapid attachment patterns of *A. retusa* and *A. striata* larvae indicate that some planulae may be retained close to their natal reef. However, the extended settlement competency periods observed in *A. striata* (31 DAS) and *A. retusa* (26 DAS) suggest that some planulae also have the potential for dispersal away from their natal reef before settling. This information is important for understanding and predicting the likely sources of larval supply to Moorea, and examining the potential likelihood of reef interconnectivity via larval dispersal in French Polynesia.

## 11-28

**Reproductive Biology, Embryogenesis And Larval Development Of The Gorgonian *calicogorgia Granulosa* (Gorgonacea: Plexauridae)**

**In-Young CHO*[1]**, Jun-Im SONG[1]

[1]Division of EcoScience, Ewha Womans University, Seoul, Korea, Republic of

The sexual reproduction and larval development of the gorgonian, *Calicogorgia granulosa* were examined in the southern most part of Korea Jejudo Island, Korea from August 2003 to March 2007. There are the unique soft coral communities with tropical and subtropical elements. *Calicogorgia granulosa* is a dominant species in the communities.

The reproductive mode, gametogenic cycle, fecundity and spawning time of reproduction on the species were assessed by using histological preparation and field surveys. Early developmental processes from gametes, embryos to planulae have been observed under the light and stereo microscopes.

*Calicogorgia granulosa* was found to be a gonochoric broadcaster. The ratio of females to males was 1.5 : 1. Gametes were found all year round. Gametogenesis took place three times a year and spawning of gametes occurred at new moon in March, August and November. Spawned eggs ranging from 650 to 750 μm in diameter were spherical and dark blue. Fertilized eggs developed into mature planulae over 4-6 days after spawning. The mature planulae were settled on substrata on 25 days post-spawning. Especially, they preferred to settle on the lower part of substrata. And the planulae developed into the primary polyps with 8 tentacles and oral part within 5 days after settlement. The survival rate of planulae was recorded approximately 30% in the laboratory.

## 11-29

**The Reproductive Biology And Recruitment Ecology Of Porites Bernardi**

**Jonathan MARTINEZ*[1]**, Robert RICHMOND[1], Jorg ANSON[2], Sean MCDUFF[3]

[1]Pacific Biomedical Research Center, University of Hawaii at Manoa, Honolulu, HI, [2]Kewalo Marine Laboratory, Honolulu, HI, [3]University of Hawaii at Manoa, Honolulu, HI

Porites cf. bernardi is a scleractinian coral described by Vaughn 1904. Its worldwide distribution remains uncertain although it has been reported from locations in Japan, Hawai'i & São Tomé e Principe. In Hawai'i, this coral inconspicuously grows in encrusting forms rarely larger than 10 cm2 in areas of high wave motion, inhabiting the subtidal zone to depths of 13m. No previous data are available describing the reproductive biology and larval ecology of this species.

P. bernardi is a brooding coral, which reproduces year-round. Colonies do not appear to be dependent on sperm from conspecifics for planulae production and release larvae most days of the year with peak planulation near the lunar third quarter. There is a positive relationship between adult size and reproductive output. A regression model predicts that adults larger than 0.7225 cm2 may be reproductively mature, and adults as small as 0.882 cm2 have been observed to planulate. The larvae of P. bernardi have not been observed to swim in the water column under laboratory conditions, but rather only crawl along the substrata along a single axis Larval recruitment occurred mainly in response to coralline algal chemical metabolites although modest recruitment has been observed in presence of bacterial biofilms. In bioassays, almost all of the larvae settled within 48 hrs of exposure to appropriate crustose coralline algae.

The availability of P. bernardi planulae throughout the year, and the larvae's responses to metamorphic inducers makes this a good model organism for studies of the effects of anthropogenic stressors such as pollution, elevated temperatures, acidification and sedimentation on coral reproduction and recruitment.

## 11-30

**A Review Of Sexual Reproduction in Octocorallia**

**Samuel KAHNG*[1]**, Yehuda BENAYAHU[2], Howard LASKER[3]

[1]College of Natural Science, Hawaii Pacific University, Kaneohe, HI, [2]Tel Aviv University, Tel Aviv, Israel, [3]University at Buffalo, Buffalo, NY

Since its initial discovery on Oahu in 1966, the azooxanthellate octocoral, *Carijoa riisei* (Duchassaing and Michelotti, 1860), has spread across the main Hawaiian Islands and proliferated in abundance. To help understand the substantial ecological success of *C. riisei* in Hawaii, its sexual reproduction was examined. *Carijoa riisei* is gonochoric with a male to female ratio of one. Gametogenesis is asynchronous, continuous, and does not exhibit seasonal or lunar periodicity. *Carijoa riisei* spawns negatively buoyant eggs which suggest external fertilization and possibly benthic larvae. Under favorable conditions, *C. riisei* exhibits high polyp fecundity. Asynchronous, continuous spawning of gametes is an unusual mode of reproduction which forgoes the advantages of concentrating gametes in space and time and requires dense aggregations of male and female colonies in close proximity to ensure fertilization success. Other life history traits such as fast growth, early age of sexual maturity, vegetative propagation, and superior competitive ability enable *C. riisei* to form dense, multi-colony aggregations thereby facilitating sexual reproduction. Provided *C. riisei* can achieve a critical density, this unusual sexual reproductive strategy probably enables it to exploit the ephemeral availability of space across time with a high and continuous production of larvae.

## 11-31

**Sexual Reproduction In The Soft Coral *Lobophytum* Sp. In Tung Ping Chau Marine Park, Hong Kong Sar, China**

**Chung Wing YEUNG*[1]**, Put ANG[1]

[1]Marine Science Laboratory, Department of Biology, The Chinese University of Hong Kong, Hong Kong, Hong Kong

The soft coral genus *Lobophytum* is a carpet-like encrusting coral and is commonly found in Hong Kong waters. The reproductive biology of *Lobophytum*, as well as that of other soft corals in Hong Kong has never been investigated. This study provides the first baseline information on the reproductive biology of soft corals in Hong Kong.

The sampling site in this experiment was Lung Lok Shui in Tung Ping Chau Marine Park. Three samples from five marked *Lobophytum* aggregations were collected monthly from 16 Aug 2006 to 7 Jul 2007. Histological sections of each sample were prepared and their gonadal development was observed under the microscope. All colonies in the same aggregation were assumed to come from the same mother colony, since *Lobophytum* was reported to undergo asexual reproduction and thus, its daughter colonies would remain in close proximity forming the aggregation.

From the histological analysis of the samples, all colonies bore only eggs. As *Lobophytum* was reported to be gonochoric, all the colonies sampled were therefore female. Male colonies may be missed during sampling. Oocytes from the samples measured increased in mean (±SD) diameter from 116.5±18.8 µm in Aug 2006 to 239.3±82.2 µm in Jun 2007, and dropped back to 93.0±23.2 µm in Jul 2007. This indicates that spawning of *Lobophytum* probably occurred in or before Jul 2007. The oocyte development appeared synchronized as shown in the simultaneous increase in their sizes. However, new oocytes likely developed before the release of the mature ones so that each cycle of development took more than one year to complete. Additional samples will be processed in order to confirm this initial observation.

## 11-32

**Reproductive Biology Of Temperate Soft Corals (Alyonacea: Nephtheidae) in Korean Waters**

**Sung-Jin HWANG*[1]**, Jun-Im SONG[1]

[1]Division of EcoScience, Ewha Womans University, Seoul, Korea, Republic of

There was little information about the reproductive biology of family Nephtheidae. This study were examined the reproductive diversity on three soft coral species from 2003 to 2007, and two of them were belonged to *genus Dendronephthya* and one was to *genus Scleronephthya*. They are all sympatric species in the Jejudo Island area (33° 22′ N, 126° 33′ E), and highly distributed on the horizontal and vertical rocky substrata from 3 to 50 m in depth. One species, *Dendronephthya castanea*, was a gonochoric internal brooder and two, *D. spinulosa* and *Scleronephthya gracillimum*, were gonochoric broadcasters. They showed annual reproductive cycles and similar patterns in gametogenesis. Gametes of them were matured as seawater temperatures increased, reflecting a seasonal correlation in reproductive cycle. While oocytes were observed at all times of the year, spermaries were found during a short period. *D. castanea* released lecithotrophic planulae from July to September, and *D. spinulosa* and *S. gracillimum* spawned gametes asynchronously from August to December and in August, respectively. The ratio of female to male was 2.5: 1 in an internal brooder (*D. castanea*) and 1.5: 1 in broadcasters (*D. spinulosa* and *S. gracillimum*), suggesting the correlation to mode of reproduction.

## 11-33

**Reproductive Cycle Of The Deep-Sea Coral, *drifa Glomerata* (Octocorallia: Alcyonacea), in The Nw Atlantic**

**ZHAO SUN*[1]**, JEAN-FRANÇOIS HAMEL[2], ANNIE MERCIER[1]

[1]Ocean Sciences Centre (OSC), Memorial University of Newfoundland, St John's, NL, Canada, [2]Society for the Exploration and Valuing of the Environment (SEVE), St John's, NL, Canada

This study of the mode and timing of reproduction in bathyal corals was undertaken in an effort to gather information on poorly understood deep-water species. Colonies of *Drifa glomerata* were collected between 103 and 334 m off Newfoundland (eastern Canada) from November 2004 to December 2007. They were frozen at -20˚C and studied using a mix of micro-dissection and histological procedures. The ratio of reproductively active colonies, with mature planulae, was >50% all year round, suggesting the capacity to release larvae throughout the year. Among the breeding colonies, the number of planulae within a single reproductive polyp varied from 1 to 8, with an average between 2 and 5. The number of reproductive polyps per colony varied from 2 to 1030 and was positively correlated with the size of the colony. Fecundity, expressed in planulae g-1, showed a seasonal trend with an increase between November and January and lower values in June-July of a given year. Inversely, the average size of oocytes or planulae decreased from November to January, and this trend was detectable in both polyps and branchlets. The average surface area of the oocytes or planulae was consistently greater in the polyps than in the branchlets across all dates and depths, indicating that the development pathway of planulae is from the coelenteron to the polyps. Based on these data, we believe the peak breeding season may be between November and February, when new planulae are produced and large mature larvae are released.

## 11-34

**The Influence Of Size, Morphology And Parental Conditions On Coral Reproductive Outputs**

**Jacqueline PADILLA-GAMINO*[1,2]**, Ruth GATES[3]

[1]Oceanography, University of Hawaii, Honolulu, HI, [2]Hawaii Institute of Marine Biology, Kaneohe, [3]Hawaii Institute of Marine Biology, Kaneohe, HI

Understanding factors that influence the reproductive biology of corals is fundamental to predicting the future of coral communities in the face of climate change and/or anthropogenic disturbances. While several studies have analyzed the size at which corals become sexually reproductive, few have focused on the reproductive ecology of corals belonging to larger size classes. This is due to the difficulty in transporting large colonies to aquaria for study and designing devices large enough to deploy over these colonies that allow gametes to be collected in the field. To better understand the relationships between size, morphology and reproductive capacity, this study examined *in situ* reproductive outputs (gametes) in three size classes and two morphologies of the hermaphrodite spawning coral *Montipora capitata* in Hawaii. Gametes were collected from plating and branching corals situated in two environments for each of three months in the summer of 2007. Regardless of morphology and environment, colonies spawned simultaneously and had similar egg sizes, number of eggs per bundle, endosymbiont densities and chlorophyll concentrations. There was a significant difference in the egg size and number of eggs per bundle for the different months sampled with egg size being negatively correlated with the number of eggs per bundle. Earlier in the reproductive season (June) there were a high number of small eggs per bundle as compared to later in the season (July and August) when there were a smaller number of large eggs per bundle. Current analyses are focused on comparing a suite of physiological traits in coral eggs and their parental colonies. These include endosymbiont identities and densities, chlorophyll, lipid and protein concentrations; and mycosporine-like amino acid profiles.

## 11-35

**Density And Size Of Aaptos Aaptos Sponge Gametes**

Mujizat KAWAROE[1], **Mujizat KAWAROE*[1]**

[1]Marine Science and Technology, Bogor Agricultural University, Bogor, Indonesia

The reproduction of the demospongia *Aaptos aaptos* in Pari Island (Jakarta Bay) was studied histologically during March 2007. One hundred and fifty thousand transplanted individuals sponges were sampled from northern and southern and examined with light microscopy for the presence of gametes. The species is ovoviviparous and no males were found, possibly owing to the very short period of spermatogenesis. The non mature oosit with high density were present at surrounding mesohyl layer. And the mature oosit with low density were moved to brood chamber. Sponges transplanted with fragmentation involved sexual reproduction on the prior development stage (177 days), meanwhile within 241 days, the sponge average size increased to 11,70 cm and 11,83 cm, reproduction activity have been increased. The present results demonstrated that oosit average size of *Aaptos aaptos* from transplanted and nature could be opposite with its density.

Key words : *Aaptos aaptos,* reproduction, gamete, transplanted, development,

## 12-1

**Past Frequencies Of Thermal Anomalies Determine Extent Of Coral Bleaching**

**Diane THOMPSON*[1]**, Robert VAN WOESIK[1]

[1]Biological Sciences, Florida Institute of Technology, Melbourne, FL

Coral bleaching events have increased in the past few decades due to an increase in the frequency, severity and spatial scale of anomalous sea-surface temperature (SST) events. These coral bleaching events are expected to become even more frequent as SSTs continue to rise. Yet, the frequency of past anomalous SSTs may influence coral acclimatization and adaptation. The objective of this study was to determine whether the frequency of anomalous SST events in the past influences the ability of corals to resist bleaching. We hypothesize that corals at sites that have experienced frequent anomalous SSTs over the last three centuries will be able to resist bleaching during contemporary regional thermal stress events. Wavelet analysis of coral stable oxygen isotope records was used to determine significant interannual and decadal variability at 17 reef locations. Interpolation was then used to determine the probability of interannual and decadal variability throughout the Pacific and Indian Oceans and the Red Sea. The difference between these probabilities was used as the predictive variable, as less bleaching is expected at sites with high-frequency variability (high interannual and low decadal). A global meta-analysis categorically defined bleaching severity at each site during the peak of the 1997-98 event as either: 1) no, 2) low, 3) medium or 4) high bleaching. We show that sites that experienced no or low bleaching had a significantly higher difference between the interannual and decadal modes. Therefore, corals at sites that had experienced frequent thermal anomalies in the past were more likely to resist bleaching during contemporary thermal events. Based on the frequency of past thermal events, reef corals in the Pacific Ocean may be more likely to resist bleaching during future climate change-associated anomalies compared with corals in the Indian Ocean and Red Sea.

## 12-2

**Corals in Hot Water: Physiological Responses Of *porites Lobata* in A Diurnally Fluctuation Environment**

**Daniel BARSHIS*[1,2]**, Jonathon STILLMAN[3], Ruth GATES[1], Robert TOONEN[1], Lance SMITH[4], Charles BIRKELAND[4]

[1]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, [2]Department of Zoology, University of Hawaii at Manoa, Honolulu, [3]Romberg Tiburon Center for Environmental Studies, San Francisco State University, Tiburon, CA, [4]Department of Zoology, University of Hawaii at Manoa, Honolulu, HI

The Ofu back reef in the National Park of American Samoa hosts a wide variety of corals that withstand mean temperatures (up to 30oC) and daily fluctuations (3-4oC) greater than most coral reef habitats. Despite these known stressors, back reef corals appear healthy, exhibiting limited bleaching despite high levels of environmental fluctuation. We hypothesized that frequent exposure to the fluctuating environment of the Ofu back reef enhances the corals ability to cope with environmental stress. Samples from 4 source colonies of *Porites lobata* from the back reef and 4 colonies from the neighboring forereef were cross and back transplanted to each source location. Transplants were sampled every 24 hrs for 5 days following transplantation (n=40). Heat shock protein 70 (Hsp70), ubiquitin-conjugated proteins, manganese superoxide dismutase (MnSOD), and 4-Hydroxynonenal (4-HNE) protein levels were analyzed by Western blot for each sample. Ubiquitinated protein levels were higher in back reef source colonies for all transplants and all days ($p<0.001$). The high level of ubiquitin-conjugated proteins in the back reef corals could be indicative of more rapid protein turnover, enabling them to respond to the abrupt changes in their surrounding environment. Hsp70, MnSOD, and 4-HNE levels were higher in back reef source colonies ($p<0.01$), although not consistently for all days and sites. There were no differences among levels of any protein measured between cross and back transplants for back reef or forereef source colonies, suggesting that the corals are acclimatized or adapted to their native environments. Analyses of mitochondrial DNA (coral host), and nuclear rDNA (coral host and symbiont) revealed significant population differentiation between back reef and forereef hosts but not symbionts, providing additional evidence indicating a host adaptive response to the different environments.

## 12-3

**Responses Of Coral Hosts And Their Algal Symbionts To Thermal Heterogeneity**

**Hollie PUTNAM*[1]**, Peter EDMUNDS[1]

[1]Biology, California State University Northridge, Northridge, CA

The effects of high temperature on corals have been studied extensively, but little is known of the response to frequent thermal fluctuations common in shallow reef communities. In the lagoons of French Polynesia, daily oscillations of ~3-4ºC create a potentially challenging physical environment, yet coral communities in these habitats are extensive and largely healthy. Using *Pocillopora meandrina* and *Porites rus* as model systems, this study tested the effects of fluctuating temperatures on coral physiology. Initial experiments in 2006 exposed corals to both stable treatments (28ºC) and an oscillating treatment of a seasonal magnitude (~26ºC-32ºC), with the response assessed through changes in maximum quantum yield ($F_V/F_M$), and *Symbiodinium* density, which characterize the response of the symbiont. $F_V/F_M$ was depressed under oscillating treatment, in comparison to steady-state conditions, for both species. Building on these experiments, in 2007 microcosms with uniform artificial lighting and sophisticated aquarium controllers were used to produce steady treatments of 26ºC, 28ºC, 30ºC, and a daily oscillating treatment from 26ºC-30ºC. Coral response was measured as changes in both symbiont traits ($F_V/F_M$, chlorophyll-a content, and *Symbiodinium* density) and a whole organism trait (skeletal growth). MANOVA on these four response variables revealed a significant treatment effect on overall physiology, and univariate analyses determined this effect was driven primarily by large declines (17-45%) in *Symbiodinium* density in the oscillating treatment compared to the ambient treatments. Conversely, coral growth in the fluctuating treatment was not significantly different from all other treatments. Together, these results are interesting because they suggest under the maximum range of seasonal temperatures, as well as the greatest daily temperature range, that overall response of common coral species may be held relatively constant through compensatory changes in the symbiont physiology.

## 12-4

**Effect Of Physiological State On Regeneration in *porites Lutea* (Scleractinia) At Reunion Island**

**Vianney DENIS*[1]**, Joëlle RICHARD[1], Mireille MMM GUILLAUME[1,2], Henrich JH BRUGGEMANN[1]

[1]Laboratoire d'Ecologie Marine (ECOMAR), Université de la Réunion, St Denis, Reunion, [2]Milieux et peuplements aquatiques, UMR5178 CNRS/UPMC/MNHN BOME, Muséum National d'Histoire Naturelle (MNHN), Paris, France, Metropolitan

Colonial characteristics of corals allow them to withstand partial damage, resulting in areas of skeleton devoid of living tissue. Such lesions offering a settling substrate for competitors, regeneration is consequently fundamental for colony survival. However, the rate of regeneration is influenced by different environmental stressors which may alter the strategy of resource reallocation.

We combine, probably for the first time, monitoring of zooxanthellae physiological state and environmental parameters to evolution of lesion size with time. We characterize the regeneration process in *Porites lutea* at two sites with different environmental settings. The first site has higher mean temperature, higher temperature variation and lower flow rates compared to the more exposed, second site. Artificially induced lesions (30 mm², 3-4 mm deep) in 25 replicate colonies in each site were monitored from August-December 2007 (cold season) along with environmental parameters (temperature, solar radiation, hydrodynamics). Each lesion was photographed regularly and surfaces were measured using image analysis. Zooxanthellae physiological state was assessed prior to and during lesion regeneration using a Pulse Amplitude Modulated (PAM) fluorometer to estimate environmental stress on the colonies.

Regeneration was visible after three days following lesion induction. Regeneration rate initially increases, reaches a maximum after 10-20 days, then decreases exponentially. Overall, photosynthetic yield (Fv/Fm) and lesion regeneration rates do not differ significantly between the two sites, with maximum regeneration rates reaching 0.11 $cm^2\ day^{-1}$. However, in the high-temperature fluctuation site, regeneration rates track variations in photosynthetic yield. Contrastingly, photosynthetic yield and regeneration rates vary independently in the exposed site. These results suggest environmental control on regeneration capacity of coral colonies, possibly mediated by temperature dependent reduction of photosynthetic yield of the coral symbionts.

## 12-5

**The Contribution Of Heterotrophy To Recovery From Bleaching in A Cnidarian-Algal Symbiosis**

**Cameron JOHNSON*[1]**, Tamar GOULET[1]

[1]Biology, University of Mississippi, University, MS

When elevated sea-surface temperatures cause the decoupling of cnidarian-algal symbioses, leading to reductions in the densities of the host's autotrophic endosymbionts, some species of hosts will compensate by increasing heterotrophic feeding. In this study, we experimentally bleached the symbiotic sea anemone Aiptasia pallida, and then either starved (S) or fed (F) them during a 5 week period in order to see what effect heterotrophy may have on recovery rates. In each of three repeated factorial experiments (bleaching x feeding), half of the anemones were bleached (B) by elevating the temperatures from 25°C to 32°C for one week (week 0), while non-bleached anemones (NB) remained at 25°C. At the beginning of week 1, the bleached anemones were returned to their normal temperature (25°C), and both B and NB anemones were evenly divided among 2 additional treatments; starvation (SB and SNB), and fed (FB and FNB). Zooxanthella densities were monitored using photographic analysis of reflected spectra, which was calibrated with traditional bio-assays. Over the five week recovery period, zooxanthella densities had increased in the SNB, SB and FB treatments, while the zooxanthella densities in the FNB treatment remained constant. FB anemones had higher recovery rates than SB anemones (P=0.0044). Additionally, SNB anemones had significantly increased their zooxanthella densities (P=0.0331). These results suggest heterotrophy may play an important role in the reestablishment of endosymbiont populations after a bleaching event. Monitoring availability of plankton on a given reef may therefore be another important factor in determining reef recovery from a bleaching event.

## 12-6

**Bleaching Effects On Scleractinian Coral Reproduction And Lipids Stores On The Great Barrier Reef, Australia**

**Devin TU*[1]**, Selina WARD[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia

This study investigated if bleaching reduced coral fecundity and lipids in the Great Barrier Reef. A secondary objective was to monitor the recovery rate of different coral species by using fecundity and percentage of lipid tissue in coral as a biological indicator. In addition, the study compared the severity of conditions in 1998 to the 2006 bleaching periods on the reef-flat, based on temperature and weather data. Many studies on coral bleaching focused on the 1998 bleaching event, which was considered the most severe event on the Great Barrier Reef (GBR) in that century (Hoegh-Guldberg 1999, NOAA 1998, ICRS 1998). Few have studied the effects of the 2006 bleaching event that took place in the southern Great Barrier Reef, Australia.

Results demonstrate bleaching may not always impact negatively on the physiology of *Acropora* corals. Because of high variability of samples, there were no obvious differences in fecundity between bleached and unbleached *Acropora aspera* and *Acropora millepore* colonies based on percentage of reproductive polyps, and egg size and egg number per polyps. We hypothesize that there were no significant differences in lipid content between bleached and healthy corals in several species, however complete results were not available at the time of this submission. Bleached corals may have recovered before reproductive development. Basic *in situ* data suggests that summer 2006 conditions had abnormally high SSTs and light, but were not as elevated as 1998 at Heron Island, Australia. Potentially, zooxanthellae loss in bleached coral was not significant enough to reduce reproduction and lipids in *Acropora* species. This suggests that 2006 bleaching event, unlike pervious events, did not have a major impact on corals. Future research anticipates examining changes in chlorophyll *a* and zooxanthellae densities to identify the relationship between the severity of bleaching and the physiological impact on corals.

## 12-8

**Thailand's Coral Reefs Show Resilience in The Face Of Repeated Natural Stressors**

Niphon PHONGSUWAN[1], Anchalee CHANKONG[2], Ronawon BOONPRAKOB[2], Chaimongkol YAMARUNPATTHANA[1], Sathika PAOKANTA[1], **Niphon PHONGSUWAN*[1]**

[1]Marine and Coastal Resources, Phuket Marine Biological Center, Phuket, Thailand, [2]Marine and Coastal Resources, Eastern Marine and Coastal Resources Research Center, Rayong, Thailand

Thailand's coral reefs in the Andaman Sea and Gulf of Thailand have been repeatedly affected by both man-made and natural stressors over the last 20 years and yet have demonstrated considerable resilience, in particular to natural perturbations. Natural stressors have included Acanthaster infestations on the Andaman Sea coast in the mid 1980s; monsoon storms in 1986; elevated sea water temperatures which led to extensive coral bleaching in 1991 and 1995 in the Andaman Sea and in 1998 in the Gulf of Thailand; sea-level depression in 1997-98 and the tsunami of 2004, both of which only affected reefs in the Andaman Sea. Repeated monitoring of reefs in the periods 1988-1989; 1995-1998, in 2002 and again during 2006-2007 has revealed remarkable recovery at sites affected by major bleaching in 1991 and 1995 with virtually no impacts of minor localised bleaching noted at some sites in 2003, 2005 and 2007. The tsunami of 2004 had a very limited effect on coral reefs of the Andaman Sea and where damage occurred recovery is well underway at several locations. Such resilience appears to be restricted to sites affected only by natural perturbations since many shallow reefs near the mainland, which are chronically affected by siltation from land development, show little recovery.

## 12-9

**Reefs, Resilience, And Refuges - Theoretical Considerations And Real-Life Examples**

**Bernhard RIEGL*[1]**, Samuel PURKIS[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania, FL

If global changes impact reefs relatively uniformly, reefs with viable population dynamics will be resilient but some, and maybe eventually all, corals may be forced into refuges. Resilience or refuge character can be rooted in a more clement environment, adaptation to a harsh environment, or readjustments of population (community) dynamics caused by modified mortality-, survival- and recruitment-characteristics among species. Since many "traditional reefal settings" (tropical reef crests and slopes) seem to be degrading, one may search for sustainable dynamics in different habitats such as upwelling areas, deep reefs, or non-reefs. While these habitats may harbor less species or individuals, their population dynamics may be more advantageous. Even if the environments appear less suitable and the communities depauperate, a positive net population growth identifies potential refuges. Also, pulse-instability within dominance hierarchies may promote, or be a sign of, resilience. Opportunistic species may be naturally prone to large swings in abundance and find refuge in meta-populations that allow easy expansion or restriction of range. These species may adapt to only temporarily dominate communities of more resilient species. Their adaptation to changed environments may be less likely, since their reaction to stress would be population restriction and relocation into other, presumably more favorable, habitats. Temporary local absence would be part of survival strategy. Thus monitoring and assessment programs that primarily focus on coral cover, and not the underlying dynamics, may misunderstand resilience or refuge value of a habitat – since the present abundances are variable and may be misleading. Stochasticity of timing and distribution of impacts may allow apparently rich, but increasingly maladapted communities to persist, and lead to false conclusions regarding the nature of resilience or refuge. The presently richest areas may not be those with highest survivability. We use examples from all oceans to illustrate our point.

## 12-10

**Tolerance, Refuge And Recovery Of Coral Communities To Thermal Bleaching**

**David SUGGETT*[1]**, David SMITH[1], Nat SPRING[2], Michelle ETIENNE[3]

[1]Biological Sciences, University of Essex, Colchester, United Kingdom, [2]Earthwatch Institute (Europe), Oxford, United Kingdom, [3]Seychelles Centre for Marine Research and Technology, Victoria, Seychelles

Long term viability of coral communities is dictated by their ability to withstand environmental change, such as periods of elevated temperature. Three "mechanisms" exist by which reefs may survive such change: (1) physiological tolerance, (2) geographical retreat (refuge), and (3) repopulation and growth (recovery) once ambient conditions return. Here we report these "mechanisms" in operation by corals and coral communities exposed to thermally-induced bleaching conditions in the Seychelles. During the 1998 El Niño event, sea surface temperatures (SSTs) around the Seychelles persisted above 32°C and more than 75% of all reefs bleached. Since then, SSTs have not exceeded 32°C potentially allowing reefs to recover unchecked from repeat exposure. We performed extensive surveys of the size frequency distribution of species-specific colonies and observed that certain species survived the 1998 event whilst other species did not but have rapidly recruited into the system post 1998. Laboratory experiments confirmed that these different species-groups exhibited alternative physiological properties: Older established corals were most tolerant to periods of elevated temperature, as characterised by minor 'downregulation' of photosynthesis, and exhibited a greater metabolic potential for recovery (higher heterotrophy: autotrophy). Consequently, physiological properties of key coral species determined the current community structure post 1998. Turbid lagoons containing large colonies of susceptible species were identified, suggesting that these species survived 1998 by recruiting into 'sub-optimal' habitats and thus buffered against the elevated temperatures. Our results demonstrate that community structure analysis can be an important tool in identifying the ability of species to withstand environmental variability. Furthermore, that corals will survive climatic events and possible climate change by utilising various "mechanisms".

## 12-11

**Defining And Utilizing Indicators Of Reef Resilience in The Red Sea And Arabian Gulf**

**Ameer ABDULLA*[1]**, David OBURA[2]

[1]Marine Biodiversity and Conservation Science, IUCN Global Marine Program, malaga, Spain, [2]CORDIO, Mombasa, Kenya

Defining and utilizing reef resilience indicators in the Red Sea and Arabian Gulf

Red sea and Arabian Gulf coral reefs are characterized by high endemism and a naturally high tolerance to extreme environmental conditions such as high salinity, turbidity, and temperatures. These characteristics may indicate particularly high resilience to impacts associated with Climate Change, a feature of global importance. Consequently, Red Sea and Arabian Gulf sites were surveyed for resilience characteristics in 2007 and 2008. Forty nine resilience factors were identified for the two seas and their relative importance are compared to similar studies and indices developed for the Indian Ocean and Indo-pacific. These factors were used to identify key ecological areas of high resilience that were undamaged by particularly high regional SSTs in 1998, 1999, and 2001 – 2003 and that are priority areas for conservation. An aggregate of these factors and their relative weighting may prove useful in identifying other global reef sites of particularly high resilience and conservation importance.

## 12-12

**Reef Resilience and Change 1998-2007, Alphonse Atoll, Seychelles**

**Annelise HAGAN*[1]**, Tom SPENCER[1]

[1]Cambridge Coastal Research Unit, Department of Geography, University of Cambridge, Cambridge, United Kingdom

Alphonse Atoll, southern Seychelles (7o01'S; 52o44'E), a small (11.28 km2) atoll with minimal anthropogenic influences, was severely impacted by the Indian Ocean warming event of 1997-1998. Quantitative measurements of benthic cover commenced at this location at the peak of the warming (April 1998), establishing bleaching impacts and allowing estimation of pre-bleaching cover characteristics. Underwater videography surveys of fixed transect lines were made in 2001/02, 2003, 2005 and 2007, providing quantitative information on the changing cover characteristics of 10 benthic classes. Immediately post-bleaching, the scleractinian community was dominated by few genera, particularly *Porites*, which survived the bleaching event, and *Pocillopora* and *Acropora*, which rapidly re-colonised bare surfaces, including dead coral skeletons. Lagoon corals and many shallow water corals, presumably acclimatised to warmer water conditions, were resilient to the 1998 thermal stress and may have seeded local coral recovery. In December 2006, wave fields associated with the passage of Cyclone Bondo resulted in transport of *Porites* colonies and large blocks of reef framework onto reef-flats, loss of post-bleaching coral recruits and increased macroalgal cover on the fore-reef slope. There is now a marked difference in reef health between the west and east fore-reef slope, despite a separation of only 2 km. This location provides one of the most detailed long-term (> 9 yrs) records of post-bleaching reef dynamics in the Western Indian Ocean. It demonstrates i) the interaction between, and subsequent recovery from, both physiological and physical disturbances and ii) varying resilience by atoll environment (fore-reef slope, reef crest, lagoon). Surveys 1998-2007 have shown changing relative proportions of scleractinian and macroalgal communities but no clear 'phase-shift' from a hard to a soft dominated reef community.

## 12-13

**The Effects Of Habitat On Coral Resistance And Resilience To Bleaching**

**Gabriel GRIMSDITCH*[1,2]**, Nassir AMIYO[3], Joseph KILONZO[4]

[1]IUCN Global Marine Programme, Mombasa, Kenya, [2]Cordio East Africa, Mombasa, Kenya, [3]Kenya Wildlife Service, Mombasa, Kenya, [4]Kenya Marine and Fisheries Research Institute, Mombasa, Kenya

This study examines the bleaching responses of scleractinian corals at four sites in Kenya (Kanamai, Vipingo, Mombasa Marine Park and Nyali) representing two distinct lagoon habitats (relatively shallow and relatively deep). Bleaching responses were monitored for the general coral community and zooxanthella densities and chlorophyll levels were monitored for target species (*Pocillopora damicornis*, *Porites lutea* and *Porites cylindrica*) during a non-bleaching year (2006) and a year of mild bleaching (2007). The objective of this study is to determine whether corals in different habitats display varying resistance and resilience to bleaching stress and to indicate which environmental characteristics are responsible for the variation in response. Considerable differences in bleaching responses between shallower and deeper lagoon sites were observed, with shallower sites Kanamai and Vipingo exhibiting much lower bleaching and paling incidence than deeper sites Nyali and Mombasa Marine Park. These shallower lagoons display much more fluctuating thermal and light environments than the deeper sites, with higher maximums, lower minimums, higher standard deviations and higher diel variation. These results suggest that corals in the shallower lagoons have acclimatized and/or adapted to the fluctuating environmental conditions they endure on a daily basis and have become more resistant to bleaching stress. Furthermore, in deeper sites that did exhibit significant bleaching (Mombasa Marine Park and Nyali), it was found that coral recovery occurred more quickly in the protected area compared to the non-protected area.

## 12-14

**Ocean Dynamics Drive Coral Reef Processes in The Andaman Sea**

**Claudio RICHTER*[1]**, Mélanie BON[1], Laura FILLINGER[1], Carin JANTZEN[1], Cornelia RODER[1], Gertraud SCHMIDT[1], Niphon PHONGSUWAN[2], Somkiat KHOKIATTIWONG[2]

[1]Center for Tropical Marine Ecology, Bremen, Germany, [2]Phuket Marine Biological Center, Phuket, Thailand

Coral reefs are rich benthic ecosystems thriving in nutrient-poor waters. A striking feature of the Andaman Sea is the exposure of offshore reefs to large amplitude internal waves. These solitary-like waves (or solitons) are generated by the ebb and flow of water across the shallow ridges of the Andaman-Nicobar island arc and propagate along the density discontinuity (pycnocline) between warm surface and colder deep waters pycnocline with speeds of ~2 m $s^{-1}$ and amplitudes of up to 80 m. Here, we show that the dissipation of the solitons' energy in shoaling water enhances pelagic-benthic coupling along the continental margin, due to turbulent mixing near the sea bed, entrainment of interstitial and subpycnocline nutrients, and formation of bores. These 'solibores' supply nutrients and plankton to the benthos of the Similan Islands. Lowered temperature, pH and light hamper, however, coral photosynthesis and calcification, and their resilience against macroalgal competitors and grazers, resulting in low or negative reef growth. The frequency and intensity of cold bores (with temperatures drops of up to 10°C within only minutes) may on the other hand increase the corals' resilience to thermal stress. The findings have important repercussions on the Similan reefs which have been impacted by earlier bleaching and recent Tsunami. Because solitons are ubiquitous in the Andaman Sea and elsewhere, they may be an important yet so far overlooked mechanism structuring benthic communities in tropical waters.

## 12-15

**Opposing Effects Of Water Quality On Coral Bleaching Resistance And Recovery**

**David OBURA*[1]**, Haji MACHANO[2], January NDAGALA[3], Monica ZAVAGLI[4]

[1]CORDIO East Africa, Mombasa, Kenya, [2]WWF Tanzania, Dar es Salaam, Tanzania, [3]Mafia Island Marine Park, Mafia Island, Tanzania, [4]Ramsar Secretariat, Gland, Switzerland

The Mafia-Rufiji-Kilwa system of coral reefs and islands in central Tanzania is influenced strongly by outflow from the Rufiji river, which forms the largest delta system in Tanzania. Within this area, the impact of coral bleaching and mortality in 1998 varied considerably among reefs, with estimated mortality of corals varying from 0 to 100%, from surveys and observations conducted in the subsequent 9 years from 1999 to 2007. A new assessment method that includes estimation of a broad scope of factors hypothesized to influence coral resistance and tolerance to bleaching, and reef recovery following mortality, was conducted in November-December 2007 on 15 reefs in the region, sampling coral communities in 10-12 and 3-5 m depth zones. Quantitative and semi-quantitative data were collected on benthic cover, coral community structure, coral population structure, coral condition, herbivorous fish community structure, and indicators of physical site properties including connectivity, cooling and flushing, shading and screening and acclimatization potential. The two major factors that affected coral community structure related to a) initial resistance to bleaching - reefs with highest indicators of mainland river influence showed the lowest evidence of mass mortality in 1998, with turbidity likely providing the greatest degree of protection from thermal stress; and b) recovery following mortality - a combination of factors that included clear water (least mainland influence), substrate robustness (maximize coral survival) and high larval supply. These factors act in direct opposition to one another: turbid waters maximized coral survival during thermal stress, but clear water maximizes coral recruitment and survival under normal conditions. Thus current status of reefs is a result of multiple interacting factors; these need to be considered in a holistic way in priority-setting for active management to minimize climate impacts to coral reefs.

## 12-16

**Two-Years Monitoring Of Water Flow Effects On Photosynthesis And Growth Of The Coral *acropora Digitifera***

**Takashi NAKAMURA*[1,2]**, Seitaro S. YAMAZAKI[1], Yeong Shyan YUEN[1], Hideo YAMASAKI[1]

[1]Faculty of Science, University of the Ryukyus, Okinawa, Japan, [2]Amakusa Mar Biol Lab, Kyushu University, Kumamoto, Japan

We conducted an outdoor aquarium experiment to clarify long-term influence of water flow on corals. Water motion has significant impacts on the physiology of corals; limitation in water-motion causes severe bleaching in the coral *Acropora digitifera* during a period with strong light and high water temperature. Although there are numbers of investigations that report the effects of water flow in short-term (hours to weeks) experiments, long-term effects especially on the interaction with seasonal change in weather are not fully understood. In this study we report effects of water flow on the coral *A. digitifera* in several water-flow conditions (flow/wave/limited-flow) over two-year period in Okinawa, southern Japan. We monitored algal photosynthesis *in hospite* of *A. digitifera* weekly with a Diving-PAM chlorophyll fluorometer. Colony growth was measured monthly by the underwater buoyant weight method. In subtropical southern Japan under the influence of monsoon climate, seasonal change in weather had strong impacts on the photophysiology of *A. digitifera*. *A. digitifera* was evenly stressed in spring as well as in summer. Notably, high photosynthetic efficiency was often recorded just after the period of rainy season. Throughout the entire experimental period, photosynthesis of *A. digitifera* in limited-flow condition showed lower activity level than that of in flow conditions. Less colony growth with the disappearance of axial polyps was also observed under limited-flow condition in contrasted with flow conditions. These adverse effects of limited-flow could be diminished by the subsequent exposure to flow. The results confirm that water-flow can keep photosynthesis as well as growth of *A. digitifera* in good conditions throughout the years. We suggest that water-flow is an important factor that should be taken into the consideration of coral reef conservation.

## 12-17

**Wave Effects On Coral Reefs**

Malcolm L. HERON[1], William J. SKIRVING[2], **Scott F. HERON*[3]**

[1]Marine Geophysical Laboratory, James Cook University, Townsville, Australia, [2]NOAA Coral Reef Watch, Silver Spring, MD, [3]NOAA Coral Reef Watch, Siver Spring, MD

The work aims to evaluate the extent to which wave mixing mitigates the phenomenon of coral bleaching on isolated reefs. The physical conditions which allow coral bleaching are high insolation, low currents and low winds. Under these conditions a stable warm layer can form at the surface of the ocean. In this work we argue that very low swell wave energy should be added to the list, not because of linear waves passing through, but because of wave breaking at the reef front. For most reefs which rise abruptly from a nearly flat seabed, linear wave theory is sufficiently accurate for estimating the amplitude of a swell wave as it propagates from open water to the encounter with the reef. At the reef front, the wave energy is redistributed into a reflected component, localized turbulent mixing, and a forward bore across the reef top and onto the reef flats beyond. Under almost all conditions the mixing at the reef front is sufficient to destroy any tendency for a stable warm surface layer to form. Therefore, corals on the exposed sides of a reef are less likely to suffer from bleaching during an event where the surface temperature is elevated elsewhere in the vicinity; unless the full water column is warmed. The bore water which overflows the reef front is well mixed and during a bleaching event carries the cooler mixed water across the reef and onto the flats nearby. The main outcome from this work is that we predict that corals on the exposed sides of a reef and those on the adjacent reef top will be protected from bleaching under any but the most severe thermal stress. Further work should discover whether these corals can act as brood stock for subsequent reef recovery.

## 12-18

**Coral Reefs Under The Impact Of Internal Waves, Similan Islands, Andaman Sea: Primary Production**

**Carin JANTZEN*[1]**, Cornelia RODER[1], Gertraud SCHMIDT[1], Christian WILD[2], Claudio RICHTER[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [2]Coral Reef Ecology Work Group (CORE), Center of Geobiology and Biodiversity Research, MÃ¼nchen, Germany

Internal waves induced significant small-scale differences in structure and dynamics of primary producers on the exposed W and sheltered E sides of Similan Islands, Andaman Sea: Living corals were less abundant on the W side of the islands (49-67 % of total hard substrate vs. 28-44 % on W sides), with a higher percentage of turf algae (W: 43-46 %; E: 12-19 %) and higher areal concentrations of chlorophyll *a* and pheophytin. Chamber incubations carried out at the same light intensities showed 30-40 % reduced levels of potential photosynthesis on the W sides, this applies for both, the hermatypic coral *Porites lutea* (mg O2 h-1 cm-1 of coral surface) and sediment-associated algae (mg O2 h-1 mg-1 of Chl *a*). *In-situ* rapid lightcurves measured with a submersible pulse amplitude modulated underwater fluorometer showed lower saturation light intensities along with higher Chl *a* content (mg cm-2of coral surface) in W Similan *P. lutea*, indicating an adaptation to lower light levels in turbid upwelling waters.

## 12-20

**Coral Reefs Under The Impact Of Internal Waves, Similan Islands, Andaman Sea: Heterotrophy**

**Cornelia RODER*[1]**, Carin JANTZEN[1], Gertraud SCHMIDT[1], Claudio RICHTER[1]

[1]Center for Tropical Marine Ecology, Bremen, Germany

Coral reefs of the exposed Western sides of the Similan Islands, an offshore island group in the Andaman Sea, experience strong swell during the SW monsoon and internal wave induced upwelling, increasing POM concentrations, turbidity and nutrient levels 3 to 4-fold relative to the sheltered E sides of the islands, Here, we test the effect of these internal bores on the autotrophic vs heterotrophic nutrition of corals.

Measurements on isotopic composition ($^{13}C$ and $^{15}N$) of zooxanthellae as well as coral host (*Porites lutea*, *Diploastrea heliopora*, *Pocillopora eydouxi*) tissue indicate that the corals of the W side of the islands are more heterotrophic than on the sheltered E sides, despite their close geographical distance (200 m), with plankton substituting the reduced measured photosynthetic activity on the W sides.

Shading experiments suppressing photosynthetic activity revealed a more effective maintenance of metabolic activity in all three species due to enhanced heterotrophy on the W side. Cross-transplantation experiments with *P. eydouxi* showed that corals from the W side, accustomed to the rough conditions there, show faster adaptability to changes and enhanced resilience to environmental disturbance. Measurements on fitness parameters such as RNA/DNA-ratios or protein concentrations further support these assumptions.

## 12-21

**Coral Recruitment in The Garden Of Good And Evil: Algae As A Driver Of Coral Reef Resilience**

**Robert STENECK*[1]**, Suzanne ARNOLD[1], Peter MUMBY[2], Valerie PAUL[3], Raphael RITSON-WILLIAMS[3]

[1]School of Marine Sciences, University of Maine, Walpole, ME, [2]Marine Spatial Ecology Laboratory, University of Exeter, Exeter, United Kingdom, [3]Smithsonian Institution, Fort Pierce, FL

Coral reefs are globally endangered ecosystems. Their resilience depends on the ecological success of reef corals. In recent decades, mortality rates of adult corals have increased due to bleaching and disease. Thus, the ability of reefs to recover depends on the successful recruitment of corals. We studied the factors driving the recruitment of Caribbean corals at multiple scales in space and time. Since 2003 we have studied eight regions (Bahamas, Bonaire, St. Croix, St. John, Mexico, Belize, Honduras, Guatemala) four to six reefs per region with replicated benthic community structure transects, fish surveys, bite rates, and coral settlement plates at multiple reefs per region. From this a clear pattern has emerged. Algal community structure regulates coral recruitment both positively, due to the presence of coralline algal species that facilitate coral settlement, and negatively, due to the presence of macroalgae and thick algal turfs that inhibit coral settlement and coralline algal species that kill newly settled corals (via smothering overgrowth, or the shedding of the coralline's surface cells). Increased algal biomass of turfs and macroalgae reduce larval settlement and post-settlement survival. Since different coralline algal species can affect coral recruitment both positively and negatively, we conducted laboratory studies to determine if settling corals are selective in settling on facilitating species and avoiding recruitment inhibiting species. We found that different coral species show different coralline-specific selectivity. For example, *Acropora palmata* metamorphoses and settles near the coralline *Hydrolithon boergesenii* whereas *A. cervicornis* settles onto *Titanoderma prototypum.* We suspect that settling corals can determine the right zone, microhabitat (e.g. subcryptic spaces) and ecological state (e.g. high vs. low algal biomass) based on the coralline flora they detect.

## 12-22

**Algal Effects On Coral Replenishment, And The Resilience Of Coral Reefs**

**Chico BIRRELL*[1]**, Laurence MCCOOK[2], Bette WILLIS[3], Guillermo DIAZ-PULIDO[4]

[1]Australian Institute of Marine Science, Perth, Australia, [2]Pew Fellow in Marine Conservation; ARC Centre of Excellence for Coral Reef Studies; GBRMPA, Townsville, Australia, [3]ARC Centre of Excellence for Coral Reef Studies; School of Biological Sciences JCU, Townsville, Australia, [4]Pew Program in Marine Conservation; ARC Centre of Excellence for Coral Reef Studies, Brisbane, Australia

The ecological resilience of coral reefs depends critically on the capacity of coral populations to re-establish in habitats dominated by macroalgae. Coral reefs globally are under rapidly increasing pressure from human activities, especially from climate change, with serious environmental, social and economic consequences. Coral mortality is usually followed by colonisation by benthic algae of various forms, so that algae dominate most degraded and disturbed reefs. The capacity of coral populations to re-establish in this algal-dominated environment will depend on direct and indirect impacts of the algae on the supply of coral larvae from remnant adults, on settlement of coral larvae and on the post-settlement survival and growth of juvenile corals. This talk summarises a recent review of this topic.

The effects of benthic algae on coral replenishment vary considerably but the thick mats or large seaweeds typical of degraded reefs have predominantly negative impacts. Some algae, mostly calcareous red algae, may enhance coral settlement on healthy reefs. Algal effects on coral replenishment include reduced fecundity and larval survival, pre-emption of space for settlement, abrasion or overgrowth of recruits, sloughing or dislodgement of recruits settled on crustose algae, and changes to habitat conditions. There is a serious lack of information about these effects, which are likely to cause bottlenecks in coral recovery and significantly reduce the resilience of coral reefs.

## 12-23

**Coral Reef Resilience To Chronic And Acute Disturbances: Lessons From 90 Years Of Monitoring in American Samoa**

**Alison GREEN*[1]**, Charles BIRKELAND[2], Douglas FENNER[3], Cheryl SQUAIR[4]

[1]The Nature Conservancy, Australia, Brisbane, Australia, [2]Hawaii Cooperative Fishery Research Unit, USGS, USA, Honolulu, HI, [3]Dept of Marine and Wildlife Resources, American Samoa, Pago Pago, American Samoa, [4]University of Hawaii, USA, Honolulu, American Samoa

In 1917, Alfred Mayor established a quantitative coral transect on the reef flat at Aua in Pago Pago Harbor, American Samoa. He recorded rich coral communities in distinct zones along the transect. In the 1950s-1980s, this area was seriously degraded by chronic pollution from two tuna canneries in the inner harbor and by coastal development. By the 1970s, coral communities had declined substantially, and there was a change in the relative abundance of coral genera and major changes in coral zonation. In 1992, a large pipe was installed to export wastewater from the tuna canneries to the harbor mouth. Since then, there has been a significant recovery of coral communities on the reef crest and outer reef flat where there is consolidated reef substratum (up to 30 m back from the reef crest). In contrast, recovery has been substantially slower behind the reef crest, where the substratum is primarily loose rubble. In particular, the *Acropora* zone recorded on the outer reef flat in 1917 (120-140m behind the reef crest) had disappeared completely by the 1990s. Recovery is now proceeding in this zone by the slow accumulation of *Acropora formosa* colonies that are large enough to become established on the loose substratum. This study demonstrates different rates of recovery after chronic disturbance due to the influence of substratum type. This is in contrast to the results of long term monitoring in Fagatele Bay National Marine Sanctuary west of the harbor (since the late 1970s), where reefs have been shown to recover from acute disturbances such as hurricanes within 10-15 years. Major differences in rates of recovery appear to be the result of different types of disturbance (acute vs chronic), and degree of substratum consolidation.

## 12-24

**What Is The Future For Extensive Areas Of Reef Impacted By Fish Blasting And Coral Bleaching And Now Dominated By Soft Corals? A Case Study From Malaysia.**

**Elizabeth WOOD*[1]**, Frances DIPPER[2]

[1]Marine Conservation Society, Hook, United Kingdom, [2]Marine Conservation Society, Ross-on -Wye, United Kingdom

Many reefs in the Tun Sakaran Marine Park, Sabah, East Malaysia have been damaged by fish blasting and to a lesser extent by coral bleaching and crown-of-thorns starfish. Coral communities that comprised a mixture of growth forms and included a greater proportion of massive or robust species are recovering better than those where the majority of corals were laminar and foliaceous. One particular problem is at clear-water sites where there were extensive stands of laminar Montipora on the reef rim and upper slope. Collapse of these colonies created rubble that typically became colonised by soft corals, particularly xeniids. The xeniids are acting as a barrier to recruitment of hard corals and provide no shelter or structural complexity, with the result that these areas are now largely devoid of fish. The implications of this changed ecology for biodiversity, reef growth and productivity are discussed.

## 12-25

**Stability Of Reef Framework And Post Settlement Mortality As The Structuring Factor For Recovery Of Malakal Bay Reef, Palau, Micronesia: 25 Years After A Severe COTS outbreak.**

Steven VICTOR[1], **Steven VICTOR*[1]**

[1]Research, Palau International Coral Reef Center, Koror, Palau

Corals in Malakal Bay reefs were devastated in the 1979 Crown of Thorns Starfish (COTS) outbreak. It has been almost 30 years since the outbreak and coral cover at the study sites have not come close to the cover before the outbreak. A question is asked: what factors may contribute to the slow recovery of these reefs: recruitment or post-settlement mortality? Two habitat types within the reef systems were monitored using coral transplants to determine if corals can survive in these environments and recruitment tiles to see if there are larvae coming into the system. The study revealed that coral survivorship is high in the fore reef areas compared to the reef channel slopes and that larvae is not a limiting factor to natural recovery. Stability of the reef framework, i.e unstable rubble substrate, and possibly high post settlement mortality, are the structuring factors that determine the recovery process in these reef systems and possibly so for similar habitats in other reef systems throughout Palau.

## 12-26

**Response And Adaptation To Climate Change Stress On Andros Island Reefs, Bahamas**

**Philip KRAMER*[1,2]**

[1]The Nature Conservancy, Sugarloaf key, FL, [2]Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami

The coral reefs along Andros Island, Bahamas provide an ideal setting to examine reef structural and functional response to climate change given that they have experienced minimal human and natural disturbances such as hurricanes over the past century. Here we show how key ecological processes of coral mortality, herbivory, and recruitment, and physical factors such as wave energy and temperature have influenced recovery from 1998 and 2005 bleaching events. Since 2002, twenty-nine fixed sites representing six coral reef types have been monitored using Atlantic and Gulf Rapid Reef Assessment (AGRRA) methodology every two years. This 6-year monitoring dataset has been augmented with baseline AGRRA data collected in 1997-98 and a historic dataset of in-situ temperature data and video and photographic monitoring data collected since the early 1970's. Extensive losses during the 1997-98 coral bleaching and disease event reduced coral cover on high relief fore reefs and reef crests from 34% down to 12%. Lingering diseases and additional temperature stress during 2005 further reduced stony coral cover below 10% on many fore reefs, with losses greatest in the Montastraea annularis complex. Coral recovery has been limited, observed mostly as regrowth of coral tissue remnants rather than direct recruitment. Even on shallow reef crests where high levels of herbivory and faster rates of coral growth occur, high predation and coral disease limit coral recruitment and recovery. Physical environmental factors correlate with observed spatial patterns of resistance to bleaching and disease events. Lagoonal patch reefs exposed to highly variable temperature and light conditions and patch reef located within inland tidal channels and associated blue holes showed minimal loss of stony corals compared to bank margin reefs. These results suggest that both functional and environmental factors account for the observed patterns in resistance and recovery.

## 12-27

**Interaction Between Fishing And Bleaching On Kenyan Coral Reefs Moderated By Disturbance History**

**Emily DARLING*[1]**, Tim MCCLANAHAN[2], Isabelle CÔTÉ[1]

[1]Simon Fraser University, Burnaby, BC, Canada, [2]Wildlife Conservation Society, Bronx, NY

Coral reef ecosystems are affected by many stressors. The possibility these stressors interact synergistically causes conservation concern, but such non-linear effects remain untested in nature. We examined the independent and interactive effects of two stressors, fishing and bleaching, on coral community structure using a 16-year time series of monitoring data from Kenyan reefs. While both fishing and a mass coral bleaching event in 1998 decreased hard coral cover, these stressors did not interact synergistically to accelerate coral decline. Instead, fishing and bleaching interacted antagonistically. Following 1998, hard coral cover on unfished reefs declined 74% (relative to pre-bleaching cover) compared to 48% on fished reefs. Multivariate community analyses suggest that the non-synergistic interaction between fishing and bleaching may be explained by changes in coral community structure associated with fishing history. Prior to 1998, unfished reefs had diverse coral assemblages (dominated by branching *Acropora* and plating *Montipora*) that were not resistant to the 1998 bleaching event. In contrast, fished reefs, composed primarily of massive and branching *Porites*, were both more resistant to and recovered more quickly from bleaching. Decades of fishing pressure thus appears to have favoured low-diversity disturbance-tolerant coral communities. By contrast, unfished reefs may be refugia for high-diversity disturbance-sensitive communities. We suggest that disturbance history, community susceptibility, and trade-offs between diversity and resilience can moderate interactions between multiple stressors and may be important factors determining resilience to future large-scale climate events.

## 12-28

**Great Barrier Reef Coral Communities: Resilient in the 1980s but Struggling in the 2000s**

**Terry DONE*[1]**, Lyndon DEVANTIER[2], Emre TURAK[2], Mary WAKEFORD[2], Abbi MCDONALD[2], Craig JOHNSON[3]

[1]Australian Institute of Marine Science, Townsville, Qld, Australia, [2]Australian Institute of Marine Science, Townsville, 4810, Qld, Australia, [3]University of Tasmania, Hobart, Australia

Coral communities were monitored using photography and video at 30 Great Barrier Reef study sites in the period 1980 – 2005. At Pandora Reef in the 1980s, regional elevation of land-based nutrients did not prevent spectacular recovery of coral cover and diversity following a sequence of environmental disturbances in the 1970s. There was high coral mortality in some habitats in the 1998 bleaching, and the standing dead corals were then flattened by a 2000 cyclone. Degree of impact and extent of recovery was related to marked differences around the reef in benthic species composition and relative abundance, notably fleshy algae, soft corals, poritids and acroporids. Relative paucity of larval derived recruits and viable fragments in 2005 suggests the strong coral population resilience of the 1980s will not be repeated in the short term, especially reflecting regional paucity in Acropora broodstock. At a small (32 m2) site at Lizard Island there were three acute disturbance events followed by good coral recovery and no tendency for phase-shift: 1982- a combination of coral bleaching and Crown-of-Thorns starfish; 1990 - cyclone waves and 1996 - Crown-of-Thorns starfish. However beyond 1996, observations and modeling using Johnson's Compete © Cellular Automaton model suggest the area may be subject to annual chronic background mortality. The apparent retardation of coral recovery may be exacerbated by projected reduced intervals between disturbances associated with global climate change. However hopefully recovery prospects will be improved as region-wide benefits of improved GBR-wide management introduced in 2004 take effect: i.e. an eightfold increase in the area of no take protected areas, and the initiation of actions to improved coastal water quality.

## 13-1

**Prioritizing Conservation Hotspots: Does Phylogeny Matter?**

**Christopher MEYER*[1]**

[1]Natural History Museum, Smithsonian Institution, Washington, DC

Most approaches to coral reef biodiversity use species richness as the metric for examining geographic patterns with the implicit assumption that all species are equal. However, some have argued various measures that incorporate evolutionary history, such as phylogenetic diversity or taxonomic distinctiveness, may be more appropriate metrics, especially when establishing conservation priorities. Most published comparisons that integrate phylogentic data into conservation planning are terrestrial and geographically restricted in scope. Using a taxonomically comprehensive phylogeny of cypraeid gastropods, a well-known, predominantly reef-associated group of snails, I examine the effects of incorporating phylogeny in prioritizing biogeographic hotspots for conservation importance. The global diversity profile of cowries is similar to most other major reef-associated groups, including corals and reef-fishes, and cowries have a range of life history attributes that make them a reasonable proxy for other reef-associated species. I compare three metrics of biodiversity: (1) richness, (2) phylogenetic diversity and (3) taxonomic distinctiveness across three phylogenetic scales: (A) genera, (B) species, and (C) ESUs (= DNA barcode lineages). This 3 x 3 approach indicates that some metrics or scales can act as effective surrogates for others in some instances. However, finer phylogenetic scales reveal the importance of inter and intra-basinal processes as engines of diversification and highlight their importance in both conservation efforts and establishing biodiversity survey focal regions.

## 13-2

**Identification And Conservation Of Evolutionary Processes in The Coral Triangle Biodiversity Hotspot.**

**Paul BARBER*[1]**

[1]Boston University Marine Program, Boston University, Boston, MA

The reefs of the Coral Triangle are the most diverse in the World. While the origins of pattern have long attracted the attention of evolutionary biologists, answering this question has largely been considered of purely academic interest. However, given the increasing threats facing the reefs of the Coral Triangle, it is becoming increasingly clear that understanding the processes generating high biodiversity in this region is critical for preserving this diversity, including the processes that create it. In this study we compare phylogeography and genetic connectivity of over 30 fish and invertebrate taxa that are codistsributed across the Coral Triangle, representing multiple reef functional groups ranging from corals to pelagic fish. Results indicate a broad array of evolutionary patterns in this shared physical environment. Some taxa exhibit the classic pattern of differentiation between Pacific and Indian Ocean populations, suggesting Pleistocene vicariance. Others show fine-scale genetic differentiation, suggesting a common history of regional geographic isolation. Still others show no genetic structure at all. Although patterns fell into these three basic classes, there were few commonalities among taxa with similar patterns of genetic structure. The unique responses of multiple taxa to a shared environment suggest a multiplicity of physical and ecological processes contributing to the evolution of high biodiversity in the Coral Triangle. While the commonalities seen among some taxa suggests some support for regional seascape conservation initiatives, the idiosyncrasies among taxa demonstrate the challenges facing marine managers in designing reserve systems that will effectively protect a broad array of biodiversity.

## 13-3

**Absence Of Geographic Barrier Across The Indo-Pacific Province For Coral Reef Fishes**

Serge PLANES[1,2], **Cécile FAUVELOT*[3]**, Vanessa MESSMER[1,4], Shital SWARUP[1], Matthieu LERAY[1], Jean-Luc TISON[1]

[1]UMR 5244 - Laboratoire Écosystèmes Aquatiques Tropicaux et Méditerranéens, CNRS - EPHE - UPVD, Perpignan, France, [2]UMS 2978 - CRIOBE, CNRS - EPHE, Moorea, French Polynesia, [3]UR 128 – CoRéUs, Institut de Recherche pour le Développement, Perpignan, France, [4]School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

With an area spanning half the world's tropical marine belt, from East Africa to western coast of Americas, the Indo-Pacific region is the largest biogeographic province. Within this province, coral reef species distributions varied greatly, with some species restricted to a single island while others are found throughout the province. In this context, the question related to the dynamic of spreading of species within such a large biogeographic province as always been a striking point. Recent phylogenetic studies on such topic remain too limited, and the results often conflicting to provide any consensus. In the perspective of providing a general view, it appears essential to compare the phylogeography of several taxa differing in life histories in order to reveal how geographic barriers may affect similarly evolutionary history of species. Here we investigate the phylogeographic patterns of seven coral reef fishes (i.e; *Acanthurus triostegus*, *Dascyllus aruanus*, *Forcipiger flavissimus*, *Lutjanus kasmira*, *Paracirrhites forsteri*, *Zanclus cornutus* and *Rhinecanthus aculeatus*) sampled among up to 29 locations throughout the Indo-Pacific with the objective of identifying common barriers to colonization and gene flow. Analyses based on sequences of the hypervariable region of the mitochondrial DNA Control Region (Dloop) revealed different phylogenetic patterns exhibited by the seven species. While some species showed marginal genetic isolation of remote islands, other showed clear phylogenetic signals. Nevertheless, all species did exhibit genetic footprint of exponential population growth. The pairwise mismatch distributions strongly differed among species revealing unique ancient demographic expansion signatures. The absence of common evolutionary histories is likely correlated with the high dispersal capabilities of coral reef fishes during their larval phase. Though recent works have emphasised local retention and small-scale self-recruitment at an ecological timescale, this does not prevent sporadic large-scale dispersal to spread molecular variants throughout the Indo-Pacific area on an evolutionary timescale.

Financial support provided by: CRISP

## 13-4

**Population Structure Of The Three-Spot Damselfish, Dascyllus Trimaculatus Across Its Distribution Range**

**Matthieu LERAY*[1,2]**, Ricardo BELDADE[1], Serge PLANES[2], Sally HOLBROOK[3], Russell SCHMITT[3], Giacomo BERNARDI[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]EPHE - UMR CNRS 8046, Universite de Perpignan, Perpignan, France, [3]Ecology, Evolution & Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

In previous studies, members of the three-spot damselfish species complex composed by four nominal species: Dascyllus albisella Gill, D. auripinnis Randall and Randall, D. strasburgi Klausewitz, and D. trimaculatus (Ruppell) were sampled from the Indian Ocean, the Pacific Rim (Japan to Wallis Island), French Polynesia, Hawaii, and Marquesas. Analyses of the control region of the mitochondrial DNA (D-loop) revealed five different clades: 3 of which correspond to the Pacific Rim (D. trimaculatus and D. auripinnis), Hawaii (D. albisella) and Marquesas (D. strasburgi) and the remaining two clades, Indian Ocean and French Polynesia (D. trimaculatus). We developed microsatellite primers to determine if clades uncovered by the mitochondrial analyses were consistent with nuclear data. Color morphs, species boundaries and incipient speciation in the three-spot damselfish complex are discussed.

## 13-5

**A Seascape Of Genes: A Complete Survey Of Coral Genetic Diversity On A Patch Reef in Kane'ohe Bay, Hawai'i**

**Kelvin GOROSPE*[1]**, Stephen KARL[2]

[1]University of Hawai'i at Manoa, Honolulu, HI, [2]The Hawai'i Institute of Marine Biology, Kane'ohe, HI

Genetic studies of corals have primarily focused on characterizing genetic differentiation on broad-geographic scales. These studies are important for informing management decisions regarding the prioritization and placement of marine protected areas. Genetic variation on the geographic scale of a single reef, however, has been largely overlooked. This has created a major gap in our understanding of coral population genetics as well as a missing link in our ability to efficiently manage these natural resources. By genotyping and mapping every single individual of *Pocillopora damicornis* on a patch reef in Kane'ohe Bay, Hawaii, this research will examine coral genetic variation on a micro-spatial scale. Eight microsatellite loci are being used to genotype approximately 3000 coral colonies. This will allow us to assess spatial patterns of genetic relatedness within a reef. Furthermore, temperature sensors deployed on a 4m grid throughout the reef are being used to characterize microhabitat variation. Thus, this research will be the first to fully characterize the genetic and environmental landscape of a reef. Correlating genetic, environmental, and spatial data lends insight into the processes that are driving variation on a small spatial scale. For example, what are the genetic resources of a single reef, and what role does genetic diversity at such a small spatial scale play in terms of reef resilience? Do genetically related colonies tend to cluster together or are they evenly distributed throughout the reef? How much does clonality (produced via fragmentation) versus recruitment of sexually-produced larvae contribute to coral abundance? Do coral phenotypic differences correlate more with genetic-relatedness or benthic microhabitat differences? Ultimately, by describing how genetic variation relates to coral survival and recruitment within a reef, this research will elucidate the connection between long-term evolutionary processes and contemporary conservation efforts.

## 13-6

**Kinship in The Orange-Fin Clownfish, Amphiprion Chrysopterus, From Moorea, French Polynesia**

**Ricardo BELDADE*[1]**, Serge PLANES[2], Sally HOLBROOK[3], Russell SCHMITT[3], Giacomo BERNARDI[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]EPHE - UMR CNRS 8046, Universite de Perpignan, Perpignan, France, [3]Ecology, Evolution & Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

The orange-fin clownfish, Amphiprion chrysopterus, are diurnal planktivores that occupy the sea anemone Heteractis magnifica. They lay benthic eggs that hatch after 6 days, releasing pelagic larvae that settle to anemones after 8–12 days. Orange-fin clownfish generally live in pairs (an adult of each gender) and remain closely associated with the host anemone throughout their lives. In Moorea, French Polynesia, settlement of this species tends to be sporadic and at a very low level. We collected fin-clips from 151 individuals, mostly inside the lagoon, all around Moorea and used microsatellites to investigate kinship among individuals. Seven related specimens were found in the southeast quadrant of Moorea. All these specimens were collected inside the lagoon relatively far from any pass. Even though the geographical origin of this group of related individuals has not been established, the present findings point to the possibility of either self-recruitment of the orange fin clownfish in Moorea or the potential for related larvae to recruit in cohorts.

## 13-7

**Phylogeography Of The Ember Parrotfish (*scarus Rubroviolaceus*) Throughout The Indian And Pacific Oceans**

**John FITZPATRICK*[1]**, Catherine LIPPE[1], Dave CARLON[1]

[1]Zoology, University of Hawaii, Manoa, Honolulu, HI

Overfishing and pollution are affecting consumers on coral reefs and impacting ecosystem structure and function. To protect and conserve these valuable ecosystems, we need knowledge of reef connectivity and dispersal patterns to inform proper establishment and design of effective fisheries management tools, such as MPAs. In the tropical Pacific, many species of reef herbivores have long planktonic larval durations and enormous biogeographic ranges, yet patterns of the population structure are largely unknown. To determine how many populations (defined as interbreeding units) exist within the range of the ember parrotfish (*Scarus rubroviolaceus*) we sampled populations from Panama to Africa and genotyped over 300 individuals at 14 microsatellite loci. We used traditional measures of population structure and the population model STRUCTURE to determine how many populations are found within this species' range. This analysis found 4 populations defined by the following biogeographic regions: 1) Indian Ocean, 2) Central Pacific, 3) Hawaii, and 4) East Pacific. Further, pairwise comparisons revealed the largest *F*ST values between Hawaii and all other populations and the East Pacific and all other populations. The isolation of Hawaii and the East Pacific from all other populations are likely the result of unsuccessful dispersal over vast stretches of water that lie between favorable habitats. However, there is a high degree of dispersal in the larvae of these fish indicated by the panmixia found at smaller scales, e.g. within Hawaii and Samoa. Our results require confirmation with other key reef herbivores, but suggest management strategies should be built around population cohesiveness within at least four regions, and emphasize the uniqueness of Hawaii and the Eastern Pacific.

## 13-9

**A Restoration Genetics Guide For Coral Reef Conservation**

**Iliana BAUMS*[1]**

[1]Biology, The Pennsylvania State University, University Park, PA

World-wide degradation of coral reef communities has prompted a surge in restoration efforts and created an urgent need for restoration genetic guidelines. The major question restoration efforts face is over what distance from the source wild and/or captive bred propagules may be moved without causing a loss of fitness in the restored population. Evolutionary processes in reef corals may resemble those observed in long-lived plant and recommendations developed for plant restoration are modified here for reef conservation. Proposed causes for loss of fitness as a result of restoration efforts include founder effects, genetic swamping, inbreeding and/or outbreeding depression. Direct evidence for any of these processes is scarce in reef corals due to a lack of model species that allow for testing over multiple generations and the separation of the relative contributions of algal symbionts and their coral hosts to the overall performance of the coral colony. However, in controlled crosses presented here, certain colony pairings produce higher performing larvae then the control batch culture. These larvae do not yet contain zooxanthellae, implying that performance differences exist among coral genets. Clearly, further research is needed to study host-symbiont-environment interactions. Meanwhile, there is ample evidence for differentiated populations, inbreeding, asexual reproduction and the occurrence of ecotypes in corals, factors that influence the design of restoration projects. Contrary to published expectations, a review of the literature shows that inbreeding is as common in broadcast spawners as it is in brooders. The use of molecular tools may aid managers in the selection of appropriate propagule sources, guide spatial arrangement of transplants, and help in assessing the success of restoration projects by tracking the performance of transplants, thereby generating important data for future projects

## 13-10

### Local Interspecific Hybridization And Restricted Transpacific Gene Flow in Tropical Eastern Pacific *pocillopora*

**David J. COMBOSCH*[1,2]**, Hector M. GUZMAN[2], Helmut SCHUHMACHER[3], Steve V. VOLLMER[1,2]

[1]Biology, Northeastern University, Nahant, MA, [2]Smithsonian Tropical Research Institute, Balboa, Panama, [3]Biology and Geography, University Duisburg-Essen, Essen, Germany

Coral reefs in the Tropical Eastern Pacific (TEP) are among the most isolated in the world. This isolation has leaded to relatively low species diversity but high regional endemism. The dominant reef-building corals in the TEP are the *Pocillopora* corals, a ubiquitous Indo-Pacific genus commonly regarded as inferior reef-builder. In addition to being the dominant corals in the TEP, the Pocilloporids have undergone a reproductive shift from internal larvae brooding throughout most of their Indo-Pacific range to free gamete spawning in the TEP.

Using genetic data from the Internal Transcribed Spacer Regions (ITS) of the nuclear ribosomal DNA gene cluster, we show here that this apparent reproductive shift coincides with inter-specific hybridization among TEP *Pocillopora* species. We document a pattern of one-way gene flow into the main TEP reef builder *P. damicornis* from one or both of its TEP congeners –*P. eydouxi* and *P. elegans*. Strong population genetic differences within *P. damicornis* further indicate that transpacific gene flow between the Central and Eastern Pacific is rare ($\varphi ct = 0.419$). These results suggest that Eastern Pacific corals exist in relative isolation from their Central Pacific counterparts, interact with each other differently via hybridization, and thus must be protected for their evolutionary uniqueness.

## 14-2

**Oceanographic Coupling Across Multiple Trophic Levels Shapes Source-Sink Dynamics in Coral Reef Metacommunities**

Will WHITE[1], Jameal SAMHOURI[2], **Robert WARNER*[3]**

[1]Dept. of Wildlife, Fisheries, and Conservation Biology, University of California - Davis, Davis, CA, [2]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, [3]Dept. of Ecology, Evolution, and Marine Biology, University of California - Santa Barbara, Santa Barbara, CA

A central goal of most studies of marine population connectivity is to determine which subpopulations have the greatest value to the larger metapopulation. That is, where are the 'sources' that are most essential to population persistence? In a single-species context, this is a straightforward question, and theoretical models typically identify sites with high recruitment, especially high self-recruitment, as having the highest value. However, the oceanographic forces that shape the larval delivery of a given species are also likely to influence the recruitment of that species' predators, prey, and competitors. We present empirical evidence from the Virgin Islands and Bahamas that oceanographic forces produce spatial coupling between the recruitment of planktivorous fishes, the recruitment of their predators, and the productivity of their zooplankton prey. Both empirical and theoretical evidence suggests that this coupling causes planktivores at the highest recruitment sites to experience higher, more strongly density-dependent mortality (a consequence of higher predator densities). At the same time, planktivores at high recruitment sites demonstrate faster growth and higher fecundity (a consequence of higher zooplankton densities) than planktivores at low recruitment sites. Furthermore, the results of both analytical and simulation metapopulation models reveal that the relative strength of oceanographic coupling between the three trophic levels strongly determines whether a given reef acts as a source or sink. Consequently, we argue that the potential for such coupling should be incorporated into future models of coral reef metapopulation dynamics and considered in the design of marine protected areas.

## 14-3

**Coral Reef Conservation Planning With Connectivity**

**Maria BEGER*[1]**, Hugh POSSINGHAM[1]

[1]The Ecology Centre, The University of Queensland, St Lucia, Brisbane, Australia

There are biophysical linkages and interactions between coral reefs and adjacent realms, as well as connections among reefs themselves. Contemporary conservation planning and reserve design theory and practice is largely incapable to deal systematically (i.e. spatially explicit, repeatable, and mathematically sound) with connectivity. This talk explores two new frameworks of how connectivity can be incorporated into the systematic design of conservation area networks.

Firstly we present a classification scheme of cross-realm connections that provides a basis for conservation planning. This includes four broad types of interactions: a) narrow interfaces such as inter-tidal zones; b) broad interfaces such as estuaries; c) constrained connections such as corridors of native vegetation used by amphibian to move between natal ponds and adult habitat; and d) diffuse connections such as the movements of birds or sea turtles between breeding and feeding habitats. We then use this classification to describe a framework of technical approaches to conservation planning that promote the persistence of these types of processes, with formulations and case studies of implementation in decision support software.

Secondly, we present new methods of incorporating marine population connectivity into systematic conservation planning. We develop a framework of incorporating the spatial, temporal and species-specific variability of connectivity and present the newly developed capability of the decision support system MARXAN to incorporate connectivity, and demonstrate the improvement of potential reserve networks with connectivity above reserve systems without for a Great Barrier Reef case study.

## 14-4

**Tropical-Temperate Connectivity Of Expatriated Fishes: Backtracking Dispersal Along The East Coast Of Australia**

**Will FIGUEIRA*[1]**

[1]Department of Environmental Sciences, Univeristy of Technology, Sydney, Broadway, Australia

Juvenile coral reef fishes from the families Pomacentridae (Damselfish) and Chaetodontidae (Butterflyfish) are commonly found along the east coast of Australia as far south as the New South Wales - Victorian border (37°S) during the austral summer months, though they typically fail to survive the ensuing winter. Previous work has highlighted the role of the East Australian Current in the transport of the larvae of these species and indicated the possibility that while some of the Pomacentrid species may be sourced from year-round populations located well south of the Great Barrier Reef (GBR), the Chaetodontids more likely originate from the southern end of the GBR. In order to evaluate these hypotheses, potential larval pathways of collected individuals were back-calculated using an individually-based larval dispersal model. Dispersion was behaviourally influenced by larval swimming and orienting (contingent upon larval age) and forced in an advective-diffusive manner using modeled flow data from the Bluelink Ocean Forcasting System. Using estimated planktonic larval durations and date of settlement (from otolith analysis) of fish collected at sites all along the south coast from 2003 to the present, a mean dispersal pathway (MDP) and point of origin probability distribution (OPD) was estimated from 100 repeated simulations. MDPs and OPDs were compared between species and among species across sites and years to look for consistent patterns. The importance of larval behaviour parameters was also assessed. Variability in the structure of the EAC led to a large degree of complexity in the estimated dispersal patterns. There is general support for the supply of some of the Pomacentrid species from temperate sites but patterns for the Chaetodontids were less clear.

## 14-5

**A numerical study on larval dispersal in the Southeast Asia and West Pacific (SEA-WP) regions using a new Indo-Pacific Ocean Circulation Model**

**Aditya R. KARTADIKARIA*[1]**, Kazuo NADAOKA[1], Yasumasa MIYAZAWA[2], Nina YASUDA[1]

[1]Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan, [2]Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

The South East Asia and West Pacific (SEA-WP) region is a significant reservoir of the world's richest marine biodiversity. However, coral reef communities of this region are now severely threatened by numerous environmental factors. It is therefore of vital importance to reveal the reef-connectivity to effectively conserve and manage this region. Recent molecular ecological studies on genetic variations have shown that the gene flow patterns in this area are associated with a number of factors but are found mostly in discordance with the present overall schematics of the surface ocean current, although the knowledge on the ocean currents in this region is still limited. To provide more detailed and reliable information on the ocean currents in SEA-WP region and thereby to examine associated larval dispersal processes in the complicated topographic area having numerous islands, we have been developing a numerical simulation model based on a new Indo-Pacific Ocean Circulation model. In addition to the complicated topographic effect, the SEA-WP region may be influenced by atmospheric disturbances including monsoon and typhoon and the various through-flows across straits and passages with the Pacific and Indian Oceans. For properly simulating ocean currents in the SEA-WP region under these effects, the Indo-Pacific Ocean Circulation model is coupled with a regional atmospheric model. The model simulation results elucidate detailed characteristics of Indonesian Through Flow (ITF) and other through-flows at Luzon strait and North Australia-Pacific passage and their effects on larval dispersal processes.

## 14-6

**Modelling Coral Larval Dispersal Patterns Within The Singapore Straits**

**Ywee Chieh TAY*[1]**, Peter Alan TODD[1], Per Sand ROSSHAUG[2], Loke Ming CHOU[1]

[1]Department of Biological Sciences, National University of Singapore, Singapore, Singapore, [2]Environmental processes, DHI, Hørsholm, Denmark

Despite almost five decades of anthropogenic impacts, the reefs of Singapore's Southern Islands support a rich community of scleractinian corals (165 species in just 10km$^2$ of reef). Ongoing reef restoration efforts are important for reducing degradation rates of the remaining reefs, but natural recruitment processes remain poorly understood. Given the dynamism of the marine environment, broadcast spawners such as scleractinian corals display great potential for exchange of genetic material. Determining the connectivity among Singapore reefs is one of the fundamental steps in understanding the sustainability and viability of coral populations, and would contribute to more informed reef management decisions.

It is logistically challenging, however, to track the dispersal patterns of millions of microscopic larvae. Coral larval dispersion patterns were therefore predicted with a 2D-hydrodynamic flexible mesh (MIKE21 FM) model coupled with a Lagrangian particle-tracking module. Neutrally buoyant, passive particles representing the generally passive coral larvae were released from various coral source reefs in the Southern Islands during mass spawning events. Particles were also released from the northern coasts of some of the neighbouring Riau islands of Indonesia at predicted spawning times. Preliminary findings indicate that the coral reefs of the Southern Islands are mainly self- replenishing. Most of the input, however, comes from an eastern cluster of islands due to the seasonal net east-west current that runs through the Singapore Straits during this period. Such connectivity patterns can be used to predict which reefs are key sources of genetic material and thus suitable for conservation priorities.

## 14-7

**Larval Dispersal In Archipelagic Basins And Interconnecting Straits Using Particle-Tracking Models**

**Cesar VILLANOY*[1]**, Marites CANTO[2], Wilfredo CAMPOS[3]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]Marine Science Institute, University of the Philippines, Quezon City`, Philippines, [3]OceanBio Laboratory, University of the Philippines in the Visayas, Iloilo, Philippines

Larval dispersal models have been used to investigate marine population connectivity in the Philippines. The unique archipelagic nature of the seas around the Philippines where semi-enclosed basins like the Sulu Sea and the Bohol Sea, interconnected with narrow straits and passages, may define scales of larval dispersal. Surface current velocities from global and regional models were used to drive particle-tracking larval dispersal models to gain insights on the role of interconnecting passages and semi-enclosed basins on dispersal patterns. The location of larval sources were based on coral reef habitat maps and the magnitude of larval sources scaled according to habitat characteristics, particularly reef fish biomass and percent live coral from field survey data. The virtual larvae contain simple behavior involving sensory and swimming capabilities. Survival rate of settled recruits is also scaled by a simple measure of fishing and environmental pressure. The results show that while hydrodynamics of straits and basins control dispersal, spatially varying magnitudes of the larval sources and survival of recruits are highly influenced by protection and degree of fishing pressure.

## 14-8

**A Preliminary Effort in Linking Connectivity Information And Coral Reef Fisheries Using A Simple Systems Model**

**Ma. Carmen ABLAN*[1]**

[1]Biology Department, De La Salle University Manila, Manila, Philippines

Connecting connectivity information to reef fisheries management is a major challenge. It requires the availability and integration of good information and a means of obtaining feedback from managers and resource users. The need in developing countries is especially urgent because management interventions to halt the decline and restore productivity of reef fisheries are increasingly becoming focused on local scales. As policies change, including connectivity in decision making becomes essential to the success of any intervention. This study presents initial work on constructing a simple systems model, using Stella 8.0. It integrates available information on recruitment, spillover and fishing of reef fish to determine fish stocks in three islands in the Bohol Sea. The effect of introducing estimates of connectivity to the model in predicting the availability of reef fish was explored in the model and compared to estimates without information on connectivity. Fish stocks over time in Balicasag, Apo and Sumilon Islands were first modeled in relation to recruitment, spillover from marine protected areas and fishing within each of these islands based on published information and data from interviews with fishers. Estimates of asymmetric migration among islands based on previous work using microsatellite markers on the sedentary damselfish *Dascyllus trimaculatus* and the further ranging *Pterocaesio pisang* was factored into the model. Values of fish stocks for each area were recalculated. When conservative estimates of connectivity based on *D. trimaculatu*s were used, fish stocks in Balicasag and Sumilon declined by 20% and 15% while those in Apo increased by 22%. Using connectivity estimates from *P.pisang*, decline of 18-33% in fish stock was predicted. Results show that different connectivity scenarios have different consequences for management and raise the question of whether we could actually produce a measure which can be useful.

## 14-9

**Segregation Of Queen Conch, Strombus Gigas, Populations From Mexico**

**Claire PARIS*[1]**, Dalila ALDANA ARANDA[2]

[1]Rosenstiel School of Marine and Atmospheric, Marine Biology and Fisheries, University of Miami, Miami, FL, [2]Recursos del Mar, CINVESTAV IPN Unidad Merida, Merida, Mexico

Despite active conservation measures, slow recovery of Queen conch (Strombus gigas) is a growing concern in the Caribbean. Although conventional expectations presume that S. gigas populations are largely connected, we present results of veliger larval drift and survival from the Yucatan peninsula in Mexico that suggest otherwise. Spatial patterns of observed and simulated larval stages during the reproductive season revealed isolation of the Alacranes Reef population on Campeche Bank (North Yucatan) from the Mexican Caribbean coast populations (East Yucatan). High levels of larval retention on Campeche Bank contrasted to the highly variable larval transport and survival along the Mexican Caribbean coast into the Yucatan Current, and eventually into the Loop Current, drive the degree of segregation. In addition, these populations do not mix downstream. In effect, the probability that S. gigas larvae originating from Alacranes Reef settle in Florida is insignificant, while a small fraction of larvae produced north of the Mexican Caribbean coast periodically reaches the Lower Florida Keys. Although this long-distance dispersal may not be sufficient to replenish the downstream populations, gene flow could prevent differentiation of the Florida Keys and Mexican Caribbean Queen conch populations. This study constitutes and essential step in understanding the structure of S. gigas populations and the needed actions for the recovery of individual populations in Mexico. Detailed larval dynamics (e.g. behavior, growth, mortality, settlement) and mapping of populations' networks at the regional and wider Caribbean scales will be an extension of this work.

## 14-10

**Does Vertical Migration Behavior Of Reef Fish Larvae Influence Their Transport?**

**Klaus HUEBERT*[1]**, Su SPONAUGLE[1], Robert COWEN[1]

[1]Division of Marine Biology and Fisheries, University of Miami / RSMAS, Miami, FL

The degree to which the population connectivity of coral reef organisms is influenced by the behavior of their dispersive larvae is controversial. One type of behavior that potentially affects larval transport is vertical migration between depths with different ambient currents. Our objective was to describe vertical migrations of pelagic coral reef fish larvae in the Straits of Florida, and estimate their influence on larval transport. Repeated time series of plankton net tows were conducted offshore of Miami using a Multiple Opening Closing Net and Environmental Sensing System (MOCNESS). The upper 100 m of the water column was sampled at 3 h intervals for a duration of 48 h, with different nets fishing at 0-25 m, 25-50 m, 50-75 m and 75-100 m. Simultaneously, a suite of environmental variables was recorded by the MOCNESS as well as a shipboard Acoustic Doppler Current Profiler (ADCP). Across several families of reef fishes, large larvae were distributed significantly deeper than small larvae, revealing downward vertical migration with ontogeny. Taking ambient light levels and visual net-avoidance behavior into account, vertical distributions of some families also varied significantly between day and night, revealing diel vertical migrations. The predominant long-shore component of the Florida Current was consistently greatest at the surface and decreased with depth, while the cross-shore current was an order of magnitude weaker and highly variable. The distribution of currents together with the observed patterns of vertical migration of larvae results in an overall reduction of larval horizontal advection speeds, with important consequences for population connectivity.

## 14-11

**Homing in Coral Reef Cardinalfish Contributes to Low Population Connectivity Among Reefs**

**Naomi GARDINER*[1]**, Geoff JONES[1]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

Recent studies have indicated greater levels of self-recruitment within coral reef fish populations, and less connectivity among populations than once appreciated. However, the ability of individuals to return to home reefs, and the spatial scales over which homing can occur are poorly understood. While cardinalfish are known to return home when displaced within lagoon environments, whether or not they can return home across open water, when displaced from one reef to another is unknown. This study employed displacement experiments to investigate the homing-ability of 5 common Indo-Pacific cardinalfish species (*Apogon fragilis*, *A. leptacanthus*, *Archamia zosterophora*, *Ostorhinchus artus* and *O. quinquelineatus*) in Kimbe Bay (PNG). Individuals were displaced ca. 500m from 'home' positions onto either the same reef or onto a neighboring reef (separated from the home site by open-water). Despite their small size (SL ca. 5-8cm) and limited swimming capabilities, all species were capable of returning to home coral heads, across open-water, within a single night. Homing capabilities from up to 5km away were also demonstrated. We argue that homing in these nocturnal foraging species contributes to the lack of connectivity among coral reefs.

## 14-12

**The Biology Of Acropora Palmata Larvae: Implications For Dispersal And Population Connectivity**

**Ainhoa LEON ZUBILLAGA*[1]**, Alina M. SZMANT[2,3]

[1]Biologia de Organismos, Universidad Simon Bolivar, Caracas, Venezuela, [2]Center for Marine Science, University of North Carolina Wilmington, Wilmington, NC, [3]Center for Marine Science, University of North Carolina Wilmington, Wilmington

The exchange of genetic material within and across coral populations will depend not just on physical factors (e.g. hydrography) but also on larval characteristics such as buoyancy, duration of development to competency and competency, swimming abilities, and other larval behaviors. A range of experimental procedures were used to determine these variables for the threatened species Acropora palmata. Eggs are buoyant upon release and rise to the ocean surface; embryos lost buoyancy over time as they developed into planulae ($F = 46.4$, $df = 9$; $p = 0.000$) presumably as they metabolized lipid stores. Embryos reached a swimming planula stage at ca. 60 h after fertilization, and gradually gained the ability to swim downwards; however, maximum swimming capabilities were not observed until 192 h after fertilization. There was no evidence of diel swimming patterns as was previously found for Montastraea faveolata. Larvae did not reach competency until they were at least 6 to 8 days old. These larval characteristics could lead to fairly extensive dispersal depending on local current conditions during the first week after spawning. There was a significant dependence ($x2 = 29.7$, $p<0.05$) between the number of A. palmata larvae that settled with the presence or absence of settlement substrate (field conditioned tiles). A. palmata larvae preferentially settled on tile sides ($12.1 \pm 6.5\%$) followed by tops ($5.3 \pm 4.2\%$) and bottoms ($1.2 \pm 1.5\%$) and these differences were statistically significant (KW: 67.9, $p<0.05$). Differences in community composition of growth on tiles surfaces were also significant ($x2 = 1801.7$, $p<0.05$). Bray-Curtis indexes indicated 56% dissimilarity between tops and bottoms, 43.5 % between sides and tops, and 47.8 between sides and bottoms. These results support previous studies that highlight the importance of substrate characteristics to larval settlement.

## 14-13

**Sensory Mechanisms Limiting Connectivity At Different Scales**

**Jelle ATEMA*[1]**, Gabriele GERLACH[2], Vanessa MILLER-SIMS[3], Michael KINGSFORD[4]

[1]Biology, Boston University, Boston, MA, [2]University of Oldenburg, Oldenburg, Germany, [3]University of Southern California, Los Angeles, CA, [4]James Cook University, Townsville, Australia

Evidence from different coral reef fish species shows that settling larvae prefer the odor of the reef where they were captured. Indirect evidence shows that this is most likely also their natal reef, where odor imprinting occurred at hatching as demonstrated in *Amphiprion* sp. imprinting on anemones. When settling, different species appear to use this odor information differently resulting in different connectivity scales.

The cardinal fish *O. doederleini* shows limited larval dispersal and strong homing. Genetic data show that it does not often survive to maturity in non-natal reefs even as close as a few km away. Behavioral experiments show that settlers from foreign reefs face severe conspecific competition, reflecting perhaps a limitation on settlement sites. Such post settlement competition would exert strong selection pressure for homing. In habituation tests they show persistent home odor preference. Other cardinal fishes behave similarly in odor choice tests. In contrast, the damsel fish *P. coelestis* can settle "abroad" and genetics shows it does so at a spatial scale of 20-100 km. This relaxes selection pressure for homing and facilitates the wider dispersal. Settlers still show evidence for imprinting on reef odor but their odor preference is less persistent. They may use their knowledge of home odor to later recognize *any* reef. This species settles on outer reef slopes where competition for settlement sites may be less severe. Finally, the damsel fish *A. polyacanthus* guards its larvae, which do not have a pelagic dispersal phase and do not show home odor preference in choice tests. Their behavior appears to allow for juvenile integration into adult habitat with very limited local dispersal.

In ocean environments it is important to understand the local hydrography and the spatial-temporal scale of mixing water masses, identifiable by the odor of their origin.

## 14-14

**Environmentally-Mediated Variation in Larval Traits And Linkages To Juvenile Survival in Two Reef Fishes**

**Su SPONAUGLE*[1]**, Tauna RANKIN[1], Kirsten GRORUD-COLVERT[2]

[1]Marine Biology & Fisheries, RSMAS/University of Miami, Miami, FL, [2]PISCO/COMPASS, Oregon State University, Corvallis, OR

Population connectivity of benthic marine organisms depends on larval transit through the ocean as well as successful settlement and survival of young recruits. Thus environmental and oceanographic processes have the potential to play a significant role in population connectivity through their influence on early life history traits such as larval and juvenile growth, pelagic larval duration (PLD), and size and condition at settlement. We examined these otolith-based traits in multiple monthly cohorts of two common coral reef fishes, the bluehead wrasse *Thalassoma bifasciatum* and bicolor damselfish *Stegastes partitus,* in the Florida Keys to evaluate the role of water temperature and larval traits on early juvenile survival. Seasonal variation in water temperature explained a significant proportion of the variation in early life history traits among cohorts of both species, with potential consequences for the amount of time larvae have to disperse to suitable settlement habitats. Within cohorts, comparison of the distribution of early life history traits among late-stage larvae, and new and older recruits demonstrated that recruit survivorship is non-random and influenced by PLD, larval size and condition at settlement, and early juvenile growth. Contrasting patterns between species in the distribution of traits of young survivors suggest that the two species experience conflicting constraints as recruits.

## 14-15

**Simulated Regional-Scale Genetic Structure of Caribbean and Southeast Asian Coral Reef Communities**

**Johnathan KOOL*[1]**, Claire PARIS[2], Robert COWEN[1]

[1]Marine Biology and Fisheries, RSMAS - University of Miami, Miami, FL, [2]Applied Marine Physics, RSMAS - University of Miami, Miami, FL

Recent advances in the development of coupled bio-oceanographic larval dispersal models have opened up new opportunities for evaluating large-scale population genetic structure in marine environments. Using this approach, it is possible to create transition matrices describing migration between different patch environments. Expected genetic structure (neutral or incorporating selection) may then be evaluated through projection using either classic matrix analysis or individual-based models. In this study, transition matrices based on larval dispersal patterns were generated and projected for two areas of interest: the Caribbean and the Coral Triangle Region of Southeast Asia (Philippines, Indonesia, Papua New Guinea). Preliminary results for the Caribbean indicate a strong east-west break (Gulf of Venezuela to Puerto Rico), which is consistent with previous field-based studies. Weaker clusters in other areas are also anticipated, as well as a cline through the Bahamas. Results for the Coral Triangle region are more complex due to current reversals, however the results suggest that if contemporary migration patterns are primarily responsible for creating genetic structure, then clusters in the Banda Sea region, in the vicinity of the Makassar Strait and the Celebes Sea, and along the eastern portion of Sulawesi should be evident. Although the results are specific to the set of life-history characteristics adopted in the simulations, they do appear to be robust, and provide a means of bridging the gap between observed marine population genetic patterns and bio-oceanographic processes.

## 14-16

**Modeling The Influence Of Genotypic Diversity On Coral Meta-Population Structure**

**Claire PARIS*[1]**, Iliana BAUMS[2]

[1]Applied Marine Physics, Rosenstiel School of Marine and Atmospheric Science, miami, FL, [2]Department of Biology, The Pennsylvania State University, University Park, PA

In sessile benthic invertebrates such as reef-building corals, fertilization is density dependent. Determining factors include the abundance, spatial distribution, and genetic makeup of those partners. Hence, the total number of larvae produced differs widely among populations in space and time. For instance, some hermaphroditic broadcast spawning corals reproduce mainly by asexual means (e.g. fragmentation) that can result in large monoclonal stands yet these species are self-incompatible. Such populations are unlikely to produce sexual offspring due to the lack of non-self mates. In turn, the genotypic (clonal) makeup of individual populations may influence the larger-scale meta-population structure. To test this hypothesis, we use estimates of clonal structure in several Acropora palmata populations in the Caribbean to scale the total larval output and simulate dispersal. Mortality rates and development times measured in the laboratory serve to parameterize the biophysical model. Sensitivity analyses of life history traits and scaled production on population connectivity networks are used to quantify the relative influence of the genetic makeup on the survivors in the meta-population.

## 14-17

**Reef Fishes As "Living Tracers Of Connectivity"**

**Patrick COLIN*[1]**

[1]Coral Reef Research Foundation, Koror, Palau

Comparisons of the distribution patterns of small reef fishes with limited larval dispersal to ocean current patterns, determined by satellite-tracked current drifters, provide an alternative method to biophysical modeling and genetic-based studies for assessing both connections and barriers within the tropical western North Atlantic (TWNA). The neon gobies (*Elacatinus*), the most speciose fish genus in the region, and other fish genera often have limited geographic distributions displaying similar distribution patterns among species. These patterns are the result of a natural connectivity experiment running since at least the last glacial low water and as such integrate the biological and physical aspects of connectivity over time. Oceanographic isolating mechanisms consistent with fish range limits have been identified and these modest zoogeographic barriers, combined with limits on fish larval dispersal, are responsible for the observed patterns of distribution. Consequently these fishes are indicators of connectivity and their zoogeography implies the TWNA is divisible into a series of enclave-like regions with limited genetic and ecological exchange among them. Even for reef fish species with longer maximum larval lives, the vast majority of larvae would recruit within their home enclaves and, as such, proposed enclaves provide an indication of ecological connectivity among nearly all reef fishes relevant to fisheries management and marine protected area design.

## 14-18

**Meso-Scale Hydrodynamic Features And The Structure Of Great Barrier Reef Fish Communities**

**Michael EMSLIE*[1]**, Alistair CHEAL[1], Angus THOMPSON[1], Hugh SWEATMAN[1], Severine CHOUKROUN[1], Julian CALEY[1]

[1]Long Term Monitoring, Australian Institute of Marine Science, Townsville, Australia

Coral reef communities are among the most diverse and threatened ecosystems on Earth leading to strident calls for urgent conservation measures, particularly the establishment of extensive networks of Marine Protected Areas. As well as protecting a range of species and habitats the reserves in a network should be linked by larval dispersal. The scale of connectivity in reef environments is uncertain. Recent findings suggest that self-recruitment is much more common than originally thought, but the balance between self-recruitment and long distance dispersal is unknown. Here we use long-term monitoring data from a significant section of Australia's Great Barrier Reef that integrates the effects of ecological processes on communities comprising more than 200 species of fishes over more than a decade. This revealed previously undescribed, strong meso-scale structure of GBR reef fish communities that were associated with major hydrodynamic features. We postulate that these oceanographic features provide temporally stable barriers to ecologically significant fish dispersal among seven major community types within 1200 kilometres of reef matrix. We also propose that self-recruitment can apply not only to local scales but also has a regional context defined by oceanographic features.

## 14-19

**Distribution, Abundance, And Genetics Of Corals Throughout The N. Gulf Of Mexico: The World's Largest Coral Settlement Experiment**

**Paul W. SAMMARCO*[1]**, Amy D. ATCHISON[1], Daniel A. BRAZEAU[2], Gregory S. BOLAND[3], Steven B. HARTLEY[4], Angela LIRETTE[1]

[1]Louisiana Universities Marine Consortium (LUMCON), Chauvin, LA, [2]Pharmaceutical Genetics Laboratory, University of Buffalo, Buffalo, NY, [3]Minerals Management Service, US Department of the Interior, New Orleans, LA, [4]National Wetlands Research Center, US Geological Survey, Lafayette, LA

Thousands of oil/gas platforms in the N. Gulf of Mexico (GOM) provide hard substratum where none existed prior to the Pleistocene. This has facilitated biogeographic extension of Caribbean reef fauna in the GOM. We quantified the distribution and abundance of scleractinian corals, hermatypic and ahermatypic, by surveying a total of 48 platforms around the Flower Garden Banks (FGB) and along four transects across the continental shelf: (T-I) Corpus Christi, TX, USA; (T-II) Lake Sabine, TX; (T-III) Terrebonne Bay, LA; and (T-IV) Mobile, AL. We also assessed genetic affinities between coral populations on the platforms and on the FGB to $\leq$ 37 m using AFLPs. The western limit for hermatypes was near the shelf edge in T-IV. The highest densities of hermatypes were at the shelf edge, ~175-225 km offshore, in T-II&III. Some hermatypes were found in T-IV - their eastern limit. Ahermatypes (*Tubastraea coccinea, Oculina diffusa*, *Phyllangia americana)* were absent inshore and in the north-central region. A GIS analysis of coral data, salinity, temperature, dis-O2, phosphate, and nitrate concentrations indicated that lower salinities and temperatures are the major factors forcing community structure. Hermatypic species diversity peaked near the FGB. Genetic analyses performed on *Madracis decactis* revealed high self-recognition and site fidelity in *M. decactis* in T-III&IV, with little recognition across the mouth of the Mississippi River. In *Tubastraea coccinea* (invasive species), cross-recognition was higher between platforms within a transect, but absent across the river mouth. The Mississippi River is an effective biogeographic barrier to dispersal. These brooders are highly effective at colonizing patchy habitats at this scale – moreso than the broadcasters *Diploria strigosa* and *Montastraea cavernosa* - rare or absent over most of the Gulf, indicating less effective dispersal capabilities.

## 14-20

**Genetic Connectivity Of Two Scleractinian Corals In Indonesia On Multiple Spatial Scales**

**Craig STARGER*[1,2]**, Paul BARBER[3], Mark ERDMANN[4], Andrew BAKER[5]

[1]Boston University Marine Program, Boston, MA, [2]Sackler Institute for Comparative Genomics, American Museum of Natural History, New York, [3]Department of Biology, Boston University, Boston University Marine Program, Boston, MA, [4]Indonesia Marine Program, Conservation International, Denpasar, Bali, Indonesia, [5]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

The Indonesian seas are home to some of the most biologically diverse marine ecosystems on Earth. They are also among the most threatened marine regions in the world. Studies focusing on genetic connectivity can shed light on the natural history of threatened populations while providing data that are useful to conservation managers. We have chosen the stony corals Pocillopora damicornis and Seriatopora hystrix to test hypotheses on barriers to larval dispersal. Microsatellite markers indicated that although coral populations are significantly differentiated across Indonesia, the level of genetic structure is much lower than that seen in other taxa. Gene flow and immigration estimates indicate that most populations are primarily self-seeding, however long distance dispersal is also occurring, maintaining connectivity across the entire Indonesian archipelago. A closer examination of connectivity on a regional scale was performed in the Bird's Head Seascape of West Papua, where conservation managers are currently incorporating genetic data into the design of marine protected area networks. Similar to the country-wise assessment, there do not appear to any major barriers to dispersal within the Bird's Head region. However, populations of both coral species are still primarily self-seeding, and the majority of genetic diversity is explained by within-population variation. A Bayesian assignment test and jackknifing approach were applied to examine the effect of population decline on overall connectivity in West Papua. Self-recruitment nearly always increased when populations were removed from the estimation of overall connectivity. This high sensitivity of the entire system to the decline of any individual population suggests that a network of marine protected areas covering a large geographic range is the best conservation strategy for maintaining connectivity in the Bird's Head Seascape. In general, coral populations exhibit much lower genetic structure on a regional scale than other taxa.

## 14-21

**Routine And Rare Genetic Connections in Corals Off Northwest Australia**

**Jim UNDERWOOD*[1]**, Luke SMITH[1], Madeleine VAN OPPEN[2], James GILMOUR[1]

[1]Australian Institute of Marine Science, Perth, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

The extent to which marine populations are connected by larval dispersal has profound influences on the ecology and evolution of species; from the short-term regulation and survival of communities to the long-term processes of adaptation to environmental change and speciation. Here, we use microsatellite DNA markers to quantify the genetic structure and infer the ecologically and evolutionarily relevant scales of dispersal of broadcast spawning coral (*Acropora tenuis)* and a brooding coral (*Seriatopora hystrix)* from isolated reefs off northwest Australia. For the brooder, whose larvae are competent to settle immediately after release, significant genetic subdivision over scales of tens of metres indicated that the majority of larvae recruit to within 100 m of their natal colony. However, occasional dispersal over tens of kilometres supplemented this localised recruitment, with putative source and sink dynamics associated with levels of disturbance and recovery from a recent and catastrophic coral bleaching. Additionally, prodigious genetic differences were detected among reef systems, indicating that dispersal over multiple generations of *S. hystrix* larvae over 100s of kilometres is rare. In contrast to the brooder, the broadcast spawned larvae of *A. tenuis* require about three days before competency is obtained, and as expected, levels of subdivision were an order of magnitude smaller compared with *S. hystrix*. However, significant differences were detected between sites separated by less than ten kilometres, providing evidence that these systems, reefs and some reef patches are predominantly self-seeding. However, genetic divergence between the coastal and offshore zones was greater than expected by the geographic separation of systems, indicating that connectivity between these zones via transport of *A. tenuis* larvae on oceanic currents occurs rarely. The primary management implication is that short-term recovery after severe disturbance requires the input of larvae from viable coral communities within kilometres to a few tens of kilometres away.

## 14-21

**Same, Same, But Different: Comparing Population Genetic Structures Of Two Species Of Coral (*Pocillopora Damicornis* & *Platygyra Daedalea*) In The Western Indian Ocean**

**Petra SOUTER*[1]**

[1]Australian Institute of Marine Science, Towsville MD, Australia

Improved management of coral reefs is vital, and information regarding levels of genetic diversity and scales of connectivity are factors that need to be considered when developing efficient management plans. This study was implemented in a geographic area where such knowledge is yet scarce but increasingly important.

Samples of *Pocillopora damicornis* were collected from 29 sites along the coast of East Africa; from Malindi in Kenya, to Mtwara in Tanzania, spanning a distance of over 800 km. Over 60% of all pair-wise comparisons showed a significant genetic differentiation, indicating predominant localised recruitment. The species exhibited mixed modes of reproduction, with 4 populations being dominated by asexual clones and another 3 populations showing signs of mixed sexual and asexual reproduction. All clonal genotypes were found to be homozygotes for a specific, and otherwise rare allele at one of the studied microsatellite loci. This finding indicates that asexual reproduction is genetically, rather than environmentally determined and that its prevalence is determined by the successful recruitment of clonal genotypes and their potential selective advantage within a given population.

*Platygyra daedalea* was sampled from 10 sites, mostly in Kenya. Genetic diversity was found to be low for this species, especially in near shore lagoonal waters. Populations sampled on reef-slopes and on the islands of Zanzibar and Mafia in Tanzania, were found to be significantly more genetically diverse, albeit not as diverse as populations studied on the GBR. The results indicate limited migration from the more diverse reef-slope populations into the lagoons, whereas the lagoonal populations were found to be largely panmictic.

Interestingly, both species show a clear divergence between populations north and south of Mtwapa creek, indicating a dispersal barrier at this location resulting in significantly different and isolated coral populations in Northern Kenya.

## 14-22

**Rapid Long-Distance Dispersal Of Pelagic Reef-Fish Larvae: Implications For Connectivity Models**

**Benjamin VICTOR*[1]**

[1]Ocean Science Foundation, Irvine, CA

There is a dearth of direct information on long-range connectivity among reef fish populations. This is mostly because little is known about the potential for distant dispersal of pelagic reef fish larvae on the scale of hundreds to thousands of kilometers. I collected a large sample of larvae in the open ocean along the equator about 1,000 km from the coast of Ecuador. The larvae were identified using mtDNA barcoding and the sequences revealed that the sample included a significant complement of the regional shore and reef-fish community, including pomacentrids, labrids, gobiids, blenniids, serranids, chaetodontids and holocentrids. In addition, freshwater eleotrid larvae were present that occur only on mainland South America. Barcoding sequences identified a microdesmid species endemic to Colombia as well as the Baja California razorfish *Xyrichtys mundiceps* (Baja California is more than 2,000 km from the collection site). Daily otolith increments from the reef fish larvae revealed that the ages of the youngest larvae converged on about 3 weeks. Given the origin of the larvae was at least as far as Colombia and likely from the Panama Bight, a surprisingly-high estimate of the rate of dispersal is obtained, about 70 km per day. This estimate is well higher than the usual South Equatorial Current velocity of 30 cm/s and indicates that the capacity of shorefish larvae to disperse far offshore in significant numbers may well be underestimated in connectivity models.

## 14-23

**Contrasting Patterns of Population Structure and Dispersal for the Giant Barrel Sponge (*Xestospongia muta*) within the Florida Reef Tract and Caribbean**

**Vince RICHARDS*[1]**, Kevin FELDHEIM[2], Mahmood SHIVJI[1]

[1]The National Coral Reef Institute, Oceanographic Center, Nova SE University, Florida 33004 USA, Dania Beach, FL, [2]Field Museum, Chicago, Illinois 60605 USA, Chicago, IL

Sponges are one of the dominant fauna on Florida and Caribbean reefs, with species diversity often exceeding that of scleractinian corals. Despite their importance as structural components and habitat providers on reefs, their dispersal dynamics are little understood. We utilized eight microsatellite markers to study the population structure and migration patterns of the giant barrel sponge (*Xestospongia muta*), a widespread species throughout Florida and the Caribbean. Bayesian multilocus genotype analyses clustered 157 samples from the Bahamas, Honduras, and the US Virgin Islands into three distinct groups. 159 samples from nine locations within 284 km of the Florida reef tract (Key Largo to the Dry Tortugas) formed a fourth group. Population structure among the four groups was high (FST = 0.155; P = 0.001), with no recent migration among the groups. In contrast, high levels of migration were detected within the Florida reef tract. Reefs in the Upper Keys (Long Key) appear to be sources of larvae to reefs in the north (Key Largo) and also to reefs in the south (Key West and the Dry Tortugas). This pattern of migration closely matches current pathways within the South Florida recirculation system, suggesting that currents play an important role in dispersing *X. muta* larvae within the Florida reef tract. Although there was an overall lack of isolation by distance among the four groups, a significant correlation between genetic and geographic distance was found among the Florida sampling sites indicating that mating within the reef tract is not random. Asexual reproduction appears not to be the cause as only 1.3% of individuals in Florida shared the same genotype (1.6% overall). Rather, limited larval dispersal along the reef tract and among Caribbean locations has probably led to inbreeding within reefs, explaining the significant deficit in heterozygosity detected ($F_{IS}$ = 0.219; P = 0.001).

## 14-24

**Genetic Population Structure Of Coral Reef Fauna In The Indo-Malay Archipelago: Implications For Connectivity And Conservation**

**Marc KOCHZIUS*[1]**, Janne TIMM[2], Agus NURYANTO[2,3], Wiebke KRÄMER[4], Leyla KNITTWEIS[5], Lemia HAMID[2], Janet HAUSCHILD[2], Stina KIRCHHOFF[2], Inga MEYER-WACHSMUTH[2], Christian SEIDEL[2], Patrick MESTER[2]

[1]Biotechnology and Molecular Genetics, University of Bremen, 28357 Bremen, Germany, [2]Biotechnology and Molecular Genetics, University of Bremen, 28359 Bremen, Germany, [3]Faculty of Biology, Jenderal Soedirman University, Purwokerto 53122, Indonesia, [4]Marine Botany, University of Bremen, 28359 Bremen, Germany, [5]Centre for Tropical Marine Ecology, Bremen, Germany

Even though the Indo-Malay Archipelago hosts the world's greatest diversity of marine shallow water species, studies on the genetic population structure and gene flow of marine organisms within this area are rather rare. Consequently, not much is know about connectivity of marine populations in the Indo-Malay Archipelago, despite the fact that such information is important to understand evolutionary and ecological processes in the centre of marine biodiversity. Therefore, the genetic population structure of several groups of coral reef organisms, such as fish, bivalves, gastropods, echinoderms, and corals was studied in the framework of the German-Indonesian research programme SPICE (Science for the Protection of Indonesian Coastal Marine Ecosystems). Most of the studied species show a complex genetic population structure characterised by restricted gene flow between some sites and panmixing between others, which can be attributed to the geological history and prevailing current regimes in the Indo-Malay Archipelago. The major observed genetic differentiation between the Indian Ocean and Western Pacific is most probably due to historical isolation by sea level changes, whereas current oceanographic conditions facilitate connectivity along the ITF on the one hand and separation at sometimes very small scales on the other hand. Prevailing current regimes at the western coast of Sumatra as well as the Halmahera eddy off north-western New Guinea prevent connectivity of populations in the Eastern Indian Ocean and Western Pacific to the central Indo-Malay Archipelago, maintaining the historical separation caused by sea level fluctuations. These factors cause vicariance between populations, which can lead to allopatric speciation, suggesting that the Indo-Malay Archipelago is a centre-of-evolutionary-radiation. These large scale genetic breaks as well as small scale genetic differentiations should be considered in conservation efforts and the spatial arrangement of marine protected areas.

## 14-25

**Population Structure And Connectivity Of The Neon Damselfish (Pomacentrus Coelestis) in The West Pacific Ocean**

**ShangYin LIU*[1]**, ChangFeng DAI[1]

[1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan

The degree to which local populations are demographically connected by dispersal is important for the design of marine reserves and resource management. We studied the genetic connectivity of *Pomacentrus coelestis* populations in the West Pacific using partial mitochondrial control region and microsatellite loci. Based on the molecular data of 142 specimens collected from 7 populations ranging from Okinawa to eastern Australia, high haplotype diversity and low nucleotide diversity were detected in all populations. This suggests that *P. coelestis* populations may have experienced rapid expansion after a bottleneck event. The results of neutrality tests, shallow coalescence of mtDNA genealogies, and the mismatch distribution of pairwise differences also indicated that populations of *P. coelestis* have possibly suffered severe declines in the past. The dating based on the coalescent approach suggested that population expansions possibly occurred approximately 27,000 years ago. The results of AMOVA and Φst pairwise comparisons showed that populations were divided into 3 groups, i.e., the north-west Taiwan (Penghu and northern Taiwan), the South China Sea (Hainan, southern Taiwan and Okinawa), and the Australian groups. On a smaller spatial scale, a genetic break was defined between the north-west Taiwan group and the southern Taiwan population. We then assigned recruits from the same locality and adjacent localities based on the genotypes revealed by 7 microsatellite loci. The results of assignments indicated that the recruits in southern Taiwan were mainly from the South China Sea (approximately 50%) and the recruits in Penghu and northern Taiwan were mixed among their natal grounds. This study highlights the influence of present current patterns and historical events on the connectivity of *P. coelestis* populations. Furthermore, this pattern of population connectivity provides implications for the conservation and management of reef fishes around Taiwan.

## 14-26

**Spatial And Temporal Instability in The Genetic Structure Of Adult And Juvenile Bicolor Damselfish (Stegastes Partitus) Within The Mesoamerican Barrier Reef System**

**J. Derek HOGAN*[1]**, Roger J. THIESSEN[1], Daniel D. HEATH[1]

[1]Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada

Population connectivity is an important but poorly understood factor relevant to the ecology, evolution and conservation of marine species. Directly estimating dispersal and connectivity among populations is logistically difficult, but much can be inferred by comparing the population genetic structure of the young, dispersive life stage with that of the more sedentary adults through time. Here we examine the population genetic structure of adult and recently settled juvenile bicolor damselfish, Stegastes partitus, sampled at seven sites along the Mesoamerican Barrier Reef System (MBRS) over a two year period. Using genotype data at 12 microsatellite loci, we tested for genetic population differentiation among life stages and sites. Our results show spatial heterogeneity in adult and juvenile population structure; however, no evidence for an isolation by distance model of divergence was found. We show that allele frequency distributions change through time and between age classes in an unpredictable manner. Since juvenile and adult samples exhibit similar levels of genetic divergence we propose that the temporal instability we observed is due to pre-settlement effects. Our results suggest that the relative contributions of upstream sources likely changes through time as a result of stochastic processes such as oceanographic flow and meteorological events. We attempt genetic assignment of recently settled juvenile fishes to directly estimate ecological dispersal in an attempt to verify that cohorts are arriving from variable source populations.

## 14-27

**Connectivity And Climate Change: Impacts On A Reef Building Coral in The Eastern Pacific**

**Nicholas POLATO*[1]**, Iliana BAUMS[1]

[1]Biology, Penn State University, University Park, PA

Connectivity is a primary factor determining community structure, species cohesion, and population persistence. Weather phenomena which alter wind and current patterns will significantly impact patterns of reef connectivity. Long-distance dispersal to the east from the coral rich central Pacific may be favored during El Nino Southern Oscillation (ENSO) events due to reversal of surface currents, providing larvae to areas denuded by recurring high Sea Surface Temperatures (SSTs) caused by ENSO, and supplementing coral populations in marginal habitats in the Eastern Pacific. In an effort to understand patterns of connectivity influencing the origin, evolution, and regeneration of coral populations in the eastern Pacific, microsatellite loci were generated for *Porites lobata*, a massive reef building species found throughout the Pacific Ocean. Sequences from a coral genomic DNA library and publicly available shotgun reads were used to develop microsatellite markers that amplify reliably in widely separate populations. Genotype data were generated for individuals collected from geographically distant populations throughout the eastern and central Pacific using multiplexed PCR reactions. Results of STRUCTURE and Fst analysis were consistent with expectations that populations on opposite sides of the Eastern Pacific Barrier are significantly differentiated. Ongoing work will apply the genotyping markers to additional populations. Nuclear sequence markers will be used in conjunction with microsatellite data to estimate the timing and extent of long distance dispersal events from central to eastern Pacific populations, and patterns of connectivity will be combined with oceanographic current models to identify primary corridors for genetic connectivity. Whether recruits to eastern Pacific populations are produced locally or regionally will affect the rate of colonization following disturbance and the ability of populations to adapt to local conditions, with important implications for the design of reserves intended to protect these habitats.

## 14-28

**Small Scale Genetic Connectivity Of Bicolor Damselfish (*stegastes Partitus*) in Marine Protected Areas Of The Mexican Caribbean**

**Carmen A. VILLEGAS SÁNCHEZ*[1]**, Jesús E. ARIAS GONZÁLEZ[2], Renata RIVERA MADRID[3]

[1]Departamento de Recursos del Mar, Centro de Investigación y Estudios Avanzados-Unidad Mérida, Yucatán, Mexico, [2]Departamento de Recursos del Mar, Centro de Investigación y Estudios Avanzados-Unidad Mérida, Mérida, Mexico, [3]Departamento de Bioquímica y Biología Molecular de Plantas, Centro de Investigación Científica de Yucatán, A.C., Mérida, Mexico

Connectivity has been defined as the demographic connection maintained between neighboring populations of a species due to the migration of individuals between them. An analysis was done of variation in nine microsatellite loci to assess genetic structure in 13 bicolor damselfish (*Stegastes partitus*) populations (N = 718) from three marine protected areas and one unprotected area in the Mexican Caribbean, and infer its conservation implications. A combination of Nei distances (D) and FST showed significant genetic differentiation between populations, and this pattern was clearly not associated with geographic distance. Significant departure from Hardy-Weinberg Equilibrium was observed in the majority of the loci: i.e. 96 of the 117 tests, suggesting inbreeding is occurring. Small-scale population structure is probably being influenced by independent population dynamics, low dispersion levels, biological characteristics specific to this species and reefscape characteristics. Correspondence Factorial Analysis (CFA) indicated differentiation between groups. The two sites with the highest genetic distance values (range: 0.006-0.414 ) in the pairwise test were those with the most complex reefscapes. Our results suggest that local damselfish populations differ at a relatively small scale, and therefore coral reef management for this species, and other species with similar biological characteristics, requires local conservation strategies.

## 14-29

**Complex Patterns of Genetic Connectivity in a Brooding Coral on the Great Barrier Reef, Australia**

**Madeleine VAN OPPEN*[1]**, Adrian LUTZ[1], Glenn DE'ATH[2]

[1]Australian Institute of Marine Science, Townsville, MC, Australia, [2]Australian Institute of Marine Science, Townsvile, MC, Australia

An understanding of the extent of larval transport in and out of reefs, as well as the direction of larval dispersal will improve our ability to forecast whether and how fast reef organisms are likely to recover from disturbance events that cause massive mortality. Assessment of connectivity on the Great Barrier Reef (GBR) is complex, as the GBR is extremely large (~350,000 km2, of which ~21,000 km2 consists of coral reef) and comprises ~2,900 separate reefs. We assessed genetic connectivity among and diversity within GBR populations of the brooding coral, *Seriatopora hystrix*. Approximately 1,800 specimens were collected across ~8.5 degrees of latitude and genotyped at ten microsatellite loci. Although extensive mixing was obvious in some areas, for example along the outer-shelf Ribbon reefs in the northern section of the GBR, high levels of genetic subdivision were generally observed among populations. Nearby populations from the same reef were in some cases as genetically distinct as populations hundreds of kilometres away. A strong signature of recent admixture (i.e., linkage disequilibrium, heterozygote deficits and high allelic diversity) was present in a subset of the populations, and where both lagoonal and exposed sites were sampled on the same reef, the latter were much more admixed. A hydrodynamic model is available for the northern section of the GBR and a comparison of hydrodynamic and genetic data will be presented.

## 14-30

**Population Genetics, Larval Dispersal, and Demographic Connectivity in Marine Systems**

**Kimberley WEERSING*[1]**, Robert TOONEN[2]

[1]Oceanography, University of Hawaii at Manoa, Honolulu, HI, [2]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kane`ohe, HI

We survey 300 published studies to synthesize life-history and population genetic structure data from a broad array of benthic marine taxa (including ten coral species and 62 reef-associated species) to determine how well pelagic larval duration (PLD) correlates with population genetic estimates of dispersal. Expanding on earlier studies, we also explore other potential biophysical correlates of population substructure (genetic marker class, habitat type, and larval swimming ability) that have not been considered in previous meta-analyses. In contrast to previous studies concluding that planktonic periods correlate well with inferred dispersal ability, we find that average PLD was poorly correlated with population connectivity ($F_{ST}$). Furthermore, even this weak correlation appears to be anchored by the zero PLD class, because removal of species that lack a pelagic phase from the analysis resulted in a non-significant relationship between $F_{ST}$ and mean PLD. A 3-way ANCOVA instead reveals that genetic marker class (mtDNA, allozymes, and microsatellites) is responsible for most of the variation in $F_{ST}$ ($F = 7.113$, $df = 2$, $p = 0.001$), while neither habitat nor swimming ability were significant factors. In contrast to the general expectation that microsatellite-based studies provide the finest resolution of population structure, we find that significantly higher values of $F_{ST}$ are obtained with mtDNA than with either microsatellites or allozymes (which were not significantly different). Useful predictors of the pattern and scale of dispersal play a central role in both ecological and evolutionary studies, but as yet remain elusive; this study suggests that mean PLD is at best a weak predictor of population genetic structure and that estimates of larval dispersal will need to encompass both behavioral and physical transport processes.

## 14-31

**Local And Regional Self-Recruitment in The Bicolor Damselfish (Stegastes Partitus) On Turneffe Atoll in The Mesoamerican Barrier Reef**

**Eva SALAS*[1]**, Helena MOLINA[1], Dan HEATH[2]

[1]Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica, San Jose, Costa Rica, [2]Great Lakes Institute for Environmental Research (GLIER), University of Windsor, Windsor, ON, Canada

The scale of larval retention is of critical importance to define units of conservation for reef fishes. By using genotype assignment techniques, we estimated the proportion of self recruitment of Stegastes partitus, a Caribbean damselfish with a long (30-day) pelagic larval phase. Adults and recently settled juveniles were collected from reefs located on Turneffe atoll and the Belize barrier reef, and were genotyped at 12 microsatellite loci. We found that self-recruitment rates are relatively low at a local, <1 km scale (18 to 23%), on two reefs located at the East and West of Turneffe atoll; however, approximately three-quarters of the larvae (76%) are retained at a 50 km, regional scale (across the atoll). The level of local self-recruitment did not differ significantly between the eastern and western sites, despite an expectation for differences in oceanographic retention regimes. The high levels of retention at the regional (atoll) scale likely reflect dispersal kernel size of the order of the atoll length (50 km). Although retention at the regional scale is high, there is still a contribution of migrants (the other 24%) that disperse longer distances, and such a level of migration explains the low level of genetic structure. Our results contribute to the understanding of the evolutionary persistence of dispersal, since a combination of dispersal and retention (as described here) provides the opportunity for both some level of local adaptation and dispersal-based risk-spreading. A 50-km regional retention scale is a size larger than most present-day marine reserves in the Caribbean. If reserves are small and isolated, they are unlikely to provide conservation and fisheries benefits when self recruitment levels are locally low.

## 14-32

**Direct Estimates Of Self-Recruitment And Local Connectivity in A Coral Reef Metapopulation**

**Geoffrey JONES*[1]**, Serge PLANES[2], Pablo SAENZ AGUDELO[2], Simon THORROLD[3]

[1]School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]Laboratoire Ecosystemes Aquatiques Tropicaux et Mediterraneens, CNRS-EPHE-UPVD, Universite de Perpignan, Perpignan, France, [3]Biology Department MS#50, Woods Hole Oceanographic Institute, Woods Hole, MA

Direct estimates of larval retention and connectivity are essential to parameterize marine metapopulation models and to optimize the design of marine protected area networks. For coral reef fishes, while there are some estimates of self-recruitment at isolated populations, there are no direct estimates of exchange between adjacent sub-populations or between protected and unprotected areas. Here we use a likelihood-based parentage analysis to assess the relative magnitude of self-recruitment and exchange among five sub-populations of the panda clownfish *Amphiprion polymnus* in Bootless Bay, Papua New Guinea. These small sub-populations varied in size between 28 and 84 individuals. Each was confined to a discrete ~1ha patch of shallow sand that was separated from other subpopulations by 2 to 5km. All adults were fin-clipped and all juveniles that settled over a 7 month period were collected for genetic analyses. We used nine microsatellite loci and the FAMOZ software to assign settlers to putative parents, with unassigned juveniles considered to be immigrants from other unknown populations. The overall level of self-recruitment for the combined 5 sub-populations was ~25%. This figure was apportioned to an average of 10% self-recruitment within subpopulations and ~15% exchange among the sub-populations. The data suggest that both fine-scale self-recruitment and exchange among populations 2-5km apart contribute to the persistence of this clownfish metapopulation, along with substantial larger-scale dispersal. We hypothesize that *A. polymnus* is characterised by a multimodal distribution of larval dispersal distances that varies according to the spacing of sub-populations.

## 14-33

**Temporal Patterns in Genetic Structure Within And Among Cohorts Of Settlement-Stage Larvae And New Recruits Of A Coral Reef Fish**

**Tauna RANKIN*[1]**, Su SPONAUGLE[1], Dean WILLIAMS[2]

[1]Marine Biology and Fisheries, RSMAS/University of Miami, Miami, FL, [2]Biology, Texas Christian University, Fort Worth, TX

High fecundity coupled with extensive and often variable mortality of early life stages leads to highly variable recruitment dynamics of many marine organisms, including coral reef fishes. Sources of variation in recruitment strength can be the result of random (e.g. temperature, current trajectories) and selective (e.g. starvation, predation) processes. Identifying sources of variation in and mechanisms important to early survival may provide a means of predicting population structure and connectivity among populations. Most population genetic studies have concentrated on spatial patterns of genetic structure. The goal of this study was to identify temporal genetic variation within and among cohorts of settlement-stage larvae and newly recruited juveniles and to determine 1) whether allelic frequencies vary among monthly cohorts of settling larvae due to fluctuating larval transport or chance reproductive success of a small proportion of adults, and 2) whether temporal variation within monthly cohorts is indicative of selective or random loss of alleles (i.e. genetic drift). To investigate the presence and mechanism of temporal shifts in a population's genetic composition, six monthly cohorts of newly settled bicolor damselfish *Stegastes partitus* were sampled in the upper Florida Keys, USA over four years. Late-stage larvae were collected in light traps and newly recruited juveniles were collected a few days later on the reef. Exon-primed intron-crossing polymerase chain reaction amplifiable introns (EPIC-PCR) and a 400 base pair region of the mitochondrial control region I were compared within cohorts and among different months and years. When differences in allelic frequencies among monthly cohorts were detected, calculations of relatedness were used to test for a Hedgecock effect. We also determined whether allele frequencies within cohorts resulted from selective processes acting on certain loci or over all loci equally, suggesting random genetic drift.

## 14-34

**Genetic Connectivity Of The Shallow And Deep Reef: Intra-Reef Genetic Structure Of *seriatopora Hystrix* On The Northern Great Barrier Reef**

**Pim BONGAERTS*[1]**, Norbert ENGLEBERT[1,2], Tyrone RIDGWAY[1], Cynthia RIGINOS[3], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]IBED, University of Amsterdam, Amsterdam, Netherlands, [3]School of Integrative Biology, University of Queensland, Brisbane, Australia

Whilst many reef communities in the Great Barrier Reef Lagoon are limited to shallow waters, there are a large number of reefs that extend beyond 25m depth (especially along the Great Barrier Reef margin). These deeper reefs appear to be less prone to disturbance than their shallow counterparts as the effects of several major stressors on coral reefs (e.g. elevated sea surface temperatures and storm-induced waves) are largely confined to shallow depths. As such, the relatively undisturbed deep reef has the potential to function as a refugium and subsequently as a "re-seeding" reproductive source for the shallow, aiding in recovery after a disturbance. Coral species that transcend the distinct shallow and deep reef habitats (i.e. depth-generalist species) and thrive under a large range of environmental conditions have the highest potential to provide a viable recruitment resource for the shallow. However, due to the lack of appropriate markers, very little is known about local recruitment processes and the extent of recruitment occurring between shallow and deep reef habitats. In this study we explore the extent of gene flow in the brooding coral *Seriatopora hystrix* between the deep reef slope (27m), the reef crest (6m), and back reef (2-3m) on two outer-reefs of the northern Great Barrier Reef. Nine microsatellite loci, specifically developed for *Seriatopora hystrix* were amplified and their variation assessed. Preliminary results indicate that populations are largely self seeding, which challenges the idea that reef systems may be rapidly repopulated from external larval sources after a disturbance and rather highlights the importance of local recruitment processes for shallow coral reef recovery.

## 14-35

**Low Genetic Diversity And Gene Flow Suggests Vulnerable Atlantic Coral Outposts**

**Flavia NUNES*[1]**, Richard D. NORRIS[1], Nancy KNOWLTON[1]

[1]Scripps Institution of Oceanography, La Jolla, CA

Coral species diversity in the Atlantic Ocean is concentrated in the Caribbean Sea, but coral populations are also found along the coasts of Brazil and West Africa, and on mid-Atlantic islands. These coral "outposts" are typically rocky reefs harboring a low number of coral species, often rich in endemics. In order to study the levels of genetic diversity and gene flow among these low-diversity outposts and the Caribbean, 130 individuals of *Montastraea cavernosa* sampled from 6 Atlantic populations in the Caribbean (Panamá, Belize and Puerto Rico), North Atlantic (Bermuda), Western South Atlantic (Brazil) and Eastern Tropical Atlantic (São Tomé, West Africa) were genotyped at two nuclear and one mitochondrial loci. For the two nuclear loci, Caribbean and North Atlantic populations displayed high levels of genetic diversity and similar allele frequencies, whereas the Brazilian and West African populations each had markedly lower levels of genetic diversity and distinct allele frequencies relative to other populations. The mitochondrial locus had much lower diversity than the nuclear loci, with one fixed allele in the South Atlantic populations (Brazil and São Tomé), and one very common allele being nearly fixed in the Caribbean and North Atlantic populations. Surprisingly, no population differentiation was observed among Caribbean and North Atlantic populations of *M. cavernosa* over all loci, suggesting these populations are well-connected over evolutionary time scales. Populations from Brazil and West Africa, however, were significantly differentiated from all other populations over all loci, including each other, except for the mitochondrial locus, where they display the same genotype. Genetic diversity and connectivity may be important factors that contribute to the resilience of a coral population to disturbance. Low genetic diversity and low levels of gene flow in Brazil and West Africa suggest that isolated outposts may be more vulnerable to degradation and loss relative to Caribbean populations.

## 14-36

**Genetic Parental Analysis Reveals Both Local Retention And Large Scale Connectivity Of Clownfish in Kimbe Bay**

**Serge PLANES*[1]**, Geoffrey JONES[2], THORROLD SIMON[3]

[1]UMR 5244 - Laboratoire Écosystèmes Aquatiques Tropicaux et Méditerranéens, CNRS - EPHE - UPVD, Perpignan, France, [2]School of Marine and Tropical Biology, and ARC Centre of Excellence for Coral Reef Studies, James Cook University, TOWNSVILLE, Australia, [3]Biology Department MS # 50, Woods Hole Oceanographic Institution, Woods Hole, MA

Many marine species produce larvae that can be pelagic for weeks or months and the potential for long distance dispersal by prevailing currents is extremely high. Marine populations have, in turn, been assumed to be demographically "open", consisting of many sub-populations that are connected by larval dispersal. However recent work has consistently demonstrated high levels of self-recruitment in reef fish populations. Because of the technical difficulty of tracking larvae, direct measures of dispersal have not previously been obtained. We report on the potential of genetic parental analysis to estimate local self-recruitment and connectivity among distant areas by identifying the parent (and their location) of a new recruit settling at a certain location. We sampled (fin-clip) the entire adult population of clown fish (*Amphiprion percula*) from the reef around a small island, Kimbe Island, Papua New Guinea, together with new recruits from Kimbe Island and several other locations throughout Kimbe Bay. Parental analysis demonstrated significant self-recruitment (about 50%) to the Kimbe Island sub-population, but also significant connectivity among three distant locations within Kimbe Bay. As many as 10% of new recruits at these distant locations - up to 50km from Kimbe Island - were spawned by Kimbe Island adults. At small spatial scale, we observe strong retention (up to 50%) within small lagoon around Kimbe island that question about the ability of the species to achieve the pelagic larval phase within these lagoon. Finally, we demonstrate that some parents at specific sites within Kimbe Island were more efficient in producing self-recruitmenting juveniles than adults at other sites. Genetic parental analysis opens the possibility for new perspectives in understanding success of the larval phase and investigating process determining connectivity in the perspective of better management of marine populations.

Financial support provided by: CRISP

## 14-37

**Genetic Connectivity in Philippine Waters: Insights On Patterns, Scales, And Processes Based On Various Marine Taxa**

**Rachel RAVAGO GOTANCO*[1]**, Marie Antonette JUINIO-MENEZ[1]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines

An understanding of connectivity among reef environments is of critical importance to the design and implementation of management and conservation schemes. Predicting patterns of reef connectivity remains a challenge, as connectivity is the result of a complex interaction of biological and physical factors and processes operating across a wide range of spatial and temporal scales. Genetic patterns of a variety of reef-associated species with varying dispersal potential, from different marine biogeographic regions in the Philippines provide insights on ecological and historical processes that structure marine populations in these regions. Genetic patchiness at scales finer than expected from potential dispersal based on life history traits coupled with local hydrographic features indicate key factors affecting benthic recruitment success determine genetic patterns. For species such as Tridacna crocea, Linckia laevigata, and Siganus fuscescens, these include the influence of distribution and extent of suitable habitats and degree of environmental disturbance. Within biogeographic regions, genetic patterns coupled with community structure and hydographic regimes provide useful insights relevant for fishery management considerations. Patterns of genetic variability among northwest Luzon populations of S. fuscescens and Tripneustes gratilla provide insight into the spatial scales and putative boundaries for connectivity and gene flow. Genetic patterns across regions, as in the case of T. crocea, S. fuscescens and Siganus argenteus populations across the eastern Philippine seaboard, and South China Sea and Sulu Sea populations of T. crocea and L. laevigata, indicate the influence of broadscale hydrographic features on population genetic structure. In the case of the spiny lobster Panulirus longipes, genetic connectivity coupled with subspecies distribution patterns provides insight into long-term evolutionary scale processes shaping genetic structure and species biogeography.

## 14-38

**Long-Distance Gene Flow And Fine-Scale Genetic Differentiation in The Indo-Pacific Reef Fish, *zebrasoma Flavescens***

**Jeff EBLE*[1]**, Rob TOONEN[1], Larry BASCH[2], Brian BOWEN[1]

[1]Hawaii Institute of Marine Biology, Kaneohe, HI, [2]University of Hawaii Pacific Cooperative Studies Unit, Honolulu, HI

The remoteness of the Hawaiian Archipelago has proven to be a formidable barrier to the dispersal of marine species, resulting in high levels of endemism and corresponding genetic divergence. However, across the 2500 km of Hawaii's islands and atolls, marine populations have historically been assumed to be panmictic. To compare patterns of connectivity within the archipelago to broader trans-Pacific patterns, we surveyed both mtDNA and nuclear markers in the Indo-Pacific reef fish, *Zebrasoma flavescens*. Adults were collected at multiple spatial scales (N = 824) from 21 sites including: (a) four West Pacific locations, (b) six sites within the newly created Northwestern Hawaiian Islands (NWHI) Marine National Monument, and (c) 10 sites within the Main Hawaiian Islands, four being located around the largest island in the archipelago, the island of Hawaii. Additional tests for sweepstakes recruitment were conducted on 212 newly recruited fish collected from seven Hawaii Island sites. Analysis of cytochrome *b* sequences demonstrated modest population structure across the West Pacific ($\Phi$st = 0.04; P = 0.034) and stronger genetic differentiation between the West Pacific and Hawaii ($\Phi_{st}$ = 0.09; P = 0.004). Analysis of 14 microsatellite loci indicate restricted gene flow between the newly established NWHI reserve and the main Hawaiian Islands ($F_{st}$ = 0.008, P = 0.024), and genetic subdivision at scales of less than 50 km around Hawaii Island ($F_{st}$ = 0.019, P < 0.001).

## 14-39

**Population Structure And Genetic Connectivity Of Corals in Subtropical Eastern Australia**

**Annika NOREEN*[1]**, Peter HARRISON[1], Madeleine VAN OPPEN[2]

[1]Department of Environmental Science and Management, Southern Cross University, Lismore, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

This study examines the population differentiation, genetic diversity, and connectivity of corals in the eastern Australian subtropics and the Great Barrier Reef. Several eastern Australian subtropical reefs have high coral cover (up to 85%) and relatively high species richness (90-140 species). High-latitude reefs might be increasingly vulnerable because of ocean acidification, lower genetic diversity and lower connectivity among reefs. We address some of the issues underlying these ecological questions using population-level genetics of five coral species. Over 1,200 samples have been taken from *Seriatopora hystrix, Pocillopora damicornis, Acropora solitaryensis, Goniastrea favulus* and *Platygyra daedalea* from subtropical reefs (Lord Howe Island, Middleton and Elizabeth reefs, the Solitary Islands and Flinders Reef) and several Great Barrier Reef locations. Nuclear DNA was extracted from each sample, and between 5 and 10 fluorescently-labelled microsatellite markers were amplified for each species using PCR. The alleles were then genotyped and scored. *Seriatopora hystrix*, a brooding coral, has highly differentiated populations between most of the locations. However, some populations sampled are undifferentiated despite considerable environmental variability, e.g. Lord Howe Island east coast versus western lagoon. Additionally, the Elizabeth reef lagoon population clusters with the Middleton reef lagoon population, despite being 50 km apart, as do their respective outer channel populations. The *S. hystrix* population at Flinders reef, southern Queensland, is most similar to that of Lord Howe Island, over 600 km further south. The three Great Barrier Reef locations are admixtures of several genetic populations and, as a group, highly differentiated from subtropical reefs. There is discernable gene flow between some populations, notably Middleton and Elizabeth reefs' outer channel to Lord Howe Island.

## 14-40

**The Missing Link To Population Genetic Structure in Brooding Corals: How Far Do Sperm Swim?**

**Patricia WARNER*[1,2]**, Bette WILLIS[1], Madeleine VAN OPPEN[2]

[1]School of Marine and Tropical Biology and ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

The processes that govern the population genetic structure of brooding corals may be different to those that govern broadcast spawning species because of differences in the frequency and scale of dispersal characteristic of internal versus external fertilization. Given that small and isolated populations may be at greater risk of decline and extinction compared to large and panmictic populations, investigating genetically effective population sizes of brooding species is important. Effective population sizes in hermaphroditic reef corals are expected to be several magnitudes smaller than the census size, due to inter-annual variation in census population sizes and fecundity, as well as possible influences of both asexual reproduction and self-fertilization. Analysis of highly polymorphic DNA markers of the brooding coral, *Seriatopora hystrix*, on the Great Barrier Reef (GBR) shows that allelic diversity is high across the GBR, but much smaller in each population, suggestive of small effective population sizes. Heterozygote deficits, indicative of non-random mating, are common in this species, which is consistent with rapid settlement of the larvae shortly after release. Knowledge of fine-scale connectivity patterns within populations of brooding corals may help to elucidate the broad-scale patterns in genetic structure. Limited sperm dispersal may amplify signals of geographic subdivision, but current knowledge of the frequency and scale of dispersal of spermatozoa in brooding species is limited, and is absent for *S. hystrix.* To determine the spatial extent of spermatozoa dispersal, the genotypes of all colonies within a mapped study population in the Palm Islands, central GBR, were compared with those of the brooded larvae of adults sampled from the center of the mapped population. Furthermore, we assessed the timing of spermatozoa and larval release with histological monitoring of adult gametogenic tissue throughout the reproductive season.

## 14-41

**Fine-scale Spatial Genetic Structure in the Caribbean Staghorn Coral *Acropora cervicornis***

**Silvia LIBRO*[1]**, Steve VOLLMER[1]

[1]Marine Science Center, Northeastern University, Nahant, MA

Localized spatial genetic structure (SGS), i.e. the non-random association of genetic relatedness among individuals in space, can be caused by a variety of demographic and evolutionary processes including limited dispersal, inbreeding, and selection. SGS has been studied extensively in plants, in order to estimate fine-scale patterns of dispersal, but has rarely been examined in sessile marine taxa. Here we investigated the possibility that SGS might be important in the staghorn coral *Acropora cervicornis*. Staghorn corals from four populations were mapped along permanent transects and genotyped with five microsatellite loci. Our results show that *A. cervicornis* exhibits localized SGS within reefs (out to 14 meters) due to both the spatial aggregation of clones and the non-random association of genets on reefs. We show that patches of *A. cervicornis* can be highly inter-related as well with relatedness on the order of cousins. We also detected moderate to high levels of population genetic structure among reefs over spatial scales as small as 2kms, but no evidence of isolation by distance among reefs. We suggest that the localized SGS, high relatedness among genets within reefs, and strong population structure between reefs is the results of rare cohort recruitment.

## 14-42

**Understanding Patterns Of Gene Flow in Coral Reef Fishes: Multiple Species And Multiple Scales.**

**Joshua DREW*[1]**, Paul BARBER[2]

[1]Marine Program, Boston University, Woods Hole, MA, [2]Marine Program, Boston University, Boston, MA

Understanding the spatial scales over which populations of coral reef fishes are connected is important for elucidating evolutionary patterns as well as in setting conservation priorities. In this presentation we compare patterns of genetic connectivity of several common coral reef fishes over multiple spatial scales. On the finest scale, between the islands of Fiji we see broad scale genetic homogenization with most, but not all of the species we examine. However, on the next highest spatial scale (between Fiji and the rest of Melanesia) we see evidence for regional endemism within five species of fishes. Expanding further, we investigate two species of fish *Amphiprion melanopus and Pomacentrus moluccenis* [Pomacentridae] whose species ranges are entirely within Melanesia and Indonesia. Here we see evidence for restricted gene flow across the Indo-West Pacific archipelagos ultimately leading to the evolution of peripheral populations into reproductively isolated monophyletic clades. Finally at the largest spatial scales we use the widely distributed species *Halichoeres hortulanus* [Labridae], to investigate gene flow across the Indian and Pacific oceans, and discover significant barriers to gene flow between these oceans occurring in the Indonesian archipelago. Our results demonstrate that despite having pelagic larvae and the ability to distribute genes over broad geographic differences, some coral reef fish populations are geographically structured, but the magnitude of that structure depends on the spatial scale considered.

## 14-43

**Connectivity in A Caribbean Octocoral: A Tale Of Three Datasets**

**Howard LASKER*[1]**, Jaret BILEWITCH[1], Stefano GOFFREDO[2]

[1]Program in Evolution, Ecology and Behavior, and Dept of Geology, University at Buffalo, Buffalo, NY, [2]Department of Evolutionary and Experimental Biology, University of Bologna, Bologna, Italy

Characterizations of connectivity vary with the spatial and temporal scales inherent in the techniques used to assess connectivity. The Caribbean octocoral, *Pseudopterogorgia elisabethae* has been harvested on the Little Bahama Bank for over 10 years. The harvest, which involves cropping colonies, leaves areas with reduced numbers of reproductive colonies. This reduction in reproductive colonies should reduce local recruitment, since *P. elisabethae* surface broods and has negatively buoyant planulae. We examined connectivity among populations on the Little Bahama Bank and throughout the northern Bahamas on differing spatial and temporal scales by comparing recruitment before and after harvesting, comparing the population size/age structure between harvested and unharvested areas and examining population genetic structure.

Recruitment at sites in 2004 and 2005 varied with local population density, but changes in recruitment due to harvesting were no greater than inter-annual variation in recruitment at all sites. However, the size structure of populations that were subjected to up to 3 episodes of harvesting had depressed proportions of small colonies suggesting that local recruitment and the extended depression of local recruitment affected population demographics. Microsatellite analyses of populations on the Little Bahama Bank detected minimal population clustering but did identify significant $F_{ST}$ values. We found high levels of structure on larger scales. The data suggest that in any single year recruits readily move over scales $>10^{-1}$ km. However, over the scale of a decade and summed across harvesting encompassing several kilometers a substantial portion of recruitment is local. Over scales of decades and 10 to >100 km there is sufficient migration to reduce but not eliminate population genetic structure. There is limited migration across oceanographic barriers.

## 14-44

**Preliminary Analysis of *Acropora palmata* Gene Flow in Reefs of the US Virgin Islands**

**William SCHILL*[1]**, Caroline ROGERS[2], Erinn MULLER[3], Anthony SPITZACK[4], Iliana BAUMS[5]

[1]Natl. Fish Health Research Laboratory, USGS-Leetown Science Center, Kearneysville, WV, [2]Virgin Islands National Park, USGS-Florida Integrated Science Center, St. John, Virgin Islands (U.S.), [3]Florida Institute of Technology, Melbourne, FL, [4]USGS-Florida Integrated Science Center, St. John, Virgin Islands (U.S.), [5]The Pensylvania State University, University Park, PA

Two regionally isolated populations of *Acropora palmata* that were previously identified are generally demarcated by Mona Island, east of Puerto Rico. To further examine pathways of gene flow in the eastern zone, we determined the genotype at five polymorphic microsatellite loci of 256 colonies of *Acropora palmata* from six sites on St. John, and 92 additional colonies from two sites at Buck Island/St. Croix, USVI. Data analysis using AMOVA demonstrated that 98% of the genetic variation was within collections, while 2% was among the island groupings. Sixty-five of the 348 colonies were clonal. The incidence of clonality may be influenced by differential spatial scales of sampling at various sites, but was lowest in samples from the South Fore Reef of Buck Island (0 of 50 colonies), and highest at the Hawksnest Bay, St. John site (21 of 42 colonies). When clonemates were removed from the analysis, the differentiation of the island groupings disappeared and the algorithm used by the program, *structure v. 2.2*, failed to identify more than a single cluster. Pairwise population *F*ST and $R_{ST}$ values, however, indicated significant differentiation for combinations of the Yawzi Point or Saltpond Bay, St. John, collections with the two St. Croix collections. We also examined distributions of sample pairs' relatedness. Within collections, mean relatedness was significantly higher between sample pairs from the two St. Croix collections than between sample pairs of other collections. Thus, the St. Croix collections seem to exhibit some cohesiveness not generally found in the St. John collections. The Saltpond Bay collection, however, was distinct from the other five St. John collections in that 5.5% of the possible pairings shared at least one allele at each of the five loci. Analyses of individuals with similar genotypes suggest potential connections between reefs.

## 14-45

**Range-Wide Population Genetics Of The *gorgonia Ventalina*/*symbiodinium* Octocoral Holobiont**

**Jason ANDRAS*[1]**, Nathan KIRK[2], C. Drew HARVELL[1]

[1]Ecology & Evolutionary Biology, Cornell University, Ithaca, NY, [2]Biology, Auburn University, Auburn, AL

The conspicuous and ecologically dominant Caribbean seafan coral, *Gorgonia ventalina*, exists in an obligate mutualistic relationship with photosynthetic dinoflagellates of the genus *Symbiodinium*, ITS type B1. Here we describe the population genetic structure of the *G. ventalina*/*Symbiodinium* coral holobiont at 40 localities spanning more than 3,000 km throughout its range, using a total of 22 polymorphic microsatellite loci (13 loci from the *Symbiodinium* genome; 9 loci from the *G. ventalina* genome). The large majority of *Symbiodinium* populations within a single seafan colony were clonal, and seasonal sampling of marked colonies showed within-host symbiont populations to be temporally stable. Significant structure was detected between *Symbiodinium* populations among different coral hosts separated by as little as 5km, and overall divergence in symbiont populations followed a pattern of isolation by distance. Differentiation was also detected between *Symbiodinium* populations hosted by corals in different size/age classes at the same locality. A small fraction of seafan colonies sampled were found to host multiple symbiont genotypes. The relative proportions of these genotypes were dynamic and reversible in response to experimentally induced light and temperature stress, suggesting that the fine-scale *Symbiodinium* genetic diversity described in this study may have functional significance. Significant structure was also detected among populations of *G. ventalina*, though at a broader scale of hundreds to thousands of kilometers. The observed patterns of connectivity in populations of the coral host are consistent with data from biogeographic studies of other Caribbean marine organisms with broadly dispersing pelagic larvae. This is the first study we are aware of that considers the population genetics of both members of the obligate coral/algal holobiont. These results will have significance for our understanding of basic coral population biology, the establishment and maintenance of the coral/algal symbiosis, and conservation genetics and management of corals and other Caribbean reef creatures.

## 14-46

**Genetic Variability Of Acropora Cervicornis And A .palmata in Puerto Rico**

**Garcia Reyes JOSELYD*[1]**, Nikolaos SCHIZAS[1]

[1]Department of Marine Sciences, University of Puerto Rico-Mayaguez, Lajas, Puerto Rico

Genetic variation of natural populations may be used as a proxy for the long-term survival of populations or species. Effective conservation and management planning for the rapidly declining scleractinian species *Acropora cervicornis* and *A. palmata* require an understanding of the standing genetic variability. Over 100 colonies of *Acropora cervicornis* and *A. palmata* have been sampled from several reefs around Puerto Rico to assess levels of genetic variability. We used partial DNA sequences of the mitochondrial control region to estimate levels of genetic connectivity in adjacent and geographically distant reefs. Preliminary analysis shows that many of the reefs share haplotypes indicating historical genetic exchange between reefs. Genetic diversity is significantly different among reefs. Analysis of molecular variance suggests that most of the variability is observed within reefs than among reefs. $F_{ST}$ values were also significant for both species suggesting that there is fine scale population structure, as previous studies have indicated. Therefore, larval dispersal could be limited over long and even small distances restricting larval supply, which could influence recuperation between reefs. Populations that are considerably connected will not have a significant amount of restriction on gene flow, allowing the exchange of genes between populations. Presence of multiple mitochondrial haplotypes in a reef suggests that sexual reproduction may be contributing to the observed levels of genetic variation in Puerto Rico. The awareness of connectivity between large spatial and small spatial scales is important especially when dealing with a threatened species in order to set the degree of conservation and management strategies.

## 14-47

**Larval Retention And Population Connectivity in Two Coral-Reef Fishes**

**Mark CHRISTIE*[1]**, Christopher STALLINGS[2], Darren JOHNSON[1], Mark ALBINS[1], Jim BEETS[3], Brian TISSOT[4], Stephen THOMPSON[5], Mark HIXON[1]

[1]Department of Zoology, Oregon State University, Corvallis, OR, [2]Florida State University Coastal and Marine Laboratory, St. Teresa, FL, [3]Department of Marine Science, University of Hawaii at Hilo, Hilo, HI, [4]Washington State University, Vancouver, Vancouver, WA, [5]Cascadia Conservation Trust, Sisters, OR

Patterns of demographic connectivity among and retention within local populations of marine fish are poorly understood due to the difficulty of directly tracking pelagic larvae. To address this issue, we conducted population genetic analyses of two species of coral reef fishes. In 2005, bicolor damselfish (*Stegastes partitus*) were collected from 5 islands within the Exuma Sound, Bahamas, bordering an area of 100 by 175 km. Fifty adults and fifty recruits from each site were genotyped at 7 polymorphic microsatellite loci. In 2006, 500 adult and 500 recruit yellow tang (*Zebrasoma flavescens)* were collected from 9 sites distributed around the Big Island of Hawai'i and subsequently genotyped at 15 microsatellite loci. Overall levels of genetic differentiation (e.g., $F_{ST}$) were low for both systems, such that there were no significant patterns of isolation by distance when Euclidean or along-shore distances were employed. However, significant differences between populations of bicolor damselfish located on the eastern and western sides of the Exuma Sound were detected. This pattern suggests that there is limited dispersal across the eastern and western sides of the Exuma Sound and higher levels of connectivity among sites located north and south of one another, coinciding with prevailing northerly currents. Additionally, the high levels of polymorphism found within the genetic markers allowed for the detection of parent-offspring pairs in both species using novel statistical methods. The existence of parent-offspring pairs of fish in the same region provides unequivocal documentation of larval retention and self-recruitment. Given that the overall levels of genetic differentiation in both systems are low, parentage analysis in marine systems may prove to be a powerful tool for informing population-level genetic analyses as well as for providing insights into gene flow and dispersal at ecological timescales.

## 14-48

**Levels Of Population Genetic Structure Of Table Top Acropora Corals At Village, Island And Pacific-Wide Scales And The Value Of Local Marine Protected Areas.**

**Steve PALUMBI*[1]**, Jason LADNER[2]

[1]Department of Biology, Stanford University, Pacific Grove, CA, [2]Stanford University, Pacific Grove, CA

To estimate the movement of coral larvae among populations and to estimate the connectivity of coral populations at various geographic scales, we measured mtDNA variation in populations of the table top corals Acropora hyacinthus and A. cytherea from 20 populations from the Philippines to Palmyra atoll. The same thirteen mtDNA haplotypes are seen across the Pacific, indicating that long distance gene flow is possible. Between archipelagos (Philippines, Micronesia, Fiji, American Samoa, Palmyra), coral populations always showed strong genetic differentiation, suggesting such long distance gene flow is rare. Within archipelagos, coral populations on separate islands usually showed strong genetic differences. Populations on different reefs on the same islands showed strong differentiation in about half of the comparisons. The two coral species showed little mtDNA genetic differentiation from one another when sampled from the same reefs, but additional data from nuclear genes showed higher levels of genetic distinction. Results suggest that, over ecologically relevant time scales, coral larvae generally travel short distances along reef complexes on an island, and have low dispersal abilities among islands. Use of coral protected areas to house healthy stands of corals to reseed damaged reefs would require these coral gardens to be placed at short distances from one another.

## 14-49

**Quantifying The Spatiotemporal Trends in Marine Connectivity: Merging Seascape Genetics And Biophysical Modeling Within A Graph-Theoretic Framework**

**Eric TREML*[1]**, Patrick HALPIN[2]

[1]The School of Integrative Biology, University of Queensland, Brisbane, Australia, [2]Nicholas School of the Environment and Earth Sciences, Duke University, Durham, NC

Marine population connectivity, via larval dispersal, is critical for population persistence and is a key factor influencing how a species might cope with habitat loss and degradation due to local anthropogenic factors and future climate change. However, identifying the patterns in marine population connectivity poses one of the greatest challenges in marine ecology. Although several studies have discovered a general scale of population connectivity, little progress has been made in identifying the spatiotemporal structure of this connectivity. The objectives of this research were to 1) identify the probable dispersal routes and spatial population structure for several marine species throughout the Tropical Pacific, 2) test isolation-by-distance hypotheses of genetic differentiation for several marine species using traditional and graph-theoretic metrics, and 3) develop a framework for integrating these connectivity estimates into the regional marine conservation planning efforts. By exploiting techniques in population genetics, biophysical modeling, and graph theory, this work explored the hypothesis that the spatial genetic structure of marine populations is determined by the location and strength of biophysical connectivity. For this work, dispersal probabilities were derived for multiple species throughout the Tropical Pacific using a spatially-explicit biophysical modeling approach. These probabilities incorporated high-resolution hydrodynamics, pelagic larval duration, simplistic larval behavior, mortality, and settlement probability. The resultant spatiotemporal structure, including persistent dispersal corridors and barriers, were uncovered using clustering and connectivity algorithms from graph theory. The correlation between the biophysical connectivity predictions and the observed population genetic structure was tested within a Mantel regression framework. Finally, this research evaluated methods for integrating the spatial structure of marine population connectivity into regional conservation planning.

## 14-51

**Where Have All The Larvae Gone? Connectivity Within The Hawaiian Archipelago**

**Rob TOONEN*[1]**, Chris BIRD[1], Anuschka FAUCCI[2], Iliana BAUMS[3], Derek SKILLINGS[1], Brian BOWEN[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]Department of Biology, University of Hawaii, Kaneohe, HI, [3]Pennsylvania State University, University Park, PA

The Papahânaumokuâkea Marine National Monument, encompassing all of the Northwestern Hawaiian Islands, is the largest Marine Protected Area in the world (>350,000 km2), and studies of connectivity between reef habitats across this broad region are currently lacking. To this end, we are surveying a broad range of fish and invertebrate species to understand connectivity patterns throughout the Hawaiian Archipelago. We now have data for more than a dozen species, and using Monmonier's algorithm as implemented in BARRIER, we have determined areas of restricted gene flow across many species within the Hawaiian Archipelago. Comparing these concordant population genetic breaks with results of a layered Lagrangian model of larval dispersal developed by Kobayashi, we argue that connectivity among coral reef habitats is unlikely to match passive diffusion models based solely on fluid dynamics. We also show that variability among even closely-related species is the norm, and argue that such broad taxonomic surveys are necessary to draw robust conclusions about general patterns of connectivity that will guide management or conservation efforts. Our data show a number of concordant breaks that were previously unknown and suggest that population structure across the Hawaiian Archipelago does not fit predictions based on broad-scale oceanographic currents or advection-diffusion models of larval dispersal driven by geostrophic flow.

## 14-53

**Does Behavior Drive Population Genetic Structure in The Cardinalfish *ostorhynchus Doederleini*?**

**Gabriele GERLACH*[1,2]**, Jelle ATEMA[3], Michael KINGSFORD[4]

[1]University of Oldenburg, Oldenburg, Germany, [2]Marine Biological Laboratory, Woods Hole, [3]Boston University, Boston, MA, [4]James Cook University, Townsville, Australia

Many marine fish and invertebrates show a dual life history where settled adults produce dispersing larvae. While ocean currents are a major force in larval dispersal, recent studies and our own research show far greater retention than predicted by advection models. Based on microsatellite markers, we compared the genetic structure of adult cardinalfish, *Ostorhynchus doederleini,* at different reefs at the Capricorn Bunker Reef (Great Barrier Reef, Australia) at a geographical scale from 2 to 140 km over 5 different years. While the genetic structure in 2003 and 2005 showed statistically significant genetic differences between all reefs the populations seemed to have mixed up in 2006 probably driven by storm events. Surprisingly, significant differences were found again in 2007 and these populations were genetically similar to those from 2003 and 2005. Such a rapid reconstitution of the former genetic structure might be explained by behavioral mechanisms leading to different mortality of settling larvae. In order to test this, we collected adult *O. doederleini* at 4 different reefs and settling larvae from 2 reefs. In a random order we introduced a single larva into a tank containing 2 adults from either reef and observed the aggressive behavior towards this larva. The aggressive interaction of adults were significantly stronger when they originated from reefs different from those where larvae were collected; 7 out of 43 tested larvae were killed by foreign adults while no larvae were killed by adults from their own reef population. Our results indicate that differential aggressive behavior of adults might select against foreign, genetically dissimilar larvae and result in differential mortality of settling larvae from different origin.

## 14-54

**Connectivity And Gene Flow in The Dominant Caribbean Reef-Building Coral, *montastraea Annularis***

**Nicola FOSTER*[1]**, Claire PARIS[2], Iliana BAUMS[3], Mark VERMEIJ[4], Shannon GORE[5], Phillippe BUSH[6], Croy MCCOY[6], Sascha STEINER[7], Judith MENDES[8], Ernesto WEIL[9], Carolina BASTIDAS[10], Juan SANCHEZ[11], Claudia AGUDELO[11], Renata FERRARI[12], Patricia GONZALEZ[13], Michael MCCARTNEY[14], Reia GUPPY[15], Owen DAY[16], Jamie STEVENS[1], Peter MUMBY[1]

[1]School of Biosciences, University of Exeter, Exeter, United Kingdom, [2]University of Miami, Miami, FL, [3]The Pennsylvania State University, University Park, PA, [4]University of Hawaii, Lahaina, HI, [5]BVI Conservation and Fisheries Department, Tortola, Virgin Islands (British), [6]Cayman Islands Government, George Town, Cayman Islands, [7]Institute for Tropical Marine Ecology, Roseau, Dominica, [8]University of West Indies, Mona, Jamaica, [9]University of Puerto Rico, Lajas, Puerto Rico, [10]Universidad Simon Bolivar, Caracas, Venezuela, [11]Universidad de los Andes, Bogota, Colombia, [12]Fundacion de Ecologia de Punta Cana, Punta Cana, Dominican Republic, [13]Universidad de La Habana, Havana, Cuba, [14]University of North Carolina, Wilmington, Wilmington, NC, [15]University of newcastle, Newcastle, United Kingdom, [16]Buccoo Reef Trust, Carnbe, Trinidad and Tobago

Understanding patterns of connectivity among populations of aquatic organisms is essential for the development of realistic, spatially explicit models of population dynamics and for determining the placement of effective marine reserve networks. Traditionally, two approaches have been used to infer levels of larval connectivity among aquatic (generally marine) populations. The first uses oceanographic models of currents to predict potential levels of dispersal among sites and the second uses population genetics to infer aspects of connectivity from observed gene flow. Rarely have both methods been applied simultaneously. Here, we analysed variation at six polymorphic microsatellite loci to assess gene flow among 30 populations of the reef-building coral, *Montastraea annularis,* across the Caribbean. This data was then compared to the results from a model of larval dispersal. Using geographical coordinates and genetic distance matrices, an area of reduced gene flow was identified between populations in the eastern and western Caribbean. A further area of lowered gene flow was detected between populations in Belize and those in Honduras and Nicaragua. The observed breaks in gene flow were consistent with the results of the larval dispersal model. Such information regarding the connectivity of populations should be incorporated into future management plans.

## 14-55

**The Importance Of Behavior On Self-Recruitment: A Modeling Approach**

**Jean-Olivier IRISSON*[1]**, Claire PARIS[2], Laurent CHERUBIN[2], Michel DE LARA[3], Serge PLANES[1]

[1]UMR 5244, Biologie et Ecologie Tropicale et Mediterranenne, Université de Perpignan, Perpignan, France, [2]RSMAS - University of Miami, Miami, FL, [3]CERMICS - Ecole des Ponts et Chaussées, Paris, France

All early models of the pelagic phase of coastal organisms made the simplifying assumption that larvae could be treated as passive particles in a flow. This was justified in the early nineties because of both computational limitations and lack of knowledge about the behavioral ecology of marine larvae. However, for more than a decade now, the swimming abilities of coral reef fishes, in particular, as well as their vertical distribution, have been investigated using several methods. All agree on the tremendous swimming speeds and endurance displayed by fish larvae, on their ability to influence their vertical and horizontal distributions and on the potential impact of these factors on connectivity. Yet, no numerical model integrates this kind of behavior more extensively than for the last instants of larval life.

We present two numerical models of the whole larval phase which both feature larval behavior. One explicitly integrates larval swimming in a mesoscale environment, around an island, and estimates the impact of swimming on self-recruitment. Because we still know very little about the orientation behavior of larvae in oceanic waters, we deduce their swimming decisions from an optimization method with realistic constraints and a biologically sensible objective (i.e. recruitment). Swimming along these optimal trajectories substantially enhances the possibility of self-recruitment compared to a passive scenario. The other model examines the influence of statistically modeled vertical distributions of larvae in the context of many inter-connected fish populations in the Caribbean. The distribution is shown to markedly modify the connectivity matrix. Overall, both models show that larval behavior has a great influence during the pelagic phase. Many studies show that larvae probably use their swimming abilities to reduce rather than to enhance dispersal, and our findings demonstrate that they can do so very efficiently.

## 14-56

**Long PLDs, Larval Behavior, and Connectivity in Spiny Lobster**

**Mark BUTLER*[1]**, Robert COWEN[2], Claire PARIS[2], Hirokazu MATSUDA[3], Jason GOLDSTEIN[4]

[1]Department of Biological Sciences, Old Dominion University, Norfolk, VA, [2]Rosenstiel School of Marine & Atmospheric Sciences, University of Miami, Miami, FL, [3]Fisheries Research Division, Mia Prefecture Fishery Research Center, Mia, Japan, [4]Department of Zoology, University of New Hamphire, Durham, NH

Among marine taxa, the pelagic larval duration (PLD) of spiny lobsters lies at the extreme. With PLDs ranging from 4 to 24 mos, spiny lobster larvae potentially disperse thousands of kilometers unless they possess behaviors or are captured in retentive environments that constrain their transport. Attempts to model connectivity in spiny lobsters have been hampered by a poor understanding of PLDs, ontogenetic changes in behavior, and by overly simplistic models. We have combined laboratory and field studies of larval behavior and distribution with advanced oceanographic modeling to predict dispersal of Caribbean Spiny Lobster (Panulirus argus). We successfully, and for the first time, reared P. argus from egg to juvenile and have determined its PLD (6 mos) along with stage-specific responses of larvae to light and chemical cues that may affect dispersal. Our experiments revealed distinct differences in response among larval stages consistent with observations of larval vertical distribution in nature, determined from monthly depth-stratified plankton tows. We also discovered that the strong-swimming postlarvae are attracted to coastal chemical cues up to 30 km from shore, particularly cues emanating from red macroalgae. These data have been used to parameterize a lobster Lagrangian particle model linked with the Hybrid Coordinate Ocean Model, similar to methods used for fishes. Simulations of P. argus larval dispersal suggest that with larval behavior: (a) the probability of successful recruitment increased by more than an order of magnitude, (b) median dispersal was ~200 km compared to ~ 800 km in simulations using passive dispersal, and (c) local patterns of retention and advection of larvae were idiosyncratic. We are now determining if model predictions of recruitment magnitude are consistent with empirical estimates of larval supply in the Caribbean.

## 14-57

**Combining Modeling And Empirical Approaches To Track Connectivity Across Temporal And Spatial Scales**

**Heather GALINDO*[1]**, Donald OLSON[2], Stephen PALUMBI[1]

[1]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [2]Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL

Biological connections among marine populations via larval dispersal affect both demographic and evolutionary processes, yet describing the actual patterns of connectivity has remained a challenge. Recent integration of oceanographic and population genetic models has proven an effective tool for generating hypotheses about connectivity patterns we can then test with empirical datasets. We will present examples of this approach at various scales and discuss the advantages and limitations of this method in each case. First, we will describe how this approach has been successfully used to detect major geographic breaks in genetic structure for a free-spawning coral at the scale of the Caribbean basin. Next we will outline how this approach can be modified for application at both smaller spatial and temporal scales. Smaller spatial scales can potentially be achieved through finer geographic resolution of oceanographic models coupled with local collection of empirical data. In addition, better temporal resolution can be gained by matching recent oceanographic datasets with a cohort genetics approach where the genetic signatures of arriving larvae are tracked both within and between settlement seasons. The explicit integration of oceanography and population genetics gives us a powerful way to both generate and test hypotheses about patterns of marine connectivity. In addition, this modeling framework is extremely flexible and can be adapted to a variety of geographic regions and marine species.

## 14-58

**Realized Connectivity: Post-Settlement Survival Linked To Larval Source**

**Scott HAMILTON*[1]**, Robert WARNER[1]

[1]EEMB, UCSB, Santa Barbara, CA

Experiences during larval life may influence phenotypic traits, performance, and the probability of post-settlement survival. For a reef fish on an oceanic island, we used otolith (ear stone) elemental profiles of lead (Pb) to assign recent settlers to (1) a group that developed in nearshore waters elevated in Pb, or (2) those that developed in offshore waters depleted in Pb, potentially dispersing from upstream sources. Larval history influenced early life history traits: offshore developers initially grew slowly but compensated with fast growth upon entering nearshore waters, and metamorphosed in better condition with higher energy reserves. While 45% of settlers developed nearshore, only 23% of survivors after the first month displayed a nearshore otolith profile. Importantly, selective mortality was mediated by larval history, in that the post-settlement intensity of selection was much greater for fish that developed nearshore, potentially because only exceptionally strong offshore larvae survived to settle in the first place. Given the potential for asymmetrical post-settlement survival based on larval history, successful management may require knowledge of 'realized connectivity' on ecological scales, which is the proportion of individuals from different sources that survive to reproduce. Simply counting new settlers may be misleading.

## 14-59

**Fishy Chronology: Using The Chemical Chronology Of Otoliths To Investigate Shared Environments Among Reef Fish**

**Paul CHITTARO*[1]**, J. Derek HOGAN[2]

[1]NWFSC, NOAA, Seattle, WA, [2]GLIER, University of Windsor, Windsor, ON, Canada

Understanding the extent to which populations are connected is necessary for effective management. Although it is difficult to directly track fish during their pelagic larval stage, their otoliths have proven to be an invaluable tool since they record not only the time but also aspects of the environment in which the fish resides. The goal of this study is to provide information regarding the environments through which fish traveled, as well as the number of source populations that supply reef fish. To do this we use the otoliths of newly settled bicolor damselfish (Stegastes partitus), that were collected from Belize and Mexico in 2002 and 2003, and we determine the concentrations of elements (via laser ablation) along a transect from the otolith core to edge (representing their larval development and pelagic dispersal, until their settlement). We compare otolith chemical chronologies of individuals (at the site and regional scale, as well as at different time periods) in order to identify the extent to which individuals occupied similar environments during the course of their lives and the number of source populations from which they originated.

## 14-60

**Multiple Scales Of Larval Dispersal in A Coral Reef Fish**

**Mark TUPPER*[1]**

[1]The WorldFish Center, Penang, Malaysia

The management of coral reef fisheries is increasingly turning to an ecosystem-based approach involving networks of marine protected areas (MPAs). Central to this approach is knowledge of the connectivity between potential MPA sites. Recent studies have demonstrated high levels of retention in pomacentrids, which lay demersal eggs and have a short (9-21 days) planktonic phase. In this study, tetracycline was used to mass-mark goatfish (Parupeneus multifasciatus) embryos, taken by stripping ripe adults captured from a spawning aggregation site in Guam. This species has a planktonic phase of approximately 35 days. Marked fish were then recaptured by beach seining for newly settled juveniles and their otoliths examined for evidence of a tetracycline mark. A total of 11,000 otoliths were sampled, and 17 displayed a clear tetracycline mark. Goatfish settled over a range of dispersal scales. Some fish settled just tens to hundred of meters from the aggregation site. Most fish settled 1 km to 10s of km from the aggregation. Two fish settled about 100 km away at the downstream island of Rota in the Northern Marianas Islands (NMI). This has implications for transboundary management, as it is now evident that some of the NMI's reef fish stocks originate in Guam.

## 14-61

**Connectivity Of Coral Reef Fish Populations: Estimates From Transgenerational Mass-Marking Of Embryonic Otoliths Using Enriched Stable Isotopes**

**Simon THORROLD*[1]**, Geoffrey JONES[2], Serge PLANES[3]

[1]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [3]Laboratoire Écosystèmes Aquatiques Tropicaux et Méditerranéens, CNRS-EPHE-UPVD, Université de Perpignan, Perpignan, France

Theoretical studies suggest that connectivity plays a fundamental role in the dynamics, community structure, genetic diversity, and resiliency to human exploitation of coral reef fishes. Modeling efforts have been hindered, however, by the paucity of empirical estimates of, and processes controlling, population connectivity in coral reef ecosystems. While progress has been made with older life stages, connectivity as a function of larval dispersal remains unresolved for most marine populations. We have developed a new technique, based on transgenerational marking of embryonic otoliths with enriched barium isotopes, to quantify population connectivity in coral reef fishes. Gravid females are injected with an enriched stable Ba isotope solution that generates a unique isotope signature in the otoliths of all larvae subsequently spawned by the individual for up to 3 months after the injection. Otoliths of juvenile fish are then scanned for the tag using laser ablation inductively coupled plasma mass spectrometry. Validated in benthic and pelagic spawning fishes, the first field study using transgenerational marking has recently being completed in Kimbe Bay, on the northern coast of New Britain, Papua New Guinea. Results suggest that natal homing of larvae may be a common life history strategy in reef fishes, and thus appropriate spatial scales for management and conservation of coral reefs are likely much smaller than previously realized.

## 15-1

**Hydrodynamic Modeling Of A Fringing Reef Embayment: Hanalei Bay, Hawaii**

**Ronald HOEKE*[1]**, Curt STORLAZZI[2]

[1]Joint Institute of Marine and Atmospheric Research(JIMAR), University of Hawaii/NOAA, Honolulu, HI, [2]Coastal and Marine Geology Program (CMG), USGS Pacific Science Cente, Santa Cruz, CA

Concerns about watershed management and its connection to nearshore ecological health at Hanalei Bay, Kauai, Hawaii, USA, have prompted a concerted interagency effort to gain better understanding of circulation, sedimentation, and water quality within the bay. Recent advances in computational hydrodynamics have resulted in the development of suites of software to model such coastal processes. These models have proven successful at a number of sandy, continental coastal sites, but few have been applied to insular coral reefs. Here we present the application of the Delft3D computational hydrodynamic software package to Hanalei Bay, a wave-dominated, microtidal coral reef embayment. Numerical output using model parameters traditionally used for sandy continental margins is contrasted with adaptations for microtidal, oceanic fringing reef environments and compared to in situ observations. Analyses reveal the importance of: (1) wave refraction/diffraction effects, (2) spatially varying bottom friction values that range over an order of magnitude, and (3) shortcomings of numerical solutions of these two processes when applied to fringing reef environments. The relative contribution of tides, winds, and waves to the bay's hydrodynamics are calculated for a range of conditions. The contribution of waves is several orders of magnitude greater than other physical processes in determining overall circulation and flushing of the bay, and dominates the near-bed shear stresses at most locations in the bay.

These findings show the precision of current computational hydrodynamics in high-energy, morphologically complex environments, such as Hanalei Bay, to be relatively poor at this time. Despite this, these techniques do provide valuable order-of-magnitude estimates of hydrodynamic processes and create a qualitative synoptic picture. These spatially explicit, fine scale estimates would be difficult with other methods.

## 15-2

**Modelling Larval Retention Around Reefs By Local Scale Circulation Features**

**Paulina CETINA-HEREDIA*[1]**, Sean CONNOLLY[2,3], Michael HERZFELD[4]

[1]School of Marine & Tropical Biology, James Cook University, Townsville, Australia, [2]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [3]ARC centre of Excellence, Coral Reef Studies, Townsville, Australia, [4]Division of Marine and Atmospheric Research, CSIRO, Hobart, Australia

Larval transport is mediated by circulation patterns. Low frequency, large scale currents can advect larvae for long distances, connecting populations over 100 km. However, local scale circulation features, such as lee reef eddies, can retain larvae near reefs and enhance self-recruitment. To accurately estimate larval dispersal, it is necessary to consider these local scale circulation processes. This study aims to approximate larval retention around reefs as a consequence of recirculation and stagnant flows provoked by the interaction of currents with the complex reef bathymetry that reefs normally display. To characterize eddies formed in the lee of reefs (different shapes) under different circulation regimes (low and/or high frequency dominant) and quantify the retention of larvae we simulate larval transport with a 3D finite difference hydrodynamic model (Sparse Ocean Hydrodynamic Code) in the Northern Section of the Great Barrier Reef. The life span, strength and size of eddies is quantified, using vorticity and the Okubo Weiss invariant as diagnostic variables. Finally, an approximation of larval retention as a function of reef geometry and prevalent circulation regime is attempted to provide a novel tractable approach accounting for local scale circulation features on larval dispersal in regional scale metapopulation models.

## 15-3

**Characterization Of Hydrodynamic And Biophysical Anomalies On The Florida Reef Tract**

**Lewis GRAMER*[1]**, Elizabeth JOHNS[2], James HENDEE[2]

[1]Cooperative Institute of Marine and Atmospheric Studies, University of Miami, Miami, FL, [2]Atlantic Oceanographic and Meteorological Laboratory, National Oceanographic and Atmospheric Administration, Miami, FL

NOAA's Integrated Coral Observing Network (ICON) project uses an artificial intelligence software system to implement heuristic models of coral reef ecosystem response to physical, chemical and biological conditions. These heuristic models use categorical, "if-then" rules to recognize and report patterns in environmental data integrated in near real-time from multiple external sources. One such model is described that detects and distinguishes episodic, biologically significant hydrodynamic processes acting upon coral reefs in the Florida Keys National Marine Sanctuary. Data are gathered from in situ sensors, satellites, and high-frequency radar at three shallow reef locations 100-200m inshore of the outer edge of the reef crest: Sombrero Reef in the Middle Keys, Molasses Reef in the Upper Keys, and Fowey Rocks off the Miami coast. The model recognizes apparent changes in biological production and circulation that may impact the reef ecosystem. Primary model criteria are in situ sea temperature variability occurring at near-tidal periodicities, wind velocity variability, and sea color-derived satellite chlorophyll a concentrations. Model forecasts are then verified using secondary data not utilized by the model as input, including satellite-derived regional sea surface temperature and ocean color imagery, radar-derived ocean surface currents, in situ salinity, and divers' visual reports. Three classes of nutrient delivery events are characterized by the model products: those forced respectively by wind-driven upwelling and downwelling; by net tidal transport of eutrophic water from Florida Bay; and by interaction of Florida Current frontal features with topography, which may be modulated by internal waves breaking on the reef slope. Multiple events of each type are characterized within a 23-month period in 2006-2007.

## 15-4

**Spatial And Temporal Variability in Velocity Shear Over Fringing Coral Reefs And Its Implications On Water Column Structure And Particulate Flux**

**Curt STORLAZZI*[1]**

[1]Coastal and Marine Geology Team, US Geological Survey, Santa Cruz, CA

Long-term hydrodynamic data from a number of bottom-mounted instruments and spatially-extensive, but temporally-limited, hydrographic surveys have been collected to better understand coastal dynamics on and among fringing coral reefs in Hawaii, USA. These high-resolution data (waves, currents, temperature, salinity, and turbidity) suggest that wave- and wind-driven flows appear to be the primary control on flow over shallow portions of the reefs while tidal and subtidal currents dominate flow over the deeper, outer portions of the reefs and insular shelf. Near-surface current directions over the fore reef vary on average by more than 40º from those near the seafloor, and the orientation of the currents over the reef flat differed on average by more than 65º from those observed over the fore reef. This shear occurred over relatively short vertical (O~meters) and cross-shore (O~100's of meters) scales, causing material distributed throughout the water column, including the suspended particles causing turbidity (e.g. sediment or larvae) and/or dissolved nutrients and contaminants, to be transported in different directions under constant oceanographic and meteorologic forcing, depending on its initial location. When the direction of the flows over the fore reef and the reef flat are counter one another, which is quite common, they cause a zone of cross-shore horizontal shear and often form a front, dividing turbid, lower-salinity water inshore from clear, higher-salinity water offshore. It is not clear whether these zones of high shear and fronts are the cause or the result of the location of the fore reef, but these features appear to be correlated alongshore over relatively large horizontal distances (O~kilometers). When two flows converge or when a single flow is bathymetrically steered, eddies can be generated that, in the absence of large ocean surface waves, tend to accumulate suspended particulate material.

## 15-5

**Experimental Characterization Of The Oceanic Water Fluxes in A Macro-Tidal Intermittently Open Lagoon Bounded By Semi-Submerged Coral Reef**

**Cristele CHEVALIER*[1]**, Jean-Luc DEVENON[2], Gilles ROUGIER[3]

[1]Cyroco, IRD, Marseille, cedex 09, France, Metropolitan, [2]Laboratoire d'Océanologie et de Biogéochimie, Université de la Méditerranée, Marseille, cedex 09, France, [3]Laboratoire d'Oceanographie et Biogeochimie, Université de la Méditerranée, Marseille cedex 9, France, Metropolitan

In the macro-tidal lagoons, of the Indian Ocean, coral reefs can be momentarily submerged by water at high tide and partially emerged at low tide. This process contributes to lagoon and open sea exchanges, although the reefs are often considered as impervious and the water fluxes assumed to occur only through the passes. We study the influence of this reef hydrodynamic control, by developing an original experimental approach combining small ship side mounted ADCP measurement following transects thru passes and near reefs, with more classical high resolution ADCP moorings. The aim is to gain insight in spatial variability of fluxes at a reasonable cost that moorings alone cannot be able to provide. This new strategy of measurement is exemplified at the occasion of an experimental campaign on the Mayotte lagoon and the results of this experiment are presented. Particularly, it is shown how the mounted ADCP data are validated. A specific tidal analysis methodology is then proposed to get the spatial variability of the tidal component of the current thru the passes and above the reef. This variability is identified by least square fitting of spatial distribution of the tidal amplitudes owing the availability of repeated transects associated with fixed point temporal sequences of current issued from moored ADCP currentmeters. This method has been validated against a priori known theoretical spatial distribution as well as in-situ already available data. All these analysis allow us to estimate the tidal induced fluxes thru the passes and above the reefs and to evaluate their respective part in water lagoon renewal.

## 15-6

**Morpho-Space Exploration Of Simulated Coral Morphologies And Three-Dimensional Images Of Scleractinian Corals**

**Maxim FILATOV*[1]**, Chris KRUSZYÑSKI[2], Jaap KAANDORP[1], Robert VAN LIERE[2], Mark VERMEIJ[3], Rolf BAK[4]

[1]Section Computational Science, University of Amsterdam, Amsterdam, Netherlands, [2]Center for Mathematics and Computer Science, Amsterdam, Netherlands, [3]University of Hawaii at Manoa, Maui fieldstation, Lahaina, HI, [4]Netherlands Institute of Sea Research (Nioz), Den Burg, Nepal

We developed a method for the quantitative analysis of three-dimensional images of complex-shaped scleractinian corals obtained with X-ray Computed Tomography scanning techniques. The analysis is based on a number of morphometric quantities, i.e. branching rate, branch thickness, branch spacing etc. We use this method for the quantitative comparison of morphological variation in closely related species in the Caribbean coral genus *Madracis*: *M. decactis, M. carmabi, M. Formosa* and *M. mirabilis*. We compare the *Madracis* morphologies with a range of simulated morphologies. In the simulations the morphologies were obtained in an accretive growth process where layers of materials are deposited on top of previous ones. The local thickness of new layers is controlled by the simulated physical environment (local availability of light and nutrient) and the amount of translocation of nutrient over the surface of the object. With the simulation model, varying a model parameter representing the amount of local translocation of nutrient over the surface of the object, we simulate a range of morphologies where branching forms gradually transform into more spherical shapes. By varying a parameter controlling the contribution of local light intensity we can change the overall branching pattern. Some of the simulated morphologies are almost indistinguishable from three-dimensional images of actual *M. mirabilis* and *M. decactis* colonies; some three-dimensional images (*M. formosa*) cannot be completely captured by our model. Our aim now is to find missing model parameters and to detect which actual morphologies can be predicted by our model using a systematic comparison of actual and simulated morpho-spaces.

## 15-7

**Use Of The Coral-Sel Technique in Water Flow Research**

**Carolyn MARGOLIN*[1]**

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

When flow experiments are carried out in open flow-through systems, several non-targeted variables also change with changing flow rate. These may include temperature, oxygen level, and food availability. In order to keep these factors constant across flow treatments, it is necessary to place all corals into a single water system while still exposing them all to different water flow rates. In order to accomplish this, a rotating "coral-sel" was constructed in an outdoor tank at the University of Miami's Aplysia Resource Center on Virginia Key. The coral-sel allows corals to be placed at three set distances from the center of rotation of the apparatus. This allows the corals to experience one of three set water flow rates while simultaneously being immersed in water with identical characteristics other than flow rate. These rates can be adjusted using a gear system on the external component of the coral-sel. Clod card techniques were used in order to test differences in flow rates at each of the specified distances prior to attachment of coral to each site. Fragments of *Montastraea faveolata* were attached to plates at each of the tested positions. Each fragment was monitored for survival, change in weight, change in surface area, and zooxanthellar activity. These data were used to determine the effects of water flow on the coral holobiont in terms of growth, calcification, and zooxanthellar activity. Statistical analysis showed that changes in fragment surface area were inversely related to water flow speed. However, the greatest increases in weight occurred at mid-flow rates (15.7 cm/s). Area and weight data were used to determine calcification rates. Apparent calcification rates were greatest for fragments exposed to mid-speed flow rates (15.7cm/s).

## 15-8

**Importance of the infragravity band in the wave energy budget of a fringing reef**

**Anne-Christine PEQUIGNET*[1]**

[1]Oceanography, University of Hawaii, Honolulu, HI

In an effort to understand and quantify wave energy at the shoreline of fringing reefs, a series of pressure sensors and current meters were deployed across fringing reefs on Guam and Oahu, Hawaii as part of the PILOT (Pacific Island Land-Ocean Typhoon) experiment. Spectral transformation of waves from the forereef to the shoreline is analyzed in terms of energy flux along the cross shore transects. Reflection, dissipation and non linear interactions are estimated during various offshore wave conditions and phases of the tide.

The wave transformation across the reef is strongly dependent on wave frequency and the wave energy spectrum on the reef flat is dominated by infragravity waves. This results from the combined effects of strong dissipation of sea and swell through breaking and friction, weaker dissipation of infragravity energy through friction and the generation of infragravity energy as the waves cross the forereef and the reef crest. Infragravity waves are reflected both at the forereef and the shoreline, whereas sea and swell waves are not reflected despite the steep reef face.

The wave energy in the sea and swell band at the shoreline of a fringing reef depends predominantly on the reef platform water depth, whereas the infragravity energy appears to depend more strongly on the offshore wave energy.

Although general trends in wave transformation may be observed on fringing reefs of different bathymetries, the presence of morphological features (such as porous reef face, longshore variation due to spurs and groove...) significantly affects wave transformation and makes each reef a unique breakwater system.

## 15-9

**Nonlinear Wave Transformation Over Shallow Fringing Reefs**

Okey NWOGU[1], **Zeki DEMIRBILEK*[2]**, Mark MERRIFIELD[3]

[1]University of Michigan, Ann Arbor, MI, [2]U.S. Army Engineer R & D Center, Vicksburg, MS, [3]Univeristy of Hawaii, Honolulu, HI

A set of field experiments were conducted to investigate spectral wave transformation over shallow fringing reefs due to nonlinear wave-wave interaction and wave energy dissipation. The experiments were conducted at a site located along the southeast coast of the Island of Guam. A cross-shore transect of four Aquadopp current profilers and three pressure transducers were used to measure the waves and currents over the reef. The offshore wave conditions were recorded with a directional wave buoy.

Numerical simulations were conducted with a nonlinear Boussinesq wave model. The effect of wave breaking is parameterized in the Boussinesq equations with an eddy viscosity based turbulent shear stress while the effect of bottom friction is parameterized with a quadratic drag law shear stress term. The Boussinesq model was initialized at the offshore boundary with buoy data. Comparisons of the measured and predicted spectral densities over the reef flat showed that the quadratic drag law parameterization for bottom friction could not adequately reproduce wave energy dissipation over rough coral surfaces. Although the bottom friction factor could be tuned to match the overall wave height, it dissipates wave energy across a broad range of frequencies including the infragravity band, in contrast to the field data that showed a preferential dissipation of the wave energy in the incident wind-wave frequency band.

One hypothesis for wave energy dissipation over shallow rough surfaces with the characteristic roughness scales of the order of 10 percent of the water depth is that the turbulent boundary layer is no longer restricted to a thin layer near the bottom but rather permeates the entire water column. This would lead to an eddy-viscosity type formulation for bottom friction as opposed to the quadratic shear stress formulation. Preliminary tests conducted with an eddy-viscosity based formulation of frictional dissipation matched the measured data much better.

## 15-11

**Hydrodynamics And Circulation On Monsoonally Influenced Reef Platforms: Interactions Between Processes And Morphology**

**Paul KENCH*[1]**

[1]Geography, Geology and Environmental Science, The University of Auckland, Auckland, New Zealand

Improved understanding of hydrodynamics and controls on circulation processes in coral reefs systems has been highlighted in numerous studies due to the importance of such processes on ecological and biological functions. In contrast, few studies have considered the importance of reef platform hydrodynamics on geomorphic processes (e.g. sediment transport and island building) or interactions between reef morphology (other than the reef rim) and hydrodynamic processes. The hydrodynamics of reef platforms are controlled not only by the deep water to reef flat transition but subsequent transformations of energy on reef surfaces. This study examines the wave and current processes on reef platforms in the Maldives. Specific aims are to examine the influence of predictable shifts in monsoons on reef platform hydrodynamics and to evaluate morphological feedbacks on reef circulation. Detailed wave and current records were obtained from three small reef platforms in the central Maldives. The reef platforms vary in shape, have similar size, and all have vegetated reef islands that occupy 21 to 45% of reef area. Instruments were deployed at six locations on each reef to capture spatial variations in wave and current processes and experiments were repeated under differing monsoon conditions. Results show that the magnitude of wave energy and wave direction is modulated by variations in monsoon conditions (from the west and northeast). The presence of reef islands and moats exerts a major control on circulation patterns. However, circulation changed markedly between different monsoon phases. The degree of alteration in circulation is related to reef shape, reflecting the sensitivity of different shaped reefs to changes in wave approach and wave transformation. Consequently, circulation is shown to reverse between monsoon phases on circular reef platforms but exhibited more subdued changes on elongate reefs.

## 15-12

**Aster Bathymetry in Computational Fluid Dynamic Simulation Of Rongelap Atoll Hydrodynamics, Marshall Islands**

**Eric PETERSON*[1]**

[1]Institute for Sustainability and Innovation, Victoria University, Melbourne MC VIC, Australia

ASTER green, red and near infra-red (NIR) imagery with a resultion on the order of handheld GPS echo soundings was calibrated to model bathymetry of Rongelap Atoll to a depth of 10 meters. Beyond that depth nautical charts and echo soundings were used to model bathymetry. The combined result is illustrated in Figure 1.

Figure 1 Bathymetric model of Rongelap

Shape files of depth contours were converted to ordered ASCII X,Y,Z vertex files input into the finite element meshing program GAMBIT (FDI and ANSYS). These data were then ordered in volumetric and substrate surface elements of coral reefs and input to the FLUENT computational fluid dynamics (CFD) package. Bluelink (Australian Bureau of Meteorology and CSIRO) was used to apply boundary conditions, and results are hydrodynamic charts of the atoll. The resulting map of substrate shear stress at Rongelap is displayed in Figure 2.

Figure 2 Benthic shear stress of Rongelap Atoll

## 15-13

**Finite-element model of the Great Barrier Reef circulation**

**Jonathan LAMBRECHTS*[1]**, Eric DELEERSNIJDER[1], Vincent LEGAT[1], Emmanuel HANERT[2], Eric WOLANSKI[3]

[1]Institute of Mechanics Materials and Civil Engineering, Université catholique de Louvain, Louvain-la-Neuve, Belgium, [2]Department of Meteorology, University of Reading, Reading, United Kingdom, [3]James Cook University, Townsville, Australia

An unstructured-mesh, finite element, depth-integrated model of the hydrodynamics of the whole Great Barrier Barrier Reef (GBR), Australia, has been developed and implemented on a parallel computer. Far away from reefs, islands and important bathymetric features, the mesh size may be as large as a few kilometres,whereas, in the vicinity of reefs and islands, the grid is drastically refined, leading to meshes that can be 100 metres in size. This enables our model to simulate motions characterized by a wide range of space and time scales. Large scale currents, i.e. the tides, the wind-induced circulation and the bifurcation of the East Australian Current, are reproduced with an accuracy that is comparable to that achieved by today's large-scale models of the GBR. The model is also successful at representing small-scale processes, such as tidal jets, their instabilities, as well as the eddies developing in the wake of islands and headlands. Both large and small scales have been validated.

A study of multi-scale reef connectivity has been undertaken.

Biological applications based on this hydrodynamical model have been undertaken such as a model of the threat from lethal jellyfish at the GBR coast and a study of multi-scale reef-connectivity.

## 15-14

**Momentum Balances Across A Wave-Dominated Coral Reef**

**James HENCH*[1]**, Hunter LENIHAN[2], Stephen MONISMITH[1]

[1]Environmental Fluid Mechanics Laboratory, Stanford University, Stanford, CA, [2]University of California, Santa Barbara, Santa Barbara, CA

For many coral reefs, circulation is dominated by waves breaking over the reef crest that drive a strong circulation over back reef habitats. Unlike classical work on beaches, where the primary momentum balance is between radiation stress gradients and set-up of the free surface, flows over coral reefs typically have mean flows into a lagoon, and thus friction can also be important in the momentum balance. Unfortunately friction on coral reefs is difficult to estimate a priori due to the remarkably high rugosity. Here we studied a nearly tideless system in Moorea, French Polynesia to isolate the effect of wave forcing on coral reef circulation. An array of 7 stations spanning the forereef, reefcrest and backreef areas, were each instrumented with pressure sensors and velocity profilers. The resulting data were used to estimate the contribution of each term in the cross-reef momentum balance, as well as corresponding bottom friction coefficients. Initial results show that the momentum balance varies markedly with distance from reefcrest and transitions from a radiation stress and set-up balance, to a friction and set-up balance.

## 15-15

**Defining Drag Coefficients For Coral Reefs**

**Johanna ROSMAN*[1]**, James HENCH[1]

[1]Environmental Fluid Mechanics Laboratory, Stanford University, Stanford, CA

Coral reefs form a very rough bottom boundary that is porous to water flow. Drag due to a coral reef is typically modeled using a simple quadratic drag law with a bulk drag coefficient; however, several different definitions have been used in the literature and a wide range of values have been reported. We have developed a formal framework for estimating drag coefficients for flow over coral reefs in the absence of surface waves. We consider three different definitions, in which the above-canopy, within canopy and depth-average velocity are used for the drag parameterization. Using a simple two layer model we derive expressions for the drag coefficient in terms of morphological and flow parameters. We show that drag coefficients can vary by more than an order of magnitude for the same geometry and flow, depending on the definition used.

## 15-16

**Roughness and the Effects of its Spatial Variability on Coral Reefs**

**Clifford HEARN*[1]**

[1]ETI Professionals at USGS, St Petersburg, FL

Topographic and bathymetric complexity are key controls on the hydrodynamics of coral reefs. They exist on all spatial scales from microns to kilometers on reefs and within hydrodynamic studies are all treated as part of the spatial spectrum of the generalized concept of 'roughness'. Coral reef hydrodynamics treats roughness in a variety of ways at different spatial scales. Roughness has a major influence on the way that currents flow over reefs and the processes by which energy is transported and dissipated. A fundamental property of roughness is that the average roughness below any specified spatial scale is itself spatially variable on that scale. This means that a hydrodynamic model of a reef will necessarily include spatially varying smaller-scale roughness. This paper considers one feature of this phenomenon which is the change in roughness length, or frictional drag coefficient, encountered between distinct topographic zones of a reef such as the fore-reef, reef-flat and back-reef. The analysis is based on frictional Reynolds numbers for the individual zones of the reef which are combined into a 'reef Reynolds number' which is a measure the relative magnitudes of large scale and small scale roughness. The paper examines the implications of the larger scale variability of roughness on the connectivity between the zones of a reef as provided by the transport of materials and turbulence.

## 16-1

**Sampling State And Process Variables On Coral Reefs**

**Roger GREEN*[1]**, Brian MCARDLE[2], Robert VAN WOESIK[3]

[1]Department of Biology, The University of Western Ontario, London, ON, Canada, [2]Department of Statistics, The University of Auckland, Auckland, New Zealand, [3]Biological Sciences, Florida Institute of Technology, Melbourne, FL

Contemporary coral reefs are forced to survive through and recover from disturbances at a variety of spatial and temporal scales. Understanding disturbances in context of background processes will lead to accurate predictive models of population trajectories over time. Most reef studies and monitoring programs examine the state (variables) of reefs, by assessing the coverage of major benthic organisms; few studies examine the key ecological processes that drive the state variables. Here we outline a sampling strategy that captures both state and process variables, at a spatial scale of 10s of kilometers. Specifically we are interested in 1) examining spatial and temporal patterns in coral population size-frequency distributions, 2) determining vital processes, including rates of recruitment and mortality, 3) examining relationships between processes and state variables and whether size distributions reflect population performance, and 4) assessing which state and process variables relate to environmental forcing functions. Our effective sampling units are randomly selected 75 x 25 m stations, spaced approximately 250-500 m apart, representing a 103 m spatial scale. Stations are nested within sites, spaced approximately 2 km apart, representing a 104 m spatial scale. Three randomly selected 16 m2 quadrats placed in each station, and marked for relocation, are used to assess processes across time; while random belt-transects, re-randomized at each sampling event, are used to sample state variables. Both quadrats and belt-transects are effectively sub-samples from which we derive estimates of means for each station at each sampling event. This nested sampling strategy is allowing us to examine population performance, critical stages in demographic performance and vital rates across locations that can be easily applied to Marine Protected Areas to examine whether and how protecting areas may influence major state and process variables.

## 16-2

**Synoptic Ecological Tools For Coral Reef Science**

**Bruce HATCHER*[1]**, Jinyu SHENG[2], Serge ANDREFOUET[3]

[1]Bras d'Or Institute for Ecosystem Research, Cape Breton University, Sydney, NS, Canada, [2]Dalhousie University, Halifax, NS, Canada, [3]Institut de Recherche pour le Développement, Nouméa, New Caledonia

Coral reefs are well-suited to applications of spatial ecology because of their clear geomorphologies, sessile life forms and water-borne vectors of interaction. The challenges of portraying the pattern and pace of change in coral reef ecosystems are increasingly addressed through emerging technology and theory that permit the depiction of the spatial distribution of ecological units at relevant scales of reef existance, and the prediction of interaction parameters across ecological time-space. Acquisition and interpretation of remotely sensed data and imagery provides the maps, and hybrid numerical models of physical advection and bio-physical dispersion provide the movies that combine to support hypothesis testing. The addition of numerical optimization models to the domain supports scenario-based adaptive management. The devil is in the details of scaling and interfacing the pixelated technologies and reconciling the physical versus biological variabilities. Ecological connectivity among coral reef ecosystems is the current test bed the integration of synoptic ecological tools. Through our collaborative experience, we have learned a set of lessons and techniques, which are offered for your consideration.

## 16-3

**Multi-Scale Approach For Assessing The Effects Of Land-Based Contamination On The Southeast Fringing Reef Of Molokai**

**Laetitia HEDOUIN*[1]**, Bernardo VARGAS ANGEL[2], Amanda REICHELT-BRUSHETT[3], Xavier POCHON[1], Ruth D. GATES[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]Coral Reef Ecosystem Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, [3]School of Environmental Science and Management, Southern Cross University, Lismore, Australia

On a global scale, there is now deep concern as to whether coral reefs will survive shifts in the marine environment associated with global climate change; however, on a local scale, many of the reefs in Hawaii are most imminently and seriously threatened by coastal development and changes in land use. Few tools are currently available for assessing the impacts of land-based contamination on the health of reef corals. The first step in developing such tools is to identify biological traits in corals that are responsive to land-based contamination. The current project focuses on corals sampled on the SE coast of Molokai that are threatened by sediment stress e.g. high to low sediment deposition rates. Ecological, physiological and histological characteristics have been measured in corals sampled at 8 stations along the fringing reef of Molokai that cross a gradient of sediment stress. Data have been statistically analyzed to identify biological traits that most tightly correlated with the stress exposure regimes measured at each sampling station. Protein concentration, chlorophyll a concentration, and zooxanthellae densities decrease with increasing sediment loads suggesting that these physiological measures are useful indicators of sediment exposure in corals. Ecological, physiological and histological data represent different temporal windows of the biological response of corals to sediment stress. We are currently exploring whether the integration of these data streams collectively provide greater insight into the biological effects of sediment stress on coral health than each of them alone.

## 16-4

**Using Cellular Diagnostics To Link Land-Based Sources Of Pollution With Coral Reef Degradation in South Florida**

**Phillip DUSTAN*[1]**, John FAUTH[2], Kenneth BANKS[3], Eric PANTE[4], Bernardo VARGAS-ANGEL[5], Craig DOWNS[6]

[1]Department of Biology, College of Charleston, Charleston, SC, [2]Department of Biology, University of Central Florida, Orlando, FL, [3]Department of Environmental Protection, Broward County, Fort Lauderdale, FL, [4]Department of Biology, University of Louisana at Larayette, Lafayette, LA, [5]Coral Reef Ecosystem Division, NOAA Pacific Island Fisheries Sciences Center, Honolulu, HI, [6]Cellular Diagnostics and Proteomics, Haereticus Environmental Laboratory, Amherst, VA

This project is a first step in identifying the chain of causality between land-based pollutants, responses of individual reef-building corals, and health of coral reef communities in the South Florida watershed. We tested the feasibility of using cellular diagnostics to link land-based sources at four paired inshore and offshore stations off Broward Country, FL (control, sewage wastewater outfall, an inlet mouth and a wastewater outfall adjacent to an inlet). Live coral coverage was <4% at all sites and cluster analysis grouped all inshore sites (except one) together based on having the least bare substrate and co-occurrence of the cyanophyte, Lyngbya spp.

Cellular diagnostics performed on tissue samples of a scleractinain coral (Porites astreoides) revealed that corals at all sites were stressed compared to colonies from a more pristine site in the Bahamas. Offshore corals consistently had higher accumulations of stress markers than inshore colonies. Stress responses of corals from the wastewater outfall and additional samples collected within the Florida Keys National Marine Sanctuary were consistent with sewage exposure, while responses of offshore colonies were consistent with xenobiotic detoxification. Accumulations of biomarkers of xenobiotic response and decreased protein turnover were associated with decreased rates of coral regeneration. In addition, lesion regeneration rates were significantly greater than zero only at three inshore sites and the offshore control site. Results of our study confirm the assessment of The World Research Institutes's Reefs at Risk Program; coastal development and treated wastewater discharge are chronic sources of stress for coral reefs along Florida's extensive reef tract.

## 16-5

**Development and Application of Variable Fluorescence Techniques and Instrumentation for Monitoring and Assessing Coral Reefs**

**Maxim GORBUNOV*[1]**, Dan TCHERNOV[2], Liti HARAMATY[3], Yael HELMAN[3], Frank NATALE[3], Sophia JOHNSON[3], Paul FALKOWSKI[3]

[1]Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, [2]The Interuniversity Institute of Eilat, The Hebrew University of Jerusalem, Eilat, Israel, [3]Rutgers University, New Brunswick, NJ

The development of advanced technologies for environmental monitoring of coral reef ecosystems requires an understanding of how different environmental factors affect the key elements of the ecosystems and the selection of specific monitoring protocols that are most appropriate for the identification and quantification of particular stressors. Documenting the environmental state of reef communities is critical to developing remediation strategies that can both reduce anthropogenic insult and distinguish between common natural factors and anthropogenic stressors. Bio-optical methods are particularly useful for rapid and non-destructive assessment of the viability of coral reef organisms. Here we present a methodology and instrumentation called Fluorescence Induction and Relaxation (FIRe) System for assessment of photosynthetic and physiological status of coral. We have designed and developed bench-top, diver-operated and moorable instruments. The variable fluorescence technique relies on the relationship between chlorophyll fluorescence yield and the efficiency of photosynthetic processes and provides a comprehensive suite of photosynthetic and physiological parameters, including the quantum yields of photochemistry in Photosystem II (PSII), the functional absorption cross section of PSII, the rates of photosynthetic electron transport on the acceptor side of PSII and between PSII and PSI, coefficients of photochemical and non-photochemical quenching. In combination with conventional biochemical and molecular biological methods, the FIRe technique was employed to study the impact of common natural stresses (episodes of elevated temperature and excess irradiance), as well as selected anthropogenic factors (heavy metal contamination and pollution) on coral. The analysis revealed that different stressors lead to specific damage to the coral symbioses and are characterized by unique FIRe fluorescence signatures that can be can be used for quantitative assessment of coral health and selective identification of the stressors.

## 16-6

**Potential Application Of Pam Fluorometry in Reactive Coral Health Monitoring Programs: A Pilot Study**

**Jeremy SOFONIA*[1]**

[1]Marine and Coastal Science, Sinclair Knight Merz Pty. Ltd., Perth, Australia

Regulatory authorities in Australia increasingly require proponents of commercial development to detect, and respond to, changes in water quality and coral heath prior to the onset of mortality. The use of pulse-amplitude modulated (PAM) fluorometry as an instrument to detect sub-lethal change within photosynthetic organisms is well documented, however, the use of this tool on scleractinian corals *in-situ* is challenging as ambient environmental conditions directly affect the measured result, monitoring is often restricted to daylight hours and dark adaptation of individual colonies logistically difficult. The use of PAM in reactive coral health monitoring programs is currently limited as sampling is implemented on a set schedule, under a wide range of ambient conditions, and often comprising large coral populations over a wide geographic area. Here two photosynthetic corals, *Turbinaria mesenterina* and *Porites lobata*, are observed *in-situ* across a natural range of light (0 – 320 µmol m-2 s-1) and temperature (18.9 – 30.0 °C). Three fluorescence parameters were estimated including effective quantum yield of photosystem II (ΦpsII), slope of the initial linear range, alpha (α), of the photosynthesis-irradiance (P-I) curve and the maximum relative electron transport rate (rETRmax). Of these, obtaining ΦpsII was comparitively faster and better correlated to changes in ambient light (PARamb). Mean ΦpsII was significantly higher in *T. mesenterina* than *P. lobata* in both regimes, however, responses to PARamb were virtually identical (*T. mesenterina*: y= -0.0011x + 0.668, R2= 0.59; *P. lobata*: y= -0.0009x + 0.621, R2= 0.67) and temperature had no significant effect. The use of α and rETRmax from so-called rapid light curves (RCL) were comparatively non-informative and logistically restrictive. It is hypothesised that specific correlations between ΦpsII and PARamb, if established prior to development, may be used as a benchmark to compare the photosynthetic condition of coral symbiotes and potentially provide a rapid assessment of sub-lethal change.

## 16-7

**A Comparison Of Thermal History And *fv/fm* in Inner Lagoon And Outer Barrier Reef *montastrea Faveolata.***

**Karl CASTILLO*[1]**

[1]Marine Science Program, University Of South Carolina, Columbia, SC

Pulse amplitude modulated (PAM) fluorometry has been suggested as a tool to complement monitoring efforts for predicting environmental stress in corals. However, documented changes in maximum quantum yields ($F_v/F_m$) of corals during non-bleaching periods have been limited. Here, thermal exposures of inner lagoon and outer barrier reef *Montastrea faveolata* were examined. The hypothesis that inferred differences in thermal histories would be reflected in $F_v/F_m$ values was tested. Ambient seawater temperatures adjacent to corals at 1, 3, 6, 9 and 15 m depth were measured every 10 min from October 2006 to June 2007 in the inner and outer reefs of southern Belize. Maximum and mean diel seawater temperature and number days above the local bleaching threshold of 29.8 °C were not significantly different between locations and across each depth. However, minimum and standard error of the mean diel seawater were significantly different between locations and across several depths. Since aspects of seawater temperature varied across locations and depths, the photophysiology of these corals was assessed to test for an association between physical and biotic factors. In June 2007, $F_v/F_m$ for *M. faveolata* were measured *in situ* across the same gradient and compared between both locations. $F_v/F_m$ correlated positively with depth in both locations, and was significantly higher in the inner reefs. To test for a cause-and-effect relationship between temperature and photophysiology, samples of *M. faveolata* were collected and exposed to controlled temperature treatments. Exposure to elevated temperature caused $F_v/F_m$ to be depressed to a greater extent in corals from the outer compared to inner reef, but this effect was not constant at all depths. These results suggest that thermal stress though important may not be the only factor influencing the observed difference in $F_v/F_m$ values for *M. faveolata* from the inner lagoon and outer barrier reefs at this location.

## 16-8

**Shifting Bleaching Thresholds: Acclimatization Or A Flawed Model?**

**Ray BERKELMANS*[1]**

[1]Australian Institute of Marine Science, Townsville, Australia

Time-integrated bleaching thresholds are one of a suite of locally specific bleaching indices that have been developed based on *in situ* measured temperature data. In recent years these have been adopted as an early warning system on the Great Barrier Reef (GBR), augmented by satellite-based early warning systems such as 'HotSpots' and 'ReefTemp'. The original bleaching thresholds were developed after the 1998 bleaching event, but how well have they performed since then, especially in predicting the 2002 GBR bleaching event? This study reviews the efficacy and accuracy of the time-integrated bleaching thresholds using statistical and empirical techniques. The results show that time-integrated bleaching thresholds accurately predicted bleaching (and non-bleaching) at most reefs in 2002. However, a number of reefs in the central GBR exceeded bleaching thresholds in 2004 and 2005 without bleaching. These anomalies are not explained by selective mortality or other meteorological factors, including global radiation and UV. They are also not explained by pre-season acclimatization. Long-term thermal acclimatization remains the most likely explanation. Mortality thresholds based on 50% mortality of thermally sensitive and locally abundant coral taxa were derived for six reefs that suffered high mortality during past bleaching events. An analysis of these curves in relation to their bleaching thresholds indicates that at most of these sites thermally sensitive taxa die <1 °C above their bleaching threshold and many <0.5 °C above their bleaching threshold. These results highlight the fine line that exists between recovery and death of thermally-sensitive corals following bleaching.

## 16-9

**Integrating Satellite and In Situ Light, Wind and Temperature Data for Ecological Forecasting of Coral Bleaching at Four Sites in the Caribbean**

James HENDEE[1], Tao ZHENG[2], Lew GRAMER[3], **Erik STABENAU*[4]**, Derek MANZELLO[5], Shunlin LIANG[6]

[1]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, [2]Department of Geography, Central Michigan University, Mount Pleasant, MI, [3]Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL, [4]South Florida Natural Resources Center, Everglades National Park, Homestead, FL, [5]Rosenstiel School for Marine and Atmospheric Sciences, University of Miami, Miami, FL, [6]Department of Geography, University of Maryland, College Park, MD

Satellite and in situ irradiance instruments provide different perspectives on the ocean environment, the former providing regional coverage of incident radiation, the latter providing both site-specific light penetration data, as well as validation of the satellite readings. Physiological studies of corals reveal that sea temperature and light, under elevated and sustained conditions, induce coral bleaching. At the Atlantic Oceanographic and Meteorological Laboratory (AOML), ecological forecasts (ecoforecasts) such as coral bleaching are produced using an artificial intelligence tool that integrates various data sources (e.g., satellite and in situ) in near real-time, and includes heuristic and numeric modeling capabilities. To improve upon existing ecoforecasts of bleaching, satellite acquired Photosynthetically Available Radiation (PAR) data were produced by Central Michigan University during April through August, 2007 for four stations of AOML's Integrated Coral Observing Network (ICON), located in the Bahamas, Jamaica, Puerto Rico and St. Croix. The satellite derived instantaneous PAR values were estimated within nine pixels of a 3x3 window centered on a site's latitude and longitude. In situ sea surface PAR values at each site were used to validate the average of the nine estimated values, with time interpolation applied to match surface measurement and satellite observation times. The satellite and surface PAR data agreed well at all four sites. Irradiance at the coral surface was calculated using attenuation coefficients ($K_d$) derived from readings from well-maintained sub-surface irradiance sensors at each site and were extrapolated to each region using the satellite PAR readings. Satellite and surface wind and sea temperature data were combined with these readings to produce regional bleaching ecoforecasts. Inherent problems of high spatial and temporal variability in solar radiation at any defined point provide unique challenges to large-scale implementation. Although major bleaching was not observed during this time frame, output from the ecoforecasting construct shows promise for future implementation.

## 16-10

**GBROOS – An Ocean Observing System for the Great Barrier Reef**

**Scott BAINBRIDGE*[1]**

[1]Australian Institute of Marine Science, Townsville, Australia

The Great Barrier Reef Ocean Observing System (GBROOS), a geographic node of the Australian Integrated Marine Observing System (IMOS), is an observation network currently being deployed along the Great Barrier Reef (GBR) in Northern Australia. The project aims to quantify and monitor the impact of the Coral Sea, in particular cool and warm water intrusions, on the GBR and to provide the real-time physical data required to understand the impact of climate change and other environmental factors on coral reef ecosystems.

The project has four components. Sets of long-term oceanographic moorings consisting of paired deep (200m) and shallow (30-70m) moorings will be deployed to detect water moving onto and long the GBR from the pole-ward East Australian and the equatorial Hiri western boundary currents. Upgraded Remote Sensing capacity (SST and Ocean Colour), coupled with real-time underway sampling to validate the remotely sensed data, will give large-scale information about the GBR.

Sensor networks located at seven sites, using high-speed communications and a range of buoy mounted sensors, will provide real-time information about small-scale phenomena. This component provides a platform for the development and testing of the next generation of smart technologies and approaches for real-time observing systems.

The observational data will have significant impact on our understanding of global change, its potential impact on the physical and chemical conditions in marine environments and the associated changes to the biology and structure of the GBR. GBROOS is setting up the infrastructure to support a new generation of observation systems from sophisticated real-time moorings to the communication and data systems for 'smart' sensor systems. This data, coupled with model and scenario engines, will increase our ability to understand changes in the physical environment and the impact these have on coral reef systems.

## 16-11

**Ecological Forecasting for Coral Reef Ecosystems**

**James HENDEE*[1]**, Lew GRAMER[2], Derek MANZELLO[3], Erik STABENAU[4], Chris LANGDON[3], Mike JANKULAK[2]

[1]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, [2]Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL, [3]Rosenstiel School for Marine and Atmospheric Sciences, University of Miami, Miami, FL, [4]South Florida Natural Resources Center, Everglades National Park, Homestead, FL

Assessment of coral reef ecosystems implies the acquisition of precision data and observations appropriate for answering questions about the response of multiple organisms to physical and other environmental stimuli. At the National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorological Laboratory, we model marine organismal response to the environment in terms of a Stimulus/Response Index (S/RI). S/RI is computed using an approach called heuristic programming, from parameters bounded in subjective terms, which are defined within the software numerically, so as to match research and our understanding of the process in question. The modelled organismal response is called an ecological forecast, or ecoforecast, and the likelihood and severity of the response is reflected in a rising S/RI. We have had success to date in modelling coral bleaching response to high sea temperatures plus high irradiance and other parameters. The approach requires, a) highly robust instrumentation (in situ, satellite, or other) deployed for long periods and producing high quality data in near real-time, b) a basic understanding of the process, behavior and/or physiology being modelled, and, c) a knowledge of approximate threshold levels for single or synergistically acting environmental parameters that elicit the phenomenon in question. We use both traditional (e.g., sea temperature, salinity, light), as well as novel (e.g., pCO2, pulse amplitude fluorometry) oceanographic instruments to produce a continuous S/RI that has been used as an overall indicator of ecosystem health at all ICON coral reef monitoring locations. We are now actively researching ecoforecast models of species-specific spawning, and of enhanced water column productivity on reefs. Results from recent monitoring efforts, as well as the implications of adapting this technique for use in other locations or on data streams managed by other agencies, will be presented.

## 16-12

**Advancing Spatial-Temporal Continuity in Coral Reef Ecosystem Pattern Detection: The Morphology, Distribution And Chemical Environments Of Coral Habitats Encompassing Coiba National Park, Panamá.**

**Luis CAMILLI*[1]**, Oscar PIZARRO[2], Richard CAMILLI[3]

[1]Center for Habitat Studies, Moss Landing Marine Laboratories, Moss Landing, CA, [2]Australian Centre for Field Robotics, University of Sydney, Sydney, Australia, [3]Applied Ocean Physics & Engineering Dept, Woods Hole Oceanographic Institution, Woods Hole, MA

Quantitative study of environmental change in coral ecosystems is challenging, costly, and hindered by inadequate scales of observation. A synoptic perspective of reef biogeochemical dynamics and community structure was revealed using new technologies and methods designed to enable high resolution underwater habitat assessment with non invasive monitoring capabilities and rapid information output. A towed, chemical sensor platform and a diver-based, automated imaging system were developed to compare reef architecture and benthic morphology across spatial scales ranging from centimeters to kilometers, and resolve sub-meter variability in ambient water chemistry across basin scale seascapes. Acoustic bathymetry, stereo-optical imaging, in-situ underwater mass spectrometry, CTD, chlorophyll, and CDOM data were coupled with precision navigation to enable multi parameter biogeochemical and structural comparisons of coastal and island coral habitats surrounding Parque Nacional Coiba, a UNESCO World Heritage site in Pacific Panamá. Baseline chemical data (O2, CO2, CH4, N2) and 3-D digital reef mosaics generated in this research were augmented with traditional monitoring protocols, time series data from a moored observatory, video sampling and remote sensing analysis to create and validate comprehensive, thematic water chemistry and benthic habitat maps. This integrated approach shows considerable promise for locating, predicting and quantifying natural and anthropogenic environmental stressors affecting the distribution, diversity and health of tropical coral communities.

## 16-13

**Landscape Mosaics Of Coral Reefs: A New Survey Technology For Mapping And Monitoring Reef Condition**

**Brooke GINTERT*[1]**, Nuno GRACIAS[2], Diego LIRMAN[1], Arthur GLEASON[1], Philip KRAMER[3], R. Pamela REID[1]

[1]University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [2]Department of Electronics, Computer Engineering and Automatics, Universitat de Girona, Girona, Spain, [3]The Nature Conservancy, Summerland Key, FL

Efficient survey methodologies that provide comprehensive assessment of reef condition are fundamental to coral reef monitoring. Current state-of-the-art techniques in coral reef assessment rely on highly trained scientific divers to extract indices of reef health (e.g. substrate cover, species richness, coral size, coral mortality, and coral recruitment). Landscape video mosaics are an innovative survey technology that provide large scale (up to 400m2), spatially accurate, high resolution images of the reef benthos without extensive survey times or a need for scientific divers. Based on diver-acquired video of the reef benthos and novel mosaicing algorithms, landscape mosaics have been used in the laboratory to extract indices of benthic cover, coral colony size, and colony health that compare favorably with diver surveys. The spatially explicit images allow users to make accurate benthic measurements (such as colony area and diameter, as well as distance relationships for spatial analysis) directly from mosaic products. Repeated mosaic surveys of the same area are easily referenced for change detection analysis and provide an image-based monitoring capability that can survey hundreds of coral colonies over time without the use of *in situ* tagging and underwater relocation. In addition, landscape mosaics provide a large-scale visual permanent record of the state-of-the-reef at the time of collection that is accessible to both the scientific community and general public. To date this technology has been used to detect and monitor changes in reefs responding to hurricanes, ship groundings, and mass bleaching events.

## 16-14

**Imaging Coral Community Structure At High Resolution Over Large Areas On The Reef Terraces Of The Chagos Archipelago**

**John TURNER*[1]**, Robert GIBBS[1]

[1]School of Ocean Sciences, Bangor University, Bangor, United Kingdom

A new technique is described to image large areas of coral reef at high resolution to analyse coral community structure and improve public awareness of reef environments. A major problem encountered in mapping any benthic community is obtaining an *optical* image that covers sufficient area at high resolution to identify species and investigate spatial relationships. Such large images are difficult to obtain in turbid waters (hence acoustic methods are used) and also in clear waters, where either the water depth is so shallow that camera to subject distance is short, or in deeper water where distance is long but resolution poor. Previous research on reef biotope mapping has identified the need to formulate an image *within* a 20-30 m2 pixel, so typical of satellite remote sensing imagery used in wider scale mapping. A diver-operated rig was designed to carry a high resolution digital underwater video camera and lighting, such that accurate circular tracks of reef could be sequentially imaged about a central point. Each ring increased in diameter to overlap the preceding circle, ensuring 100 % cover. The technique was deployed at 5 sites between 10 and 20 m depth on different reef slopes around 4 atolls of the Chagos archipelago. Software was written to mosaic 3,570 video images recorded across 21 rings to create a 76 square metre image of each site, resulting in a resolution of 2 mm at 1m distance from the reef. Images of the different sites were analysed using MapInfo GIS to assess spatial relationships between coral colonies, and to examine recovery at colony scale on a previously bleached reef. The images are being used for monitoring and conservation policy formulation. Sections of images will be reproduced at life-size in the new London Zoo Chagos reef exhibit, to assist in the public understanding of reefs.

## 16-15

**Bioeroding Sponges Need To Be Monitored**

**Christine SCHÖNBERG*[1]**, Katherine E. HOLMES[2]

[1]Dept. of Animal Biodiversity and Evolution, Carl von Ossietzky University, Faculty 5, Biology and Environmental Sciences, Oldenburg, Germany, [2]Center for Biodiversity and Conservation, American Museum of Natural History, New York, New York, NY

Bioeroding sponges are important in the balance of coral reef construction and destruction. Due to changes in environmental conditions, these sponges can become epidemic and have occasionally been recognised for their value as bioindicators. Recent studies revealed increases in bioeroding sponge abundances in the Caribbean and on the Australian Great Barrier Reef, which was largely explained with deteriourating conditions or disturbance events that led to an increased availability of suitable substrate for the settlement of bioeroders. The sponges appear to be hardier than corals, even if they are zooxanthellate. We propose to incorporate the most common species of bioeroding sponges into long-term monitoring projects. Species of the '*Cliona viridis*' complex are thought to be most suitable for this, because they occur at all study sites, but species such as the Caribbean *Cliona delitrix* should also be considered. If the procedure is kept simple (see proposal on poster), replicate studies can be conducted at very different sites and in consecutive approaches, eventually leading to a sound database on the leading endolithic agents of warm water bioerosion.

## 16-16

**Solar Radiation Dosimetry In Florida Coral Reefs Determined From Remote Sensed, Modeled, And In Situ Data**

**Mace BARRON*[1]**, Deborah VIVIAN[1], Susan YEE[1], Debbie SANTAVY[1]

[1]U.S. Environmental Protection Agency, Gulf Ecology Division, Gulf Breeze, FL

Solar irradiance has been increasingly recognized as an important determinant of bleaching in coral reefs, but measurements of solar radiation exposure within coral reefs have been relatively limited. Solar radiation dosimetry within multiple coral reef areas of South Florida was assessed using remote sensed, modeled, and measured values during a minor bleaching event (August 2005). Coral reefs in the Dry Tortugas and Upper Keys had similar diffuse down welling attenuation coefficients (Kd, m-1), but Kd values were significantly greater in the Middle and Lower Keys. Mean one percent attenuation depths varied by reef region for ultraviolet B (UVB; 9.7 to 20 m), ultraviolet A (UVA; 22 to 40 m) and visible (27 to 43 m) solar radiation. Solar irradiances determined from remote sensed surface intensity and Kd were significantly correlated with measured values, but were generally over estimated at the depth of corals. Solar irradiances modeled using an atmospheric radiative transfer model parameterized with site specific approximations of cloud cover showed close agreement with measured values. Estimated daily doses (W*hr/m2) of UVB (0.01-19), UVA (2-360) and visible (29-1653) solar radiation varied with coral depth (2 to 24 m) and meteorological conditions. These results indicate large variation in solar radiation dosimetry within coral reefs that may be estimated with reasonable accuracy using regional Kd measurements and radiative transfer modeling.

## 16-18

**Estimating Three-Dimensional Coral Colony Surface Area from Simple Field Measurements**

Lee COURTNEY[1], **William FISHER*[1]**, Sandy RAIMONDO[1], Leah OLIVER[1], William DAVIS[1]

[1]National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, US Environmental Protection Agency, Gulf Breeze, FL

Topographic surface area (SA) of coral colonies is a critical descriptor for biological and physical attributes of reef-building (scleractinian) corals. SA is directly related to coral sustainability (e.g., living tissue) and anthropocentric values (e.g., fish habitat, shoreline protection). Most existing methods to estimate colony SA are destructive and limited to laboratory settings. However, a recently-described photographic method was tested and found applicable to field colonies. A highly accurate 3-dimensional digital reconstruction is generated using specialized computer software and multiple images of a coral colony. SA determined from the reconstructed colony is within 2-5% of SA determined by laser-scanning. The method was used to evaluate three approaches, or models, for calculating SA of coral colonies from simple morphological measurements made in the field. The models included a volumetric size-class (SA = 5 sides of a cube), a hemispheric surrogate (SA = $2\pi r2$, where r is determined from height, diameter and width), and a suite of log-linear formulae generated from stepwise multiple regression of reconstructed colony SA against colony height, diameter and width. When SA determined using field collected data were compared to SA of reconstructed images, the log-linear model was most accurate (12% difference from reconstruction values), followed by the hemispheric surrogate (17% difference) and size-classes (40% difference). While only four species were included in these analyses (*Montastraea faveolata, M. cavernosa, Diploria strigosa* and *D. clivosa*), SA of specimens from seven additional species were credibly estimated (<20% difference) using the log-linear and hemispheric models. Greater differences were observed with more complex colonies which may require different models. Results from this study have been used in the Environmental Protection Agency's *Stony Coral Rapid Bioassessment Protocol* to support indicators of coral reef value and sustainability.

## 16-19

**Coral Surface Area Estimation by Computer Tomography – Comparison with Established Methods and Application in Ecological Studies**

**Malik NAUMANN*[1]**, Wolfgang NIGGL[1], Christian LAFORSCH[2], Christoph MAYR[3], Christian GLASER[4], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]Department Biology II and GeoBio-Center, Ludwig-Maximilians-Universität München, Martinsried, Germany, [3]GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-Universität München, München, Germany, [4]Institut für Klinische Radiologie, Ludwig-Maximilians-Universität München, München, Germany

In coral reef ecology, the surface area of coral colonies serves as an important reference parameter for the standardisation of coral metabolism measurements. Nevertheless, precise quantification of coral surface area remains a difficult approach. Here, we present a non-invasive alternative for improved coral surface area estimation composed of geometric measurements and surface area approximation indices (SAI) derived from comparison of new and established methodologies used in coral reef ecology. Skeleton surface areas of scleractinian reef corals from six genera (warm water corals: *Acropora*, *Fungia*, *Galaxea*, *Montipora*, *Pocillopora*, cold water coral: *Lophelia*) representing the most common morphological growth forms were quantified using computer tomography (CT) and subsequent computerised 3-dimensional surface area reconstruction. Surface area estimates for the same coral colonies were also obtained by application of three established methodologies: simple and advanced geometric approximation, paraffin-wax-coating and planar-projection photography. Comparison of the respective results yielded SAIs applicable in the calculation of the estimated surface area for the particular genus. Cumulative analysis (all six genera) of SAIs revealed closest approximation to CT-derived data by the advanced geometric approximation (AG, 30 ± 23 % average deviation), representing a non-destructive and feasible approach for coral surface area estimation in ecological studies. The commonly used and destructive paraffin-wax-coating technique showed a slightly bigger deviation from the CT reference, (37 ± 14 % average deviation), whereas the planar-projection photography differed maximal (82 ± 13 % average deviation) Advanced geometry and specific SAIs were used in field studies investigating surface area related particulate organic matter (POM) release rates of several dominant scleractinian coral genera. Results were consistent with literature data involving invasive surface area quantification techniques, thereby confirming the wide applicability of non-destructive geometric approximation in combination with CT-derived SAIs.

## 16-20

**Area-Calibrated Automation Of Coral Classification For Near And Subsurface Reef Videos**

**Ma. Shiela Angeli MARCOS*[1]**, Laura DAVID[2], Maricor SORIANO[1]

[1]Instrumentation Physics Laboratory, National Institute of Physics, University of the Philippines, Quezon City, Philippines, [2]Remote Sensing Working Group, Marine Science Institute, University of the Philippines, Quezon City, Philippines

We have developed groundwork for a computer-automated system for coral reef classification through underwater video. Unlike in common reef monitoring protocols that take weeks to finish, data acquisition through an underwater video camera is less expensive and processing can be done in one day. Two video acquisition schemes were considered: (1) near-reef videos, where the diver maintains a height of 30 cm from the reef surface, and (2) subsurface video of a reef filmed with a camera fixed beneath the surface of the water. We implement a downsampling method where rapid classification is done per block region of the reef image. This method is quicker than applying the operation to every pixel of the image.

We classify near-reef images obtained from a Philippine reef. In this data set, we classify benthic components into living and nonliving categories. We have achieved an overall success rate of 79% for test images that were not in the training set which is high considering that corals occur in a variety of appearance. Color and texture features derived from video stills were used as inputs to the classifier system.

The same automation system is tested on subsurface underwater reef video. An overall recognition rate of 60 – 70% was achieved. A more accurate recognition rate can be achieved for depths of up to 2 meters only with a small average false positive rate (24.3%). Greater depths (or camera–reef distance) incurred high false positives due to limitations incurred by camera optics and loss of clarity from the water column. A comparison between the automated coral classification system and point-count sampling is also presented. The development of an automated rapid reef classification system is most promising for reef studies that need fast and frequent data acquisition of percent cover of living and nonliving components.

## 16-21

**New Approach For Coral Surface Area Calculation Using Computerized Tomography And 3d Modelling**

**Wolfgang NIGGL*[1]**, Malik NAUMANN[1], Christian GLASER[2], Christian WILD[1], Christian LAFORSCH[3]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, Munich, Germany, [2]Institut für Klinische Radiologie, Ludwig-Maximilians-Universität München, Munich, Germany, [3]Department Biology II and GeoBio-Center, Ludwig-Maximilians-Universität München, Munich, Germany

The surface area (SA) of coral colonies represents a major reference parameter for the standardisation of flux rates involving release and uptake of organic and inorganic compounds, coral growth investigations, as well as for investigations of coral metabolic processes, e.g. photosynthesis and respiration. To date, a variety of methods used to determine the SA of corals has been developed with a set of coherent problems if applied in ecological coral studies, i.e. imprecise and rather approximate approaches that lack accuracy, or invasive and often destructive approaches that are inapplicable for experiments involving living corals and continuous SA determinations. Thus, coral science is in need for a non-invasive and precise methodology for coral surface area determination. This study introduces such a novel technique applying computerized tomography (CT) and subsequent 3D modelling. Several living coral colonies of differnt taxa were scanned by conventional medical CT. Resulting CT-data sets were processed by 3D modelling software delivering realistic 3D coral skeleton surface reconstructions and coherent SA measurements. Comparisons of CT- data sets obtained from standard bodies and coral colonies proved the accuracy of surface area determination. Our results emphasizes the usefulness and feasibility of computer tomography for surface related studies in the field of coral reef ecology.

## 16-22

**Interdisciplinary Environmental Assessments of Coral Reefs Using Remote Sensing and Numerical Circulation Models**

Serge ANDREFOUET[1], **Frank MULLER-KARGER*[2]**, Jinyu SHENG[3], Craig STEINBERG[4], Pascal DOUILLET[1], Inia SOTO[2], Bruce HATCHER[5], Sylvain OUILLON[1], Chuanmin HU[2], Bo YANG[3], Severine CHOUCKROUN[4], Guillaume DIRBERG[1], Christine KRANENBURG[2], Christopher MOSES[2]

[1]Institut de Recherche pour le Developpement, Noumea, New Caledonia, [2]College of Marine Science, University of South FLorida, St Petersburg, FL, [3]Dept of Oceanography, Dalhousie University, Dalhousie, NS, Canada, [4]Australian Institute of Marine Science, Townsville, Australia, [5]Center for Marine Ecosystem Research, Cape Breton University, Sydney, NS, Canada

An interdisciplinary international team investigated oceanographic processes that constrain coral reef ecosystems of the Meso-American Barrier Reef System (MBRS), Great Barrier Reef (GBR) and New Caledonia Lagoon (NCL). Reef connectivity, coral bleaching and sediment transport were targeted for MBRS, GBR and NCL respectively. These sites either lacked any in situ data (MBRS) or benefited from extensive time-series of measurements (GBR and NCL). Our methodological goal was to combine numerical circulation models and remote sensing to study the specific processes at each site.

The circulation of MBRS was simulated using a nested model to understand larvae propagation between reefs and river runoff dispersals, including during hurricanes. SeaWiFS climatology and time-series were used to investigate connectivity in MBRS and validate model outputs. On the southern GBR, the objective was to enhance prediction of thermal stress at reef-scale. In Both MAR and GBR shallow water bathymetry were computed from Landsat images to improve high resolution model outputs in shallow reef areas. GBR shallow bathymetry was validated against Lidar data. In NCL, numerical models provided suspended matter concentrations under different forcing, and we revisited local Landsat and MODIS optical algorithms for suspended matter estimation.

Remote sensing tools quickly provided synoptic information for each site (connectivity matrices, bathymetry, suspended matter) with useful accuracies for model calibration/validation. However, for each site, numerical models were more difficult to adapt to these new calibration/validation data sets due to the computation time and resources required to run new sensitivity analysis. The integration was faster for MBRS, motivated by limited oceanographic field data. Combining numerical output with remote sensing is promising to monitor and hindcast-forecast connectivity, thermal stress and sediment transport and we conclude by the perspectives highlighted by this program.

## 16-23

**Creios: Noaa's Coral Reef Ecosystem Integrated Observing System**

**Jessica A. MORGAN*[1]**, C. Mark EAKIN[2], Russell E. BRAINARD[3], James C. HENDEE[4], Joyce E. MILLER[3], Mark E. MONACO[5], Tyler R.L. CHRISTENSEN[1], Dwight K. GLEDHILL[1], Scott F. HERON[2], Gang LIU[1], William J. SKIRVING[2], Alan E. STRONG[2]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]NOAA Coral Reef Watch, Silver Spring, MD, [3]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [4]NOAA Atlantic Oceanographic & Meteorological Laboratory, Miami, FL, [5]NOAA Center for Coastal Monitoring and Assessment, Silver Spring, MD

Coral reefs are complex ecosystems with high biodiversity and significant economic importance. Modern *in situ* and satellite-based observations show declining trends of reef health and extent on both local and global scales. With U.S. coral reef resources stretching across 13 time zones, NOAA has responsibility for observing and managing coral reefs over a wide area. To carry out this task, NOAA has implemented an integrated coral reef ecosystem observing system to map and monitor coral reefs, their biota, and their environments. The Coral Reef Ecosystem Integrated Observing System (CREIOS) is an important component of NOAA's Coral Reef Conservation Program (CRCP) and provides a NOAA contribution to the Global Earth Observing System of Systems (GEOSS). The current configuration of CREIOS includes a wide variety of observing systems providing coverage of U.S. coral reef resources in the waters of States, Territories, U.S. flag islands and Freely Associated States in both the Pacific and the Atlantic. Key components include: (1) physical and environmental monitoring using satellite, *in situ*, and paleoclimatic observations; (2) reef mapping and benthic habitat characterization using satellite, airborne, ship-based, and diver observations; (3) ecological monitoring of benthos, mobile invertebrates, and fishes by divers and instruments; and (4) monitoring for coral bleaching and disease outbreaks by divers. NOAA makes data from these observations accessible through the Coral Reef Information System (CoRIS) and provides integrated information products to satisfy scientific and management needs.

## 16-24

**Ecological Count-Based Measures: How To Prevent And Correct Biases in Spatial Sampling**

**Assaf ZVULONI*[1,2]**, Yael ARTZY-RANDRUP[3], Lewi STONE[3], Robert VAN WOESIK[4], Yossi LOYA[1]

[1]Department of Zoology, Tel-Aviv University, Tel-Aviv, Israel, [2]The Interuniversity Institute for Marine Sciences of Eilat, Eilat, Israel, [3]Biomathematics Unit, Department of Zoology, Tel-Aviv University, Tel-Aviv, Israel, [4]Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL

Ecological count-based measures (ECBMs; i.e., measures which relate to the number of individuals in an area), such as population density, size-frequency distribution, average size, species richness and diversity, are often used to assess the ecological status of different populations or communities in a variety of ecosystems. Incorrect evaluations of ECBMs may lead to biased estimations of the ecological status of ecosystems and may result, among other things, in erroneous nature reserve management policies. The major objective of the study is to elucidate biases that can arise in the application of popular and traditional sampling methods (e.g., *quadrat*, *belt-transect* and *line-intercept*) and to develop mathematical corrections, which provide unbiased estimations for present and past collected data. We show that biases on the estimated ECBMs may arise due to boundary effect of the sampling units and that the intensity of the bias increases with proportion to the size-ratio between the sampled individuals and the sampling unit in use. Our analysis is based on analytical calculations, simulations and field observations. We developed simple mathematical corrections, which provide unbiased estimations for presently and previously collected data acquired by these widely used methods. In addition, we offer a decision rule, which do not suffer from these shortcomings. Eliminating these types of sampling errors will not only provide better assessments of the status of a given coral reef, but will also make way for more precise comparisons among coral reefs in different regions. Although we discuss the biases of ECBMs in regard to reef coral populations, the work is equally relevant in other marine and terrestrial ecosystems.

## 16-25

**Considerations in The Design Of A Monitoring Program For Fish And Macrobenthos On A Caribbean Fringing Reef**

**John MCMANUS*[1]**, Lee-Ann HAYEK[2], Felimon GAYANILO[1], Daniel HOLSTEIN[1], Kristine STUMP[1], Marilyn BRANDT[1], Wade COOPER[1]

[1]NCORE/Marine Biology and Fisheries, RSMAS, University of Miami, Miami, FL, [2]Smithsonian Institution NHB, Washington, DC

The highly heterogeneous nature of coral reefs in space and time complicates the process of designing reasonably objective, representative monitoring programs focused on fish and macrobenthos. In one-time sampling designs, one is sampling a defined space, in which the characteristics of interest of the space are the abundances of fish and macrobenthos, and often the spatial correlation relationships among these. The sample design may thus be focused on accounting for the variance in one or more combinations of these parameters over space, sometimes based on preliminary sampling. In monitoring, the characteristics of space of primary concern are the changes over time anticipated in these abundances. Because change over time may correlate weakly or unpredictably with abundance, the use of preliminary one-time sampling as a design tool may be of limited value. For both sampling and monitoring designs, factors such as high variability in sand and hard substrate patch sizes and dispersion, and 'intrusion' into hard substrate of sandy grooves in spur-and-groove systems, create problems in determining the sampling regime to be represented. These, in addition to extremes in slope and holes of various sizes in the substrate, often cause the introduction of considerable subjectivity into the design – often via decisions made in the field. We use a combination of multiple prior surveys, satellite data analysis and computer simulation, analyzed with respect to variance in time and space and practical field time limitations, to determine the pros and cons of a variety of approaches to the design of a monitoring program for a fringing reef of approximately 20 sq km in eastern Dominican Republic.

## 16-26

**Solar Irradiance And Coral Reefs: Modeling And Management Tools**

**Lore AYOUB*[1]**, Pamela HALLOCK[1], Paula COBLE[1]

[1]College of Marine Science, University of South Florida, St Petersburg, FL

Although mass coral bleachings are generally triggered by supraoptimal seawater temperatures, experiments have demonstrated that corals and reef-dwelling foraminifers bleach more readily when exposed to high energy, short wavelength solar radiation (blue, violet and ultraviolet (UVR; $\lambda \sim 280$ - 490 nm). In seawater, colored dissolved organic matter (CDOM), also called gelbstoff, preferentially absorbs these shorter wavelengths, which consequently bleach and degrade the CDOM. Alteration and destruction of watershed and coastal wetlands have reduced natural sources of CDOM that are tidally flushed into reefal waters. We have measured absorption of UVR and incident UVR at various reefs in the Florida Keys that differ in distance from shore and the degree of anthropogenic development and intact mangrove hammock of the adjacent shoreline. The absorption measurements were used to calculate the intensity of UVR reaching the benthos. Underwater irradiance (UVR and PAR) was also measured using a multichannel profiling radiometer. Preliminary results show that reefs associated with intact shorelines tend to be exposed to lower intensities of UVR than reefs associated with developed shorelines. Absorption due to CDOM at 320 nm ($a_{g320}$) also was less variable at reefs associated with intact shorelines. Inshore reefs tended to be exposed to lower intensities of UVR than offshore, clear-water reefs at similar depths. Spectral slope of $a_g$ for shallow water coastal areas was modeled from absorption data collected in the spring and summer of 2004, 2005, 2006 and 2007. Spectral slope was generally greater at offshore sites, indicating photobleaching of CDOM remaining in offshore waters. These results provide support for resource managers to protect CDOM sources to reefal waters, such as preservation of natural coastal vegetation including mangroves and tidal wetlands. Other potential applications include ground-truthing inherent optical properties and a new algorithm for satellite-derived measurements of $a_g$ and UV Irradiance.

## 16-27

**Light And Motion Sensor Program: Low Cost Coral Reef Monitoring**

**Burton JONES*[1]**, Ivona CETINIC[1], Gerardo TORO-FARMER[1], Karli HERZOG[1], Albert BIANCULLI[2], Ramon DE LEON[3], Matthew RAGAN[1], Tom REYNOLDS[1]

[1]Marine Environmental Biology, University of Southern California, Los Angeles, CA, [2]Sea Monitor Foundation, Bonaire, Netherlands Antilles, [3]Bonaire National Marine Park, Bonaire, Netherlands Antilles

The "Light and Motion Sensor Program" is an observational network comprised of low cost sensor arrays deployed along the coral reef on the lee side of Bonaire. This effort is intended to observe variability of organic components in the water column over the reef that may indicate nutrient inputs or groundwater seepage into the water column over the reef. The arrays contain temperature and light sensors at three discrete depths, providing vertical temperature structure and downwelling light attenuation. Volunteer divers download the data weekly, transmit it to the laboratory where it is processed and posted on the web, making the data from the sensor network available in "semi-real time". Data collected at each site enable us to follow daily temperature oscillations, and to evaluate processes that include upwelling, water column mixing, and along-coast propagation of variability. Downwelling irradiance in three ranges, broadband light, blue and green color bands, allows the calculation of the diffuse attenuation coefficient for those wave bands. By coupling measured light with temperature data, it is possible to evaluate the role of natural and anthropogenic sources affecting fluctuations of light attenuation. The choice of wavelengths provides an index of the presence of organic matter (Organic Index), including planktonic algae, dissolved organic matter and detrital material that can affect the fragile coral reef ecosystem. This unique, inexpensive monitoring network provides the scientific community and environmental managers with temporal and spatial information that can be used to assess environmental variability. It can also be used for recreational purposes by divers and tourists with near real-time observations of the Bonaire reef environment.

## 16-28

**Novel Optical Technique For Characterization Of Light Absorption And Distribution in Reef-Building Corals**

**Vadim BACKMAN*[1]**, Erin DALY[2], Andrew FANG[2], Margaret SIPLE[2], Mark WESTNEAT[3], Vladimir TURZHITSKY[1], Jeremy ROGERS[1], Luisa MARCELINO[2]

[1]Biomedical Engineering Department, Northwestern University, Evanston, IL, [2]Civil and Environmental Engineering, Northwestern University, Evanston, IL, [3]Zoology, Field Museum of Natural History, Chicago, IL

Light transport in coral skeleton plays an important role in coral physiology. In particular, characteristic length-scales of light diffusion in coral skeleton (mean free-path length) are long, which results in the redistribution and homogenization of the illumination of coral tissue and amplification of light availability to the algal-symbionts by several fold. We describe a novel optical technique, low-coherence enhanced-backscattering (LEBS), for characterization of light absorption and distribution in corals. Here we describe the characterization of coral colonies of different species regarding: 1) the light transport properties of their coral skeleton and tissue; 2) light absorption by coral tissue; and 3) the micro- and nano-architecture of the coral skeleton and tissue and their relationship to the optical properties. These findings help to clarify the efficiency with which different coral species collect and distribute light to their algal-symbionts and the structure-function relationship in coral skeletons and tissue.

## 16-29

**Patterns Of Vertical Zonation in Mesophotic Reef Communities Of Southwestern Puerto Rico And Vieques Island**

**Sara RIVERO*[1]**, Roy ARMSTRONG[1]

[1]Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Mesophotic reefs (30-100 m) may be the last frontier in coral reef ecology. These reefs remain largely unexplored since they require special diving technology or the use of underwater vehicles for benthic characterizations. Mesophotic reefs in three areas of Puerto Rico: La Parguera and Guanica, Southwestern Puerto Rico, and Vieques Island were characterized. In 2004 the Seabed Autonomous Underwater Vehicle (AUV) provided seven phototransects of approximately 1 km which allowed qualitative and quantitative assessments of species diversity, percent cover, and reef geomorphology. The depths sampled by the AUV ranged from 20-112 m. Percent cover of five main benthic categories were recorded: scleractinian, macroalgae, gorgonians, sponges, and black corals. Special attention was given to sponges and scleractinian corals, the latter (mainly *Agaricia* sp.) were found up to 91 m depth. Coral dominance (up to 62 % cover) in shallow depths is shifted to sponge dominance (up to 33 % cover) in deeper areas. Gorgonians, which rapidly disappear after a depth of 40 m are replaced by black corals. Maximum percent cover for all benthic groups other than scleractinians is at around 50-60 m depth, which seems to coincide with the lower limit of scleractinian distribution and increasing availability of bare substrate. The Guanica transects show high sediment, turbid waters with a higher attenuation coefficient (Kd), lower coral cover and a more gentle slope than those from La Parguera. Future plans include new deployments of the AUV in 2008 that will permit the assessment of temporal variations within some of these transects, the role of incident spectral irradiance on community structure, and the assessment of autotrophy versus heterotrophy in these little-known environments.

## 16-30

**Listening To The Reefs Of Oman: Can Sound Be Used As A Predictor Of Marine Fauna?**

**Mark PRIEST*[1]**, Stephen SIMPSON[2], Jenny MCILWAIN[1], Andrew HALFORD[1]

[1]University of Guam, Mangilao, Guam, [2]University of Edinburgh, Edinburgh, United Kingdom

Coral reefs are noisy places which can be detected from 10's of kilometres away. A cacophony of sound is produced by a variety of reef dwelling organisms; fish drum on their swim bladders and grind their teeth, urchins scrape across algae covered rocks, and snapping shrimp implode bubbles of air fired from their claws. Settlement-stage reef fish have been shown to respond to reef noise, implying it is not haphazard, and transfers useful information regarding the surrounding environment. If we can decipher nature's song what will we are able to learn from the tune?

The coastal waters of Oman contain an unusual variety of reef habitats, both tropical and temperate in nature. We used a hydrophone to record the sounds of differing reefs, spanning the Arabian Sea and Gulf of Oman, and used standard UVC techniques to assess the fish assemblages and benthic communities. Reef noise proved to be consistent over time and varied in composition between geographic locations, with each site producing unique sound profiles. This was also the case for fish and benthic communities, which also showed remarkable levels of dissimilarity. We investigate the degree to which properties of reef noise can be translated and used to predict reef quantity, quality, and species composition. Results suggest this is possible and with further refinement sound may have an application as a monitoring tool.

## 16-31

**Coral Reef Soundscapes: The Underwater Acoustic World From A Larval Reef Fish's Perspective**

**Adel HEENAN*[1]**, Stephen SIMPSON[1], Mark PREIST[2], Emma KENNEDY[3], Chantal HUIJBERS[4], Ivan NAGELKERKEN[4], Victoria BRAITHWAITE[5]

[1]The University of Edinburgh, Edinburgh, United Kingdom, [2]University of Guam, Mangilao, Guam, [3]Heriot-Watt University, Edinburgh, United Kingdom, [4]Radboud University Nijmegen, Nijmegen, Netherlands, [5]Penn State University, University Park, PA

Previous work in temperate and tropical marine reef systems has found that larval fish are attracted to generic biological reef noise during settlement (the period of transition from the plankton to the reef benthos which precedes metamorphosis into the adult form). As we develop our understanding of how sound functions in larval coral reef fish navigation, a more intriguing and complex picture unfolds. Larval fish are able to detect and locate sound sources and distinguish between artificial sounds and those they would encounter in their natural environment. Furthermore, fish larvae are selectively attracted to different components of reef noise, dependent on their life history stage. After presenting an overview of the behavioural function sound plays in the settlement process of coral reef fish, the focus of the talk will shift towards the actual acoustic environment of the reef, and what information this could potentially portray to a settlement stage fish. The results of a worldwide study of reef noise shall be presented, where we compared different tropical habitats in Curaçao and Aruba (reefs, mangroves, seagrass), different quality habitats in the Philippines (pristine, protected, overfished, decimated), and different periods of the lunar cycle at Lizard Island. Reef noise is mainly biological noise produced by resident fish and invertebrates, as such it is a clear indicator of reef type, quality, and even species composition and density. Sound is transmitted at intensities above ambient levels for kilometres, and would be audible by fishes and other migrating animals. This work highlights the value of reef noise as a cue for larval fish orientation and habitat discrimination. It also suggests that through human activity altering the natural soundscapes around reefs, there is a whole suite of anthropogenic impacts on marine systems that are currently poorly understood and largely unmitigated.

## 16-32

**Passive Acoustic Mapping Of Grouper Aggregation Sites**

**David MANN*[1]**, James LOCASCIO[1], Michelle SCHARER[2], Michael NEMETH[2], Richard APPELDOORN[2]

[1]College of Marine Science, University of South Florida, St. Petersburg, FL, [2]Dept. of Marine Sciences, University of Puerto Rico-Mayaguez, Mayaguez, Puerto Rico

Many fishes, including groupers, drums and damselfishes, produce sounds associated with mating behaviors. Passive acoustic techniques can provide synoptic, long-term time series of sound production associated with reproductive activities of these species at widely spaced sites. Passive acoustic techniques were used to study the behavior of red hind (*Epinephelus guttatus*) at spawning aggregation sites off the west coast of Puerto Rico and Mona Island, Puerto Rico. Underwater video cameras with hydrophones were used to record red hind behavior along with sound production. Male red hind produced sounds composed of a series of pulses that graded into a tonal-like sound, with most of the energy below 400 Hz. Most sound production took place during apparent patrolling of male territories. Sound production was also recorded during interactions of males with females. Not all interactions, including male-male interactions at the edges of territories, involved sound production. Long-term acoustic recorders (LARS) were used to record sound production for longer periods of time than could be accomplished with the underwater video. Two LARS were deployed on previously identified red hind aggregation sites on the west coast of Puerto Rico and five LARS were deployed on Mona Island from January-March 2007. Analysis of LARS data from the west coast of Puerto Rico and Mona Island showed similar diel periodicities of sound production, but the two sites had different peaks in sound production during the month. These results demonstrate the potential of passive acoustics for mapping spawning aggregation sites of soniferous species over large spatial and temporal scales.

## 16-33

**Utilizing Acoustic Data in Establishing Reef Fish Recruit Abundance**

**Victor TICZON*[1]**, Badi SAMANIEGO[2], Greg FOSTER[3], Sonia BEJERANO-CHAVARRO[4], Eileen PENAFLOR[1], Shiela MARCOS[5], Joseph Dominic PALERMO[1], Peter MUMBY[4], Laura DAVID[1]

[1]Ocean Color and Coastal Oceanography Lab, The Marine Science Institute, University of the Philippines-Diliman, Quezon City, Philippines, [2]Apercu Consultants Inc., Makati City, Philippines, [3]National Coral Reef Institute, Nova Southeastern University, Fort Lauderdale-Davie, FL, [4]Marine Spatial Ecology Laboratory, University of Exeter, Devon, United Kingdom, [5]National Institute of Physics, University of the Philippines-Diliman, Quezon City, Philippines

Reef fish recruitment patterns have been observed to be strongly dependent on the physical and biological habitat features of the reef. The reefs' habitat structure mediates the process of predation and competition by providing refuges and resources for settling recruits. Overall, the study aims to (1) determine the influence of rugosity and shelter features on the diversity and abundance of reef fish recruits and, (2) generate reef fish recruit diversity and abundance map of Ngaderrak Reef, Republic of Palau. Fish visual census, habitat classification, and shelter dimension measurements of major habitats, were conducted in Ngaderrak reef, and, Puerto Galera and Anilao, Philippines. Acoustic habitat mapping was only conducted in Ngaderrak. While the first three tasks were conducted in specific detail for ecological analysis, the Biosonics DTX was used to generate broad scale spatial information on habitat type, rugosity and shelter features of the entire reef area of Ngaderrak. Preliminary results show higher recruit abundance in the more physically complex microhabitats. This corroborates past studies which reflects correlation between reef fish recruit abundance and diversity with substrate complexity. The strong correlation with reef fish recruit abundance and the physical characteristics of the reef supports the use of remote sensing techniques such as Acoustic Ground Discrimination Systems (AGDS), to spatially characterize habitat features of the reef and possibly, identify areas with high recruitment potential based on the physical structure of the substratum. Acoustic survey results demonstrate the ability of AGDS to distinguish microhabitats based on the physical structure of the corals, rugosity, and substrate hardness. However, initial results show that habitat information derived from acoustic remote sensing was limited to structures with notable vertical relief. Acoustic mapping accuracy of benthic microhabitat features remains to be determined using geo-referenced video-transects of the study area.

## 16-35

**Mapping Reef Structure And Bathymetry In Belize Using Cobratac**

**Peter STETSON*[1]**, Burton SHANK[1], Phil LOBEL[1]

[1]Boston University Marine Program, Boston University, Boston, MA

The Cobratac underwater navigation system (manufactured by RJE International, Irvine, CA, USA) was tested for its mapping capabilities in shallow (<20m) hard- and soft-bottom habitats on lagoonal reefs and in the inter-reefal around Wee Wee Caye, Belize. The Cobratac was created as an autonomous underwater diving navigation system that measures depth and altitude for hydrographic and positioning purposes. It computes position using a fluxgate compass and a Doppler velocity log. The Cobratac's effectiveness as a measuring tool for the rugosity of reef structure and for mapping bathymetry was evaluated. The accuracy, density, and breadth of data collection are dependent upon speed of travel and altitude above the bottom. Multiple passes over the desired area may be necessary to collect a complete dataset. Maps will be presented illustrating the capabilities of the Cobratac in conjunction with GIS software, Surfer and ArcGis, and MatLab. Provided that the limitations of the system are understood, the Cobratac appears to be a powerful tool for easily mapping the topography of small-scale and shallow marine systems and producing readily intelligible and informative bathymetric maps. This project was supported by the Boston University Marine Program, Conservation International's Marine Management Area Study and the US DoD Legacy Program.

## 16-36

**A Web-Based Information Management Solution For Experimental Data From The Field Of Coral Reef Ecology**

**Florian MAYER*[1]**, Sven DUEWEL[2], Andreas HAAS[1], Carin JANTZEN[1], Malik NAUMANN[1], Jonathan M JESCHKE[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]Procon IT GmbH, München, Germany, [3]Dept. Biology II, Evolutionary Ecology, Ludwig-Maximilians-Universität München, Martinsried-Planegg, Germany

In the profit-oriented business and industry sector, information management (IM) solutions are well established. But in coral reef ecology, the IM aspects of experimental design, data acquisition & evaluation, documentation and publication follow the individual workers' experience rather than established standards. Although many aspects of these tasks are automatable, no useable guidance tool has been established so far, which would lead the worker through the experimental life cycle and enforce validation, documentation, completeness, correctness and consistency of data. Often, this results in loss of information, deterioration of data quality and diminished data compatibility. In this study, a dynamic web application was created to automate the scientific work process conforming to recognized scientific work practices. The application was built using Grails, a new programming framework, which combines well-proven technologies and allows for rapid software development. Initially focusing on data from coral reef field experiments, the application's data model is capable of managing any kind of manipulative or monitoring ecological experiment. The user operates the software through an intuitive Graphical User Interface and focuses on the scientific experimentation process. The software is secured by user authentication, but data can be shared among team members. It is scalable from a single-user, single-desktop environment up to a distributed network connecting teams worldwide. As the application is easily adapted to many different scientific experiments, it can serve as a prototype model for useable scientific software tools, as is shown by two adaptations: 1) COREweb automates bulk import and error-prone evaluation of an elemental analyzer's complex and varying output, 2) AZEZAweb connects to existing databases and provides pre-formed real time queries to the remotely logged in user. The application makes valuable data, especially from ecological long term studies, better available to decision makers in coastal management.

## 16-37

**Identification Of Sediment Sources Using Geochemical Fingerprinting At Pear Tree Bottom Reef, Runaway Bay, Jamaica**

**Isaac WESTFIELD*[1]**, Steven DWORKIN[1], Rena BONEM[1], Emyris LANE[1]

[1]Geology, Baylor University, Waco, TX

Pear Tree Bottom Reef, near Runaway Bay, Jamaica, has been studied by many reef scientists since T. F. Goreau's initial descriptions of Jamaican reef morphology and zonation in the 1950's. This reef is regarded as a significant example of "Buttress Zone" morphology and is noted for the presence of sclerosponges at water depths less than 30 m. Like many coral reefs worldwide, the Pear Tree Bottom Reef has seen a gradual decline since the late 1970's. Since 2005, increased sedimentation has resulted in a more drastic decline in live coral cover on the reef. It is thought that this increased sedimentation is related to two concurrent construction projects: the expansion and resurfacing of the north Jamaican costal highway near the Pear Tree Bottom River, and construction of the Gran Bahia Principe Resort along the coast adjacent to the reef.

Three major rock formations occur adjacent to the coast and within the drainage basin of the Pear Tree Bottom River: the Falmouth Limestone (~125 ka), the Hopegate Limestone (~250 ka), and the Montpelier Limestone (~1.9 ma). The Gran Bahia Principe Resort was constructed on the Pleistocene Falmouth and Hopegate Formations. The Jamaican coastal highway was also constructed on the Falmouth and Hopegate, but the road material used for its construction was quarried from the Pliocene Montpelier Formation. Sediment samples from Pear Tree Bottom and nine other reefs east and west of PTB were taken in August, 2007 before the arrival of Hurricane Dean. X-ray fluorescence, x-ray diffraction, insoluble residue and particle size measurements, and Sr 87/86 isotopic analysis have been employed to quantitatively identify the main sources of increased sedimentation on the Pear Tree Bottom Reef.

## 16-38

**The Semantic Reef: A Hypothesis-Based, Eco-Informatics Platform To Support Automated Knowledge Discovery For Remotely Monitored Reef Systems**

**Trina MYERS*[1]**, Ian ATKINSON[1]

[1]School of Maths, Physics and IT, James Cook University, Townsville, Australia

Eco-informatics is regarded as the combination of *multiple* environmental datasets and modelling tools that are used to test ecological hypotheses and derive information about environmental systems. The Semantic Reef project is developing automated data-processing, problem-solving and knowledge discovery systems to better understand and manage reef ecosystems. This project uses three core tools; the Semantic Web, Grid Computing and workflow based e-Research approaches. The resulting technology platform is designed to evaluate complex hypotheses queries and provide alerting for unusual events (e.g. spawning, algal growth, bleaching).

Remote environmental monitoring (including sensor networks) are being widely trialed and deployed with the goal of gathering data in real-time. As the volume of raw data increases, it is expected that bottlenecks will develop in the data analysis phases - current data processing still involves human intervention and manual manipulation of data.

Semantic Web technologies are standardised approaches to address the problem of machine-readable, interoperable datasets. Explicit descriptions of the data sets and structures, called *ontologies* allow machines to understand both meaning and context of data, and therefore process information into new knowledge *automatically*.

The Semantic Reef project has developed a reef ontology that has been coupled to datasets to derive *inferences* between data. This permits us to 'ask' the system questions for semantic correlation and analysis. Our initial validation of the reef ontology used ocean temperatures and community composition datasets to ground truth the ontology. Currently, the model is being further extended to map dynamic data from reef based sensor networks into the ontology in real-time. This eco-informatics project represents a new approach to solving problems of scale across reefs and the GBR in particular.

Keywords: eco-informatics, semantic web, ontologies, coral reefs

## 16-39

**Divers For The Environment: Volunteers And Scientists in Marine Biodiversity Monitoring**

Stefano GOFFREDO[1], Patrizia NERI[1], Antonio ORLANDI[1], **Francesco PENSA*[1]**, Maria SCOLA GAGLIARDI[1], Angela VELARDI[1], Corrado PICCINETTI[2], Francesco ZACCANTI[1]

[1]Department of Evolutionary and Experimental Biology, University of Bologna, Bologna, Italy, [2]Laboratory of Fisheries and Marine Biology at Fano, University of Bologna, Fano (PU), Italy

Global monitoring of the biodiversity status is recognized as a priority necessity by the international scientific community. Research institutes often lack funds and necessary manpower to perform large scale monitoring. For land environments it has been shown that citizens can be involved in research, by contributing significantly to the collection of data. Underwater research requires special operational skills and SCUBA certification, and it may be difficult to involve large numbers of volunteers. We show that, in a short time, thousands of recreational divers can be recruited for monitoring the marine biodiversity status. On a specially formulated questionnaire, volunteers reported the presence of 61 marine taxa encountered during recreational dives. During the 4-year study, 3825 divers have completed 18,757 questionnaires, corresponding to 13,539 diving hours. The volunteer sightings-based index showed that in the monitored area the environmental quality did not change significantly on the time scale, but it had a significant correlation with latitude, suggesting improvement in the southernmost areas. This condition could be related to the main presence of stressors in the northern areas, and has been corroborated by professional investigations. Our experience shows that recreational divers can collect a considerable amount of data, over a vast geographical area, thus decreasing the costs for research institutes. The greatest drawback with this collaboration is the difficulty to obtain sampling distributed uniformly in space. Projects that invite citizens to get involved in ecological research provide members of the community of every age valuable opportunities to improve their science literacy and environmental awareness. This research, patronaged by the Italian Ministry of the Environment, was supported by the ASTOI-Association of Italian Tour Operators, the Association of Diving agencies operating in Italy (IDEA, PADI, PSS, SNSI, SSI) and the popular scientific magazine Quark.

## 16-40

**Auvs Explore Reef Sustainability**

**Noelle RELLES*[1]**, Mark PATTERSON[1]

[1]Biological Sciences, VIMS, Gloucester Point, VA

The reefs surrounding the island of Bonaire are the most pristine in the Caribbean, with high percent coral cover (40-60%) and low abundance of macroalgae. The Bonaire National Marine Park sets an important precedent regarding marine protection policy and was nominated for United Nations World Heritage in 2004 due to the high number of endemic marine species. However, surveys of Bonaire's underwater biota have been few, particularly of the deeper reef (65-170 m depth). In 1985, Dr. Fleur van Duyl completed an underwater atlas of Bonaire, mapping the bottom type and benthic community to a depth of 10-12 m. During a 5 week NOAA signature expedition in 2008, the reefs were remapped using a combination of 3 Autonomous Underwater Vehicles (AUV) for survey, and Nitrox and Trimix SCUBA diving. The twilight zone of the reef was investigated using high frequency side scan sonar, multibeam sonar, video, and water quality sensors that were fixed to the AUVs. AUV technology was utilized in this project due to its cost effectiveness, and capability for deeper surveying and greater coverage over shorter time periods than previous mapping efforts. Divers using Nitrox and Trimix SCUBA served to groundtruth data collected by AUV missions at several points on the reef. At select locations, the resulting data were compared to van Duyl's snapshot from the 1980s. The resulting maps are maintained in ArcGIS, with kmz layers available for use by coral reef scientists, managers, and the public using Google Earth. The resulting maps are compared to the previous work by van Duyl (1985) and more recent work by Bak et al. (2005) and used to assess the success of Bonaire's experiment in Marine Protected Areas.

## 16-42

**Shallow And Deep-Water Gorgonian Surveys on Saba Bank, Netherlands Antilles**

**Peter ETNOYER*[1]**, Herman WIRSHING[2], Juan Armando SANCHEZ[3]

[1]Harte Research Institute, Texas A&M University, Corpus Christi, TX, [2]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [3]Departamento Ciencias Biológicas, Universidad de los Andes, Santa Fe de Bogota D.C, Colombia

Saba Bank is a large submerged platform (~2200 km2) mostly within scuba diver depth range (< 50 m), located 4 km southwest of Saba Island in Netherlands Antilles, Caribbean Sea. Ships traveling to and from oil terminals on nearby St. Eustatius occasionally anchor on the Bank, damaging benthic megafauna. Concerns about the practice prompted a recent series of investigations. Gorgonian corals are among the most common and conspicuous benthic megafauna in local shallow and deep-water (> 50 m) environments, so we sought to characterize gorgonian habitats and estimate species richness using a combination of remote sensing, scuba diving transects, and a Seabotix LBV200L remotely operated vehicle (ROV) for deeper collections. Landsat imagery and multibeam bathymetry were employed to create a block design with random survey sites. A total of 14 scuba dives and 5 ROV dives were completed in 10 days. During that time, 47 species were collected down to 130 m depth, including undescribed species in the genera *Pterogorgia* and *Lytreia*. Two different shallow-water gorgonian habitat types were identified by multidimensional scaling and hierarchical cluster analyses of species density values: 1) a higher diversity, higher density 'reef crest' environment characterized by *Eunicea* spp., *Gorgonia* spp., and *Pseudopterogorgia* spp. and 2) a lower diversity, lower density 'reef flat' environment predominantly composed of *Pseudopterogorgia acerosa, Pterogorgia guadalupensis,* and *G. mariae*. These analyses support hypotheses of habitat similarity within zones, and a gradient in diversity and abundance from the reef crest to the reef flats. Some degree of heterogeneity in gorgonian assemblages occurred along the 40 km southeast rim of Saba Bank. Our discoveries of two undescribed gorgonian species argue strongly that continued scientific exploration of Saba Bank is necessary.

## 16-43

**Crustaceans Of Saba Bank, Netherlands Antilles**

**Morgan KILGOUR*[1]**, Thomas SHIRLEY[2]

[1]Texas A&M University- Corpus Christi, Harte Research Institute, Corpus Christi, TX, [2]Texas A&M University-Corpus Christi, Harte Research Institute, Corpus Christi, TX

Saba Bank is a large (~2200 km$^2$) submerged atoll approximately 4 km west of Saba Island in the Netherlands Antilles whose crustacean fauna is poorly known. Concerns about anchor damage from oil tankers to coral habitats on the Bank prompted a study to characterize its fauna. We focused on the decapod crustaceans and used three methods to collect samples. Random collection sites were sampled within habitat types (fore reef, reef flat, back reef slope, lagoon, patch reef and atoll slope) delineated from Landsat imagery and high-resolution multibeam bathymetry data. Scuba (14 dives) was used to observe, photograph, and collect decapod specimens and also to collect sponges, small corals, gorgonians and other biogenic habitats containing cryptic and saxicolous crustaceans. A Seabotix ROV (Remotely Operated Vehicle) was used for 5 days to collect gorgonians, sponges and other biogenic debris containing crustaceans, below diver depths to 130 m. Two crab traps, each fitted with smaller shrimp traps, were baited with multiple kinds of bait and set for three 24 h periods in 300 to 400 m depths to collect specimens below ROV and scuba depths. Crustaceans collected with scuba were differentiated by depth, habitat, and reef zone; depth and location were recorded for specimens collected with the ROV or traps. More than 95 crustaceans were collected, with many representing range extensions or rare species. Assemblage composition and species richness were heterogeneous among habitats, and many species had pronounced depth distributions. Species accrual rates imply that only a portion of the decapod fauna has been sampled; additional quantitative sampling is warranted to complete an inventory of the decapod community and more fully describe their assemblage patterns.

## 16-46

**Caribbean Shallow Reef Coral $\delta^{15}$n Variability Among Species And Depth**

Kirby WEBSTER[1], Steve MACKO[1], **Kiho KIM*[2]**

[1]Department of Environmental Sciences, University of Virginia, Charlottesville, VA, [2]Department of Biology, American University, Washington, DC

Long-lived coral accumulate available nutrients as they grow, and have potential to provide a temporally integrated view of environmental conditions. Nitrogen stable isotope analysis has been a powerful tool for reconstructing inputs into aquatic ecosystems. Although isotope analysis has typically been used to infer sources of N, δ15N may also be used as a proxy for concentration of N and other inputs. However, use of any one species for such a proxy will limit the spatial and temporal extent over which the reconstruction can be addressed. Comparative analyses may be difficult if a species which is common to one area or depth is not observed in the location of interest, or if the proxy has seasonal variation. This study addresses the question as to whether a range of closely related species of the same taxa can be used in this regard. Stable nitrogen isotope analyses of Gorgoniidae family corals were measured to determine the variation among a range of species and with increasing depth in the water column. Gorgonians are common to many shallow reefs in the Caribbean and thus represent an excellent test organism over which the observations at one location could then be extended to another location in a different gorgonian species. Isotope analyses of axial surface skeletal material revealed no significant variation in δ15N values within Gorgoniidae collected from the same reef indicating that observations on species within this taxa are interchangeable. However, in *Pseudopterogorgia americana* collected over a 9 m depth gradient, a significant variation with depth was observed ($r^2 = 0.54$, $p < 0.0001$) suggesting that depth must be kept constant across sampling locations. The results of this study, combined with knowledge of general abundance and N-rich axial skeleton, support the hypothesis that gorgonian corals are an ideal candidate species for use as environmental proxies.

## 16-47

**Light Attenuation Measurements In Bermuda Reefs**

**Gerardo TORO-FARMER*[1]**, Burton JONES[2]

[1]Ocean Sciences, University of Southern California, Los Angeles, CA, [2]Marine Environmental Biology, University of Southern California, Los Angeles, CA

The implementation of low cost and effective methodologies for long term monitoring programs in coral reefs is needed, especially in geographic areas where economic and scientific resources are limited. Specifically, in-situ optical measurements can be utilized to estimate light attenuation due to suspended particles from terrestrial runoff or resuspension of bottom sediments from navigation activities near coral reef areas. Spatial and temporal variations of light penetration and attenuation were estimated using two different methods: water column hyperspectral radiometric measurements, and long term deployments of low cost underwater light intensity logger sensors. These methods were compared at stations across the north reef in the Bermuda Islands. Existing radiative transfer models were also used to compare the observations from these sensors against theoretical values. Variations in the diffuse attenuation coefficient were found among the different stations and between seasons, suggesting temporal changes in the optical field due to natural and possibly anthropogenic disturbances. Regardless of the intrinsic differences between high end and low cost methodologies, the correct interpretation of data from these light intensity loggers can facilitate and improve monitoring and management of coral reef and other coastal ecosystems.

## 16-48

**Mining ICON/CREWS Data Sets for Discovering Relationships between Environmental Factors and Coral Bleaching**

**Marc BOUMEDINE*[1]**

[1]University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

In order to assist researchers in assessing the impact of climate change on coral reefs, NOAA Integrated Coral Observing Network (ICON/CREWS) stations collect large amounts of in-situ oceanic and atmospheric data in the Caribbean region. Local effects of environmental factors such as sea temperature, wind speed and direction, light intensity, tides and water salinity on coral reef bleaching are determined by expert system technologies. Since expert knowledge is largely heuristic, the expert system knowledge base is constantly refined and enhanced as new axioms, theories or rules of thumb become available. Since expert systems can not learn independently, an approach to automatically extract new patterns and ultimately knowledge from historical ICON/CREWS data sets is proposed. In this study, patterns have been extracted from data sets generated by the Lee Stocking Islands (Bahamas) ICON/CREWS station from the May 21, 2005 till December 31, 2005. The *Apriori* association rules algorithm generates patterns in the form of rules such as: "if event $e_i$ occurs then event $e_j$ also occurs". Frequent patterns are observed between *Pulse Amplitude Modulation* (*PAM*) yield and light intensity, such as photosynthetically active radiation (*PAR*). Additional relationships between PAM yield and salinity, as well and *PAM* yield and wind speed are derived. In addition to rule generation, two classifiers have been designed in an attempt to predict *PAM* yield values from environmental factors. Our preliminary results are encouraging since more than 85% of the test instances are correctly predicted with both neural network and decision tree algorithms. These preliminary results suggest that data mining techniques are valuable approaches for complementing existing coral bleaching predictive models.

## 16-49

**The Reefpad: A Handheld Underwater Computer Aimed At Improving The Speed And Accuracy Of In-Situ Monitoring Of Coral Reefs**

**Frederic CHARPENTIER*[1]**, Peter GAYLE[2], Bernadette CHARPENTIER[3]

[1]Duwatech, Ottawa, ON, Canada, [2]Center for Marine Sciences, Discovery Bay Marine Lab, Discovery Bay, Jamaica, [3]Research an Development, Duwatech, Ottawa, ON, Canada

Coral reef monitoring is a labor and time-intensive process with inherent challenges related to increasing spatio-temporal resolution. It requires the collection of various data ranging from individual counts to photo surveys. The collected data needs subsequent transcription and processing. The hardware used today to conduct coral monitoring ranges from pencils and slates to photo cameras and other ad hoc instruments which are usually adequate but poorly integrated. The ReefPad is a low-cost handheld underwater computing device specifically designed to simplify in-situ work by decreasing data collection time while improving the accuracy and quantity of the collected data. The electronic circuitry is housed in a 10 x 16.5 cms. acrylic cylinder rated to a depth of 70 meters. It houses a main computer based on an ARM micro-processor, in addition to a PIC microcontroller, a number of sensors (depending on variables being investigated) and a 10 cms. color screen. The basic sensor configuration includes a 3-axis magnetometer and two dual-axis accelerometers. The device can also be custom fitted with digital cameras, lasers, photometers, temperature sensors and RFID readers. The accelerometers and the magnetometer allow the use of dead reckoning for underwater navigation after an initial GPS calibration at the surface prior to the dive. The motion sensors also allow the researcher to interact with the software using gestures thus eliminating the need for buttons, keyboards or writing surfaces. The graphical user interface of the ReefPad was specifically designed to facilitate immediate access to maps, hierarchical lists and referencing software through simple hand motions. The software is configurable and designed to support existing methodologies while decreasing collection times, increasing data accuracy and broadening the investigative scope.

## 16-50

**Variations in The Symbiotic Algae (Zooxanthellae) Associated With Dominant Scleractinian Corals in Hong Kong Sar, China**

**Yu Man TSANG *[1]**, Put ANG[2]

[1]Marine Science Laboratory, Department of Biology, The Chinese University of Hong Kong, Hong Kong, Hong Kong, [2]Marine Science Laboratory, Department of Biology, The Chinese University of Hong Kong, Shatin, Hong Kong

Hong Kong is a marginal environment for coral growth. This study aims at investigating the potential linkages between variation in environmental parameters (mainly seawater temperature) and variation in symbiotic algal density, chlorophyll content (chlorophyll a and c2) and the photosynthetic capacity of two dominant Hong Kong corals *Porites lutea* and *Platygyra acuta*. The phylogenetic information on *Symbiodinium* associated with *Platygyra acuta* was also examined based on restriction fragment length polymorphism (RFLP).

Seasonal photophysiological parameters of algal symbionts in *P. acuta* and *P. lutea* were monitored from October 2006 to April 2007 at A Ye Wan and A Ma Wan in Tung Ping Chau Marine Park. Investigation on their zooxanthellae density and pigment contents throughout the 18 months sampling period revealed no significant bleaching occurring in these corals. However, significant temporal variations in the zooxanthellae density (from $2 \times 10^6$ to $10 \times 10^6$ cells $cm^{-2}$ of coral surface area) for both species were recorded. Concentrations of chlorophyll a per zooxanthella were significantly higher in winter than in summer for both species (ANOVA and Kruskal Wallis Test, $p < 0.05$).

Molecular phylotyping showed *Symbiodinium* clade C to be the dominant zooxanthellae associated with *P. acuta* irrespective of their location (i.e., top or shaded region) in the coral host. *Symbiodinium* clade C formed a stable association with this coral host over the sampling period. This result supported the finding that *Symbiodinium* clade C is the major clade of zooxanthellae associated with scleractinian corals in the Pacific.

## 16-51

**Large Scale Coral Mortality in Barbados: A Delayed Response to the 2005 Bleaching Episode**

**Hazel OXENFORD*[1]**, Angelique BRATHWAITE[2], Ramon ROACH[2]

[1]Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill, Barbados, [2]Coastal Zone Management Unit, Ministry of Energy and the Environment, Bridgetown, Barbados

In common with many Caribbean countries, coral reefs in Barbados suffered significant bleaching during the high temperature event of late summer 2005. Six reef sites, including shallow (< 10 m) and deep (> 15 m) communities were monitored over the following year (October 2005 – November 2006) to determine mortality impacts and rate of recovery from the bleaching event. Quantitative benthic surveys along five 1 x 20 m band transects and five 20 m line transects at each site, were undertaken every four months. Bleached condition (measured as % of colonies fully or partially bleached) gradually dropped from a mean of 71% in October 2005, 38% in February to 17% in June, before rising again to 25% in November 2006 after summer warming. Coral mortality (measured using two independent indices: estimated % of coral colony surface recently dead; and % of benthic coral cover recently dead) remained surprisingly low for most species five months after the onset of bleaching (means: 3.8% colony surface dead; or 4.8% dead cover), but rose sharply after 10 months (means: 18.7% colony surface; or 25.9% cover), eventually declining after 15 months to a near ambient levels (means: 2.0% colony surface; or 6.1% cover). In common with other eastern Caribbean islands, recovery from bleached condition was slow, persisting for many months after water temperatures had cooled, and overall mortality impact was high on both deep and shallow reefs. In contrast were the delayed onset of significant mortality and the low incidence of coral disease following the bleaching event on Barbados reefs. High losses in live coral cover have significant economic implications for the island which derives a major proportion of its GDP from tourism, and relies heavily on healthy reefs for coastal protection. This emphasises the extreme vulnerability of small Caribbean islands to the global warming trend.

## 17-1

**Mapping Coral Reef Benthic Zones From High-Spatial Resolution Image Segmentation And Photo Transect Data**

**Stuart PHINN*[1]**, Chris ROELFSEMA[2], Ian LEIPER[2], Peter MUMBY[3]

[1]Geography, Planning and Architecture, University of Queensland, Brisbane, Australia, [2]University of Queensland, Brisbane, Australia, [3]University of Exeter, Exeter, United Kingdom

The objective of this work was to test an approach for integrating field survey data and high-spatial resolution satellite image data to map coral reef benthic zones. Commonly accessible field survey techniques and image data sets were used to define map classes based on statistical analysis of benthic cover features defined from field photos. Our approach was applied to field survey data from georeferenced photo transects and a coincident high spatial resolution Quickbird multi-spectral satellite image from Heron Reef, southern Great Barrier Reef, Australia. The first stage identified benthic cover type and percentage cover from 3592 geo-referenced benthic photos. In the second stage, frequently recurring assemblages of benthic cover types were defined from discriminant and cluster analyses of the geo-referenced photos. A label for each cluster was determined from the mean percentage cover values of each major benthic-cover class for all photo-points present in the resultant cluster. For the third stage, Definiens® image segmentation was used to generate a multi-scale segmentation of the Quickbird image into maps of reef features of a specific size. A final stage labelled the polygons at each of the different scales of image segmentation. This was done by overlaying half of the classified photo-points on the segmented image and developing training sites for labelling reef zones. Next, the remaining set of labelled polygons was used to conduct a standard error assessment. The output reef community zone map matched the validation data, while each other scale corresponded to a repetitive collection of reef features, making up "zones" which could be classified later according to communities or geomorphic features. This work presents an example of an approach suitable for the spatial scale of high spatial resolution satellite image data, the heterogeneous nature of coral reefs, and their regional variation.

## 17-2

**The Status Of The Millennium Coral Reef Mapping Project Worldwide**

**Serge ANDREFOUET*[1]**, Christine KRANENBURG[2], Damaris TORRES-PULLIZA[2], Frank MULLER-KARGER[2,3]

[1]Institut de Recherche pour le Developpement, Noumea, New Caledonia, [2]College of Marine Science, University of South FLorida, St Petersburg, FL, [3]Univ. Massachusetts Dartmouth, New Bedford

The Millennium Coral Reef Mapping Project (MCRMP) is a unique program that uses Landsat 7 satellite imagery to map the extent and diversity of coral reef worldwide at geomorphological level. The project was supported by NASA and IRD. After the creation of a suitable archive of Landsat images in 2004, a classification scheme was designed, tested, updated and applied to all coral reef regions worldwide. In late 2006, the definitive format for product distribution as GIS files was created in partnership with WorldFish/Reefbase. Since 2004, GIS products result from mostly visual interpretation of satellite images, and from automatic image classification procedures if reef types and image qualities are suitable. Geomorphological layers are interpreted and labeled to provide a first temporary product. Then, the validation process assigns a final label for each polygon from a hierarchical typology of 800 different geomorphological classes, and ensures the consistency between products from different areas. Landsat 7 data had to be complemented by Landsat 5 and ASTER images in several areas due to persistent cloud cover.

Products offer for the first time a thematically rich, spatially accurate and consistent representation of all reef systems worldwide. Accurate statistics on the extent, diversity and spatial structures of coral reefs are available as GIS files and regional atlases. This information has been used by a variety of research and management projects that took advantage of the hierarchical scheme to integrate the exact level of information needed.

The communication will take first the example of atolls worldwide as a model to describe the different steps involved, from the Landsat image interpretation to the GIS products and to different research and management applications. Then, an overview of the different products, statistics and applications worldwide by nations will be presented.

## 17-3

**Coral Reef Habitat Responses To Disturbance Events in Time: A Remote Sensing Approach**

**Julie SCOPELITIS*[1]**, Serge ANDREFOUET[2], Stuart PHINN[1], Pascale CHABANET[3], Odile NAIM[4], Terry DONE[5]

[1]University of Queensland, Brisbane, Australia, [2]Institut de Recherche pour le Developement, Noumea, New Caledonia, [3]Universite de la Reunion, Saint-Denis de la Reunion, Reunion, [4]Universite de Bretagne Sud, Vannes, France, Metropolitan, [5]Australian Institute of Marine Science, Townsville, Australia

Coral reef monitoring programs documenting benthic changes over time seldom work at the habitat scale. Our ability to predict post-disturbance habitat distributions can be improved by combining historical *in-situ* monitoring data with remote sensing imagery, to provide maps of temporal change. This study aimed to interpret habitat scale changes from high spatial resolution imagery and *in-situ* data for three Indo-Pacific reefs (Abore Reef, New-Caledonia, Saint-Leu Reef, Reunion Island, Heron Reef, Australia). The reefs were selected for their different disturbance histories and recovery dynamics. A reef was considered as a mosaic of habitats. A habitat was a hierarchical assemblage of geomorphology, substratum, coral cover and growth form. High spatial resolution aerial photographs and satellite Quickbird images were available for each site, as far back as 1973 for Saint-Leu. Field surveys were conducted in 2007 on each reef to create habitat typologies. Ten, eight and twenty habitats were characterized on Abore, Heron and Saint-Leu respectively. This information, along with historical monitoring data where available, was used to create multi-date habitat maps. Linking the map series to the disturbance histories for each reef allowed us to interpret the habitat response and retrace the history of the 2007 habitats. The maps revealed cyclone-induced reef degradation on Abore (2002) and Saint-Leu (1989), with coral recovery on the latter by 1997. On Heron, coral colonisation was observed across decades as channel dredging and bund wall constructions in 1965 increased the sea-level, altering reef flat hydrodynamics. This study showed that coral reef response to disturbances can be retraced at the habitat scale using remote sensing imagery and field data. This will be used to develop agent-based spatially-explicit models to help management and monitoring site selection with predictive habitat maps under natural and anthropogenic influences.

## 17-4

**Combining The Benefits Of Satellite And in Situ Data To Determine Location And Benthic Cover Of Patch Reefs in The Florida Keys**

**David PALANDRO*[1]**, Melanie PETERS[1], Luke MCEACHRON[1], Michael CALLAHAN[1], Jim BURD[1]

[1]Florida Fish and Wildlife Research Institute, St. Petersburg, FL

The abundance of live coral cover has declined dramatically over the past three decades in the Florida Keys. Research and monitoring in Florida has focused most of its effort on the offshore platform reefs located seaward of Hawk Channel. Of the offshore reef sites monitored annually by the Coral Reef Evaluation and Monitoring Project (CREMP), live coral cover averages less than 4%. These reef sites were once covered with dense live coral cover, dominated by *Acropora palmata* and *A. cervicornis*. Although much is known about the location and benthic cover, including change over time, for the offshore reefs, comparatively little is known about the patch reefs located in and around Hawk Channel. The ten patch reefs included in the CREMP surveys average 14% stony coral cover. Here we used the synoptic coverage made possible by IKONOS satellite imagery in conjunction with rapid *in situ* benthic ground-truthing to produce a map for the Lower Keys, extending from Big Pine Key to the Marquesas Keys. Specifically, we address the number, location, size and an estimate of live coral cover of patch reefs. Initial results show approximately 2500 patch reefs, which were previously estimated at 420. Mean live coral cover is 17%, ranging from 0.3% to 52% and dominated by *Montastraea annularis* and *M. cavernosa*. The high variability in live coal cover can only partially be explained by their geographic location and overlying environmental parameters, which require further detailed inquiry. The new findings provided by this study suggest that more effort may be required to better understand the patch reefs in this area, which are now home to the dominant abundance of live coral in the region.

## 17-5

**Calibration And Validation Of Coral Reef Benthic Community Maps From High-Spatial Resolution Satellite**

**Chris ROELFSEMA*[1]**, Stuart PHINN[2]

[1]Centre for Remote Sensing and Spatial Information Science, University of Queensland, St.lucia, Australia, [2]Centre for Remote Sensing and Spatial Information Science, University of Queensland, St.Lucia, Australia

Our ability to map coral reef environments using remote sensing has increased, through availability of suitable images, field methods and software. Appropriately developed and validated maps are essential for management agencies to decide if they will use these data for science and management decisions. The objective of this paper is to present a simple approach for calibrating and validating maps of coral reef benthic communities derived from high-spatial resolution satellite images. Two forms of field data for calibration and validation were applied in a supervised classification of high spatial resolution Quickbird image data to map coral reef benthic communities. Data were acquired in 2006 for three Fijian reefs representing areas with variable water clarity and benthic cover composition. The two types of field data were benthic cover estimates derived from: (1) photo transects and (2) spot checks. Each of the two field data sets were used separately with the satellite imagery to digitise two sets of polygons around target benthic community types. These polygons were used as training sites for two supervised image classifications, producing two maps of benthic community classes for each site, based on transects and point data respectively. An independent subset of the polygons was used as reference data for accuracy assessment. For the three sites mapped, no differences in overall map accuracy were observed between the two types of benthic community maps: 66 % for transect and 65% for spot check based maps. However, the transect based calibration polygons were considered to be more representative of the benthic cover due to the number of sample points and their spatial distribution. This approach showed that standard digital camera and GPS, can provide adequate field calibration and validation data for mapping coral reef communities from high spatial resolution satellite imagery for a ranges of environments.

## 17-6

**Spatial Prediction Of Reef Bathymetry And Geomorphology Using High-Resolution Satellite Imagery**

**Joaquin R GARZA-PEREZ*[1]**, Eugene C RANKEY[2], Robert N GINSBURG[2,3], Stacy L REEDER[4,5], Sean A GUIDRY[6], Humberto GUARIN[7]

[1]UMDI-Sisal, Fac. de Ciencias, UNAM, Sisal, Mexico, [2]MGG, RSMAS, U. Miami, Miami, FL, [3]Ocean Research and Education Foundation, Coral Gables, [4]MGG, RSMAS, U. Miami, Miami, Mexico, [5]Schlumberger-Doll Research, Cambridge, [6]ExxonMobil Development Company, Houston, TX, [7]Bert Instruments, Inc., Hollywood, FL

In general, geomorphology and depth are the basic drivers behind many physical and biotic processes on reefs and coastal environments. These factors shape hydrodynamics and gradients of environmental factors as water energy, light absorption and temperature, therefore the distribution of organisms varies accordingly. To better understand the morphology of reef systems, we generated 3-D models of bathymetry by applying generalized regression analysis and spatial prediction (GRASP) models based on high-resolution (2.4 -5 m resolution) satellite imagery. This technique utilizes the spatial structure of the sea bottom in imagery to generate accurate geomorphology models and bathymetry maps. The innovation of this methodology is the virtual independence of the differences in bottom albedo to generate a predictive map of depth. The technique has been successfully implemented in different Caribbean reef environments. The resulting grids/rasters and 3-D surfaces are used as a basis for static and dynamic modeling and spatial predictions of reef habitat distribution, biodiversity hotspots, reef condition, fish biomass and abundance, sediment transport, and hydrodynamics and connectivity.

## 17-7

**Casi Mapping Of The Farasan Islands (Saudi Arabia): Ecosystem Processes in An Atypical Red Sea Setting**

**Gwilym ROWLANDS*[1]**, Sam PURKIS[1], Bernhard RIEGL[1], Philip RENAUD[2]

[1]National Coral Reef Institute (NCRI), Nova Southeastern University, Dania, FL, [2]Khaled bin Sultan Living Oceans Foundation, Landover, MD

The Red Sea is typified by expansive fringing-reefs affixed to a narrow and steep coastal shelf. We present work from the South of the Red Sea where a rather different geomorphology exists. The little studied marine system of the Farasans consists of vast shallow sediment-rich banks rising from deep water, a morphology that profoundly affects the depositional environment. Satellite imagery and 3,000 km2 of airborne CASI imagery were acquired over this remote seascape. Hydrodynamic measurements atop the banks revealed low flushing rates and temperatures notably higher than encountered in adjacent deep water. These stressful factors appear to render the setting sub-optimal for corals. The hyperspectral CASI data coupled with exhaustive field survey allowed mapping of benthic character across the Farasan archipelago at exceptionally fine spatial resolution. In addition, bathymetry was retrieved from a spectral derivation of the CASI data, trained using numerous acoustic soundings made during the field campaign. The investigation reveals an abundance of fine-grained sediment sheets on-lapping topographic highs dominated by algal meadows. Despite the unfavourable environmental conditions, expansive areas of live coral were also found. These were concentrated either within shallow micro-atoll fields in the bank interior, or in deeper habitats within large but diffuse 'coral fields' interspersed with high algal cover. Though the region does not lack suitable substrate and is locally rich in coral, little evidence for frame-building was observed. The mapping revealed that the location of coral-dominated habitat was not random, but rather clustered in the northern (upstream) sector of the archipelago. Corals were not found to favour a particular depth regime, but the axis of orientation for these areas was consistent between banks. The study highlights an unusual coral setting in the Red Sea and successfully proves the existence of a vibrant but atypical ecosystem.

## 17-8

**An Investigation of Seagrass Patterns at Alphonse Atoll, Seychelles: Linking Structure To Function In Marine Landscapes**

**Sarah HAMYLTON*[1]**, Tom SPENCER[1]

[1]Department of Geography, Cambridge Coastal Research Unit, Cambridge, United Kingdom

The idea of landscapes as shifting patch mosaics, structured by a range of biological and physical stochastic forces, is well suited to shallow tropical environments, where seagrass patches lie within a matrix of soft sediments or rocky substrates. The interaction of wave fields and tidal currents with reef growth, carbonate sediment transport, erosion and accretion can result in linear morphologies, such as shore-normal spur and groove, striation of reef flat material and alternating sand tongues and seagrass beds. Patch-level metrics capture phenomena such as linearity in one variable, which can be evaluated over a gradient of predictable environmental change. A shift in focus, from the properties of the individual patch to the statistical properties of ensembles, enables the links between observed structures and the processes that govern them to be empirically investigated, yet studies of shallow benthic communities at this scale have tended to be restricted to qualitative descriptions only.

Remote sensing technology provides the opportunity to investigate critical controls of landscape mosaics through the application of geostatistical techniques to patch assemblages. Alphonse Atoll in the Seychelles was mapped using an aircraft-mounted, high resolution (1 $m^2$ pixel), multispectral (17 band) Compact Airborne Spectrographic Imager (CASI). Subsequent image processing and classification procedures generated habitat maps composed of vector data structures that represent reef features as discrete units, analogous to the concept of patches conventionally adopted by landscape ecologists. Combining habitat maps with georeferenced attribute data yields spatial data matrices that can be manipulated in a GIS environment to develop models that simplify natural processes by linking structure to function on coral reefs. This study demonstrates how remotely sensed habitat maps can be used to generate quantitative spatial variability models based on the geography of the data, a key property of remotely sensed imagery.

## 17-9

**Mapping The Habitats And Biodiversity Of Ningaloo Reef, Western Australia Using Hyperspectral Imagery**

**Halina KOBRYN*[1]**, Nicole PINNEL[1], Thomas HEEGE[2], Lynnath BECKLEY[1], Matt HARVEY[1], Suzanne LONG[3]

[1]Environmental Science, Murdoch University, Murdoch, WA 6150, Australia, [2]EOMAP GmbH&Co KG, D-82205 Gilching, Germany, [3]Department of Conservation and Environment, Kensington, Australia

The largest hyperspectral survey of a coral reef (3400 km$^2$) was undertaken in April 2006 and forms the core data set for mapping habitat components and biodiversity of the Ningaloo Marine Park, Western Australia. Optically deep waters of this region are ideally suited for remote sensing techniques and airborne data were collected by HyVista. The data are at 3.5 m spatial resolution for a 1km wide terrestrial coastal strip and out to 20m depth over lagoon and reef areas and covers wavelengths from visible to near infrared at 15nm intervals. Hyperspectral data were corrected for atmospheric, air-water interface and water column effects using the physics-based Modular Inversion & Processing System. This approach allows for quantitative and automated steps as well as the removal of subjectivity from the classification process, allowing improved transferability to additional sampling locations, field spectral datasets and extension of the monitoring to other seasons. Underwater field spectra were collected using an OceanOptics spectrometer as well as underwater photographs, to allow for accurate interpretation and validation. Results of this mapping can be compared to the transect data collected by divers from other studies and also to earlier habitat maps prepared by expert interpretation of aerial photography. Comparisons of classification results for Coral Bay area show promising results in the discrimination of branching, tabulate and massive corals as well as macro-algal assemblages. Remote sensing offers unique tools which are non-invasive, quantitative and enable mapping of large areas into a seamless data set which can be integrated with human use data, oceanographic circulation models and other spatial data sets. The hyperspectral data are being used to develop a high-resolution characterisation of the entire reef, shallow water habitats and terrestrial landforms of the coastal strip in order to support sound conservation and management of the Ningaloo Marine Park.

## 17-10

**Development Of A Field Test Environment For The Validation Of Coastal Remote Sensing Algorithms: Enrique Reef, Puerto Rico**

**James GOODMAN*[1]**, Miguel VELEZ-REYES[2], Samuel ROSARIO[2], Shawn HUNT[2], Fernando GILBES[2]

[1]University of Puerto Rico at Mayaguez, Miami, FL, [2]University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico

Remote sensing is increasingly being used as a tool to quantitatively assess the location, distribution and relative health of coral reefs and other shallow aquatic ecosystems. As the use of this technology continues to grow and the analysis products become more sophisticated, there is an increasing need for comprehensive ground truth data as a means to assess the algorithms being developed. The University of Puerto Rico at Mayagüez, one of the core partners in the NSF sponsored Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems, is addressing this need through the development of a fully-characterized field test environment on Enrique Reef in southwestern Puerto Rico. This reef area contains a mixture of benthic habitats, including areas of seagrass, sand, algae and coral, and a range of water depths, from a shallow reef flat to a steeply sloping forereef. The objective behind the test environment is to collect multiple levels of image and field data with which to validate physical models, inversion algorithms, feature extraction tools and classification methods for subsurface aquatic sensing. Data collected from Enrique Reef currently includes airborne, satellite and field-level hyperspectral and multispectral images, in situ spectral signatures, water bio-optical properties and information on habitat composition and benthic cover. We present a summary of the latest results from Enrique Reef, discuss our concept of an open testbed for the remote sensing community and solicit other users to utilize the data and participate in ongoing system development.

## 17-11

**Remote Sensing Of Coral Reef Biogeochemistry Based On Optical Absorptance And Light-Use Efficiency**

**Eric HOCHBERG*[1]**, Marlin ATKINSON[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Honolulu, HI

We have developed a remote sensing technique for measuring coral reef benthic primary productivity based on light-use efficiency and optical absorptance. The model is GPP = $Ed A \varepsilon$, where GPP is gross primary production, $Ed$ is seafloor-incident irradiance, $A$ is seafloor absorptance, and $\varepsilon$ is the benthic community's light-use efficiency. Both $Ed$ and $A$ are derivable from various remote sensing data sources. Given appropriate values for $\varepsilon$, it is therefore possible to use remote sensing to determine GPP across spatial scales (meters to many kilometers) and in different reef environments (e.g., fore reef, reef flat). We demonstrate the utility of our approach for measuring the range and distribution of GPP across a reef system. Because reef calcification is inherently linked to photosynthesis, it is possible to define a separate light-use efficiency ($\varepsilon$calc) and thus remotely sense that rate, as well.

## 17-12

**An Investigation Into The Effects Of Coral Cover, Colony Size-Frequency Distribution And Clustering On The Classification Accuracy Of Simulated Reef Images.**

**Alan LIM*[1]**, Peter MUMBY[2], John HEDLEY[2], Chris ROELFSEMA[3], Ellsworth LEDREW[1]

[1]University of Waterloo, Waterloo, ON, Canada, [2]University of Exeter, Exeter, United Kingdom, [3]University of Queensland, Brisbane, Australia

Numerous studies have been conducted to compare the classification accuracy of coral reefs maps produced from satellite and aerial imagery at different spatial or spectral resolutions or from images processed to different levels. So far no work has been done that specifically looks at the differing spatial elements of the coral reef ecosystem and their effects on classification accuracy. In this study, we will examine how accuracy is affected by spatial elements of the reefscape by investigating the effects of colony size-frequency distribution, spatial aggregation of the coral colonies and the proportion of live coral cover at different spatial resolutions.

One of the main difficulties of such a study would be the acquisition of images that could be used to represent these different reef-scape scenarios. Additional difficulties in using actual imagery would include ensuring that improved accuracy in one instance was not the result of advantageous environmental conditions or on how well the accuracy assessment was carried out. Thus, in order to investigate these issues, we created simulated spectral reef images which could be manipulated to reflect the desired reefscapes. With simulated images, only those characteristics of the reef that were of interest would be allowed to vary, allowing us complete confidence in the results of the accuracy assessments.

The spatial elements determine the proportion of pixels in each class which are spectrally 'purer' due to lower amount of inter-class mixing. These factors will influence the number of 'purer' pixels such that images with higher coral cover, colony clustering and skew will have a greater proportion of 'purer' pixels. However, an increase in this proportion is not always related to increases in levels of accuracy. An analysis of the interactions between the various spatial elements provides an insight into how these spatial elements influence classification accuracy.

## 17-13

**Comparison Of in Situ Temperature Data From The Southern Seychelles With Sst Data: Can Satellite Data Alone Be Used To Predict Coral Bleaching Events?**

**Ben STOBART*[1]**, Nigel DOWNING[2], Raymond BUCKLEY[3], Kristian TELEKI[4]

[1]Marine Reserves, Spanish Institute of Oceanography, Palma de Mallorca, Spain, [2]Cambridge University Coastal Research Unit, Cambridge University, Cambridge, United Kingdom, [3]College of Ocean and Fishery Sciences, University of Washington, Seattle, WA, [4]International Coral Reef Action Network (ICRAN), Cambridge, United Kingdom

Degree-heating-weeks data derived from satellite sea surface temperature (SST) readings are increasingly being used to predict where bleaching is likely to occur, though predictions have not always been calibrated and corroborated by field observations. While SST can provide a good indication of water temperature, local oceanographic conditions will determine the depth to which satellite SST readings are representative. In 2003 the Aldabra Marine Programme initiated a temperature monitoring network, currently involving 40 temperature data loggers, in the southern Seychelles at Aldabra, Assomption, Astove and St. Pierre The annual temperature cycle in the region involves a shorter period of winter lows (min 23 ºC) between June and October, and extended high summer temperatures (max 30 ºC) between December and April. We compare SST temperature data from the four locations with *in situ* temperature measurements at 6m, 10m and 20m depth. *In situ* data is most similar to satellite SST during the winter period (typically not more than 1 ºC difference), and differs most during the summer period (up to 4 ºC difference). This seasonal difference is due to water column stratification during the summer, which is typified by calm weather with weak winds (though remaining a period of occasional cyclone activity). While during the winter rough weather fuelled by strong southeasterly winds reduces stratification. During the period of stratification *in situ* water temperatures are most similar to satellite data at 6m, followed less so by 10m and 20m depth. A combination of greater stratification during the summer period, along with periods of cool water upwelling, may in some cases reduce the reliability of satellite derived SST data for predicting bleaching events. We propose that during bleaching events exposure of coral communities at Astove, St Pierre and select sites at Aldabra to thermal stress may be reduced by local oceanographic conditions.

## 17-14

**New Ecological Insights From A 21-Year Coral Reef Temperature Anomaly Database**

**Kenneth CASEY*[1]**, Elizabeth SELIG[2], John BRUNO[3]

[1]National Oceanographic Data Center, NOAA, Silver Spring, MD, [2]Curriculum in Ecology, University of North Carolina - Chapel Hill, Chapel Hill, NC, [3]Department of Marine Science, University of North Carolina - Chapel Hill, Chapel Hill, NC

A wide range of new ecological insights has been enabled by advances in satellite remote sensing of the physical characteristics of the ocean. Dramatically improved algorithms coupled with advances in computational capabilities have resulted in new products with finer resolution, longer temporal coverage, greater accuracy, and better consistency. The Coral Reef Temperature Anomaly Database (CoRTAD), based on 21 years of AVHRR Pathfinder sea surface temperatures, is one such product that is yielding insights into the spatial and temporal characteristics of thermal stress and its influence on coral bleaching and disease. The development of the CoRTAD will be presented along with selected research highlights from its application to understanding thermal stress patterns, coral disease, and marine protected area design and effectiveness. In addition, information on how the extensive collection of information in the CoRTAD can be accessed and applied to global, regional, and local coral studies will be provided.

## 17-15

**A Methodology For Using Satellite-Based Temperature And Light Measurements For Predicting Coral Bleaching Severity And Mortality**

**William SKIRVING*[1]**, Roberto IGLESIAS-PREITO[2], Susana ENRIQUEZ[2], Tyler CHRISTENSEN[1], John HEDLEY[3], Mark EAKIN[1], Ove HOEGH-GULDBERG[4], Sophie DOVE[4], Scott HERON[1], Peter MUMBY[3], Alan STRONG[1], Gang LIU[1], Jessica MORGAN[1], Dwight GLEDHILL[1]

[1]NOAA Coral Reef Watch, Silver Spring, MD, [2]Universidad Nacional Autonoma de, Puerto Morelos, Mexico, [3]University of Exeter, Exeter, United Kingdom, [4]University of Queensland, St Lucia, Australia

The current NOAA Coral Reef Watch (CRW) suite of satellite products is designed to help coral reef managers monitor heat stress to better understand and predict mass coral bleaching. Although these products perform well when used to describe the onset of coral bleaching, they are not as accurate in describing the severity and mortality associated with mass coral bleaching events. The coral bleaching HotSpot and Degree Heating Week products are based purely on sea surface temperature (SST), yet coral bleaching is a physiological response that results from a combination of temperature and light. Here, we describe a potential major evolution of the NOAA CRW satellite products. A new methodology under development combines satellite-derived SST data with a new satellite-derived solar radiation product to better predict the severity and mortality of mass coral bleaching events. This new methodology is novel in that it goes beyond just examining the thermal stress, but actually combines thermal stress measurements of the existing CRW suite with light measurements from the Geostationary Environmental Satellites to provide a measure of the total photo-thermal damage.

## 17-16

**Producing A Satellite Sst Climatology – How Long Is A Piece Of String?**

**Scott F. HERON*[1]**, William J. SKIRVING[1], Gang LIU[2], Tyler R.L. CHRISTENSEN[2], C. Mark EAKIN[1], Jessica A. MORGAN[2], Dwight K. GLEDHILL[2], Alan E. STRONG[1]

[1]NOAA Coral Reef Watch, Silver Spring, MD, [2]IMSG at NOAA Coral Reef Watch, Silver Spring, MD

Coral reef ecosystem stress often occurs in response to abnormal environmental conditions (e.g., temperature, salinity, and light) rather than the absolute level of these. For example, corals in the Persian Gulf are accustomed to warmer summer conditions than corals off the coast of Brazil; as such, ocean temperatures of 30°C would be "comfortable" for the former but stressful for the latter. Identifying anomalous conditions requires good knowledge of the baseline of usual ("normal") conditions. Here we discuss whether the existing 22-year satellite sea surface temperature (SST) record is of sufficient length to calculate a long-term average (climatology) that can sensibly be used as a baseline for monitoring the health of corals. We also discuss issues related to global warming in determining this baseline and the relevance of adaptation by corals. At present, NOAA Coral Reef Watch uses near-real-time satellite temperatures to determine regions that experience thermal anomalies that have been linked to coral bleaching events. Inherent within the present operational process is a SST climatology that was defined using satellite SST data and which underpins the satellite-monitoring success.

## 17-17

**Fore-and Back-Reef Environments Interpreted from Airborne Laser Bathymetry: Northern Extension of the Florida Reef Tract Offshore SE Florida**

**Charles FINKL*[1]**, Jeffrey ANDREWS[1], William ROBERTSON[1], Beth FORREST[1]

[1]Coastal Geology & Geomatics, Coastal Planning & Engineering, Boca Raton, FL

The northern extension of the Florida Reef Tract (FRT) off SE Florida terminates in northern Palm Beach County at a southeast trending magnetic lineament known as the Bahamas Fracture Zone (BFZ). South of this morphostructural boundary, the FRT separates into a range of topologies that are based on interpretations of color-ramped imageries derived from airborne laser bathymetry (Laser Airborne Depth Sounding, LADS). LADS provided a contiguous data set in clear coastal waters to -70 m depth for 160 km of coast from onshore to about 6 km offshore. Enhancement of the LADS digital data permitted recognition of bathymetric patterns in the 600-km2 shelf survey area. Primary parabathic provinces include: (1) nearshore rocky zones dominated by limestones, (2) coral-algal reef systems (spur and groove topography, forereef rubble fields, back reef overwash deposits), (3) inter-reefal sediment troughs (partially infilled paleo mote systems) between barrier reef tracts, and (4) deep water marine terraces (paleo coral reefs) near the shelf break. Secondary sedimentary subprovinces include back reef shoreface sands, bar and trough systems, and reef gap ramps. Tertiary topographic features include drowned karst topography that was formed during glacio-eustatic lowering of sea level and subaerial exposure of reefs and limestone bedrock surfaces. Hierarchical organization of these bathymetric features is now possible due to the increased accuracy and density of bathymetric data in LADS format. Application of airborne laser bathymetric imagery for the first time permitted comprehensive differentiation of the world's third largest barrier reef environment along the southeast coast of the Florida Peninsula, separating the northern extension of the FRT from drowned beach ridge plains to the north and the Florida Keys to the south.

## 17-18

**Integrated Multi-Sensor Remote Sensing Of The Terrace Structure Of The Shallow Dry Tortugas Coral Reef Ecosystem**

**John BROCK*[1]**, Monica PALASEANU-LOVEJOY[1], Nayegandhi AMAR[1], C. Wayne WRIGHT[2]

[1]USGS, St. Petersburg, FL, [2]Wallops Flight Facility, NASA, Wallops Island, VA

Terraces have been recognized in many reef systems around the world and on last interglacial reefs this geomorphology has been linked to changes in sea level regimes. In parallel, many reef systems have an ecological zonation that correlates coarsely with geomorphology. Benthic habitat mapping of coral reef ecosystems is typically accomplished by the classification of multi-spectral images acquired from satellites or aircraft, an approach that omits the use of reef morphology in defining habitat boundaries. Aircraft lidar surveys can map fine scale reef structure, and enable the recognition of terraces on shallow coral reef ecosystems that may control the distribution of benthic communities.

The hypothesis that the shallow Dry Tortugas coral reef ecosystem is geomorphologically organized into terraces that act to control ecological zonation was evaluated. Following a NASA airborne lidar survey in August 2004 that resulted in a one-meter scale topographic map, the Wilcox signed rank test was used to verify the presence of terraces on Garden Key Bank, Pulaski Bank and Loggerhead Key Bank, the major geomorphic units of the shallow Dry Tortugas. Next, the boat-mounted Along Track Reef Imaging System (ATRIS) was used to collect voluminous observations of benthic class and topographic complexity to investigate correlation between the recognized terracing and the spatial structure of benthic habitats. A Jaccard dissimilarity analysis of interpreted ATRIS benthic images collected on transects across all three major banks of the Dry Tortugas revealed significant within and between bank differences in terrace benthic community composition.

## 17-19

**The View From Above -Are Reefs Fractal Because Of Neutral-Random Construction?**

**Samuel PURKIS*[1]**, Kevin KOHLER[1], Bernhard RIEGL[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL

Satellite remote sensing has shown numerous aspects of coral reef seascapes to be fractal. That is they display characteristics of scale-invariance and complexity. This property is pervasive and recognised in the geometries of both framework and lagoonal bedforms in reefal settings across the Pacific. To date, the interpretation of this curious scaling has been hampered by a lack of understanding as to why the morphometrics of reefs should be fractal. We investigate this property using high-resolution terrain models of the shallow Puerto Rico insular shelf built using bathymetric LiDAR soundings. We find that a computer-simulation model constructed using simple random processes is adequate to describe the intricacies of actual coral reef terrain. This model, based on fractional-Brownian motion (fBm), produces surfaces that are visually and statistically indistinguishable from natural seabeds, at spatial scales of 0.001 - 25 $km^2$. The conformity between model and nature prompts us to question whether the processes used in the simulation can provide insight into the construction of real-world reef platforms. Through this comparison we are able to identify simple natural processes that mimic the construction of the modelled terrains. We demonstrate that random settlement of coral colonies, followed by focused development of topographic highs, is sufficient to explain the production of fBm-like reef terrain. Importantly, this negates the requirement for secondary factors such as complex lateral interactions between habitat types, and/or the overprinting of landscape-altering processes such as sedimentation and erosion, to produce a fractal reef surface. By comparison, for terrestrial systems, such secondary processes have been identified as a necessary precursor for the creation of a fractal landscape. The findings of this study add weight to the hypothesis that the fractal property of reef terrain is the product of many simple random processes interacting at a variety of scales.

## 17-20

**Coastal Zone Classification Using Data Fusion Between Lidar And Hyperspectral Data**

**Jennifer WOZENCRAFT*[1]**, Christopher MACON[1], Grady TUELL[2], Joong Yong PARK[2]

[1]USACE - JALBTCX, Kiln, MS, [2]Optech International, Kiln, MS

Bathymetric lidar systems have been producing high resolution depth data since the late 90's.With developments in remote sensing technology and techniques the bathymetric depth map is just one of many products produced by the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system. CHARTS is owned by the Naval Oceanographic Office (NAVO) and operated through the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) with the U.S. Army Corps of Engineers (USACE).

The CHARTS system is a combination of multiple sensors including the Optech SHOALS-3000T20E ( 3 kHz bathymetric lidar, 20 kHz topographic lidar, and 1Hz RGB camera) and an Itres CASI-1500 hyperspectral imager. The CASI-1500 is programmable to collect between 4 to 288 spectral bands ranging from 380 nm to 1050 nm. The sensors share the same rigid platform allowing them to each use the same inertial navigation solution.

Since the integration of the CASI-1500 with the SHOALS-3000T20E, Optech International has been developing the Rapid Environmental Assessment (REA) processor. The REA processor fuses the lidar and hyperspectral image data at many levels to produce topographic land cover and bathymetric seafloor classifications with higher accuracy than previously possible. At the signal level, information extracted from the lidar waveform is used to invert the radiative transfer model for seafloor reflectance in the hyperspectral imagery. At the classification level, independent classifications based on lidar parameters like depth, bottom reflectance, and bottom roughness and on the hyperspectral bottom reflectance are merged using the Dempster-Schafer algorithm.

In January 2007, JALBTCX collected topographic, bathymetric, and hyperspectral data in and around Hilo Bay, Hawaii. Using these datasets and the Optech REA processor, JALBTCX has produced the first production level lidar and hyperspectral fusion derived seafloor classifications.

## 17-21

**A Comparative Assessment Of Lidar And Multibeam Sonar To Characterize Coral Reef Ecosystem**

**Timothy BATTISTA*[1]**, Bryan COSTA[1,2]

[1]National Ocean Service, NOAA, Silver Spring, MD, [2]National Ocean Service, NOAA, Silver Spring

A comparison of airborne LiDAR and ship-based mulitbeam sonar was conducted in southwest Puerto Rico to evaluate the efficacy of these systems in characterizing shallow-water coral reef environments (< 30 meters water depth). Multibeam sonar acquisition in shallow-water environments is prohibitive due to the relationship between swath width and water depth. The availability of comparable data products from airborne LiDAR (i.e., bathymetry and seafloor reflectance) provides an alternative to multibeam sonar surveys to collect seafloor characterization data. The test location, Abrir la Sierra conservation area, is comprised of a suitable diversity of topographic relief, geomorphological structure and biological cover types to test the utility of data derived from the respective remote sensing platforms. An evaluation was conducted to compare the efficiency, data integrity, and effectiveness of the LiDAR and multibeam sonar systems to discriminate meaningful landscape patterns. This analysis was conducted to allow resource managers and scientists to determine the most effective remote sensing platform to characterize shallow-water tropical marine environments.

## 17-22

**Statistical Comparison Of Single-Beam Acoustic Backscatter (38 And 418 Khz) With Lidar-Derived Coral Reef Benthic Habitat Class And Topographic Complexity**

**Greg FOSTER*[1]**, Walker BRIAN[1], Bernhard RIEGL[1]

[1]National Coral Reef Institute, Dania Beach, FL

Producing coral reef benthic habitat maps from acoustic backscatter has been hindered by uncertainties in interpreting the acoustic energy parameters E1 (roughness) and E2 (hardness), typically limiting such maps to sediment classification schemes. In this study acoustic interpretation was guided by high-resolution LADS (Laser Airborne Depth Sounder) bathymetry. The acoustic survey was conducted in Palm Beach County, FL, from inshore sand to outer reef slope, using a multiplexed echosounder (BioSonics DT-X at 38 & 418 kHz). E1 and E2 values, empirically normalized to mean depth, were compared to spatially-coincident values of a LADS-derived proxy for topographic complexity (Reef-Volume) and eight LADS-delineated benthic habitat classes. The 38 and 418 kHz E1 parameters were positively correlated with Reef-Volume, in agreement with the general empirical basis for bottom seabed classification. The opposite trend was observed for the 38 and 418 kHz E2 parameters, contrary to convention, which would predict an increasing trend of E2 from sand (soft, flat) to colonized pavement (hard, flat). Tukey HSD testing proved all four acoustic parameters capable of distinguishing between habitats; significant differences ranged from 25-27 of the k(k-1)/2=28 comparisons between the eight habitat categories. An *a posteriori* discriminant analysis of each frequency, pairing E1 and E2 as predictor variables, showed that the 418 kHz signal provided superior predictive accuracy for six (consolidated from eight) habitat classes (74.3 versus 68.2%). Consideration of all results reveals topographic complexity as the primary factor controlling both E1 and E2. The information encoded in the two frequencies is generally the same, with 418 kHz being better suited for discriminating between habitats of high complexity and 38 kHz for distinguishing between sand and sand-over-hardbottom. The LADS bathymetry proved useful for demonstrating that E1 and E2 values of single-beam echosounders can indeed produce meaningful coral reef benthic habitat maps.

## 17-23

**Measuring The Rough With The Smooth: Predicting Fish Species Richness Using Lidar Derived Surface Complexity**

**Simon PITTMAN*[1]**, Bryan COSTA[2], Tim BATTISTA[2]

[1]Biogeography Branch, NOAA & University of the Virgin Islands, St Thomas, Virgin Islands (U.S.), [2]Biogeography Branch, NOAA, Silver Spring, MD

Coral reef ecosystems exhibit complex vertical and horizontal structural heterogeneity at a range of spatial scales. This heterogeneity plays an important ecological role in influencing the distribution, abundance and behaviour of marine organisms. For example, more complex structures typically support higher species richness than less complex structures. Measures of surface complexity in the marine environment have been widely used to quantify structural heterogeneity, yet most studies have focused at relatively fine (<10 m) spatial scales and within single habitat types. Here we calculate several different measures of surface complexity at multiple spatial scales from LiDAR data collected from nearshore environments of southwestern Puerto Rico. We then evaluate their relative performance as predictors of fish species richness across topographically and compositionally complex mosaics of habitat types. The value of LiDAR data as a tool to support decision making in living resource management could be immense, if remotely sensed structural complexity can be linked effectively to biological patterns and processes.

## 17-24

**Remote Sensing For Studies Of The Local Spatial Distribution Of Coral Reef Fishes**

**Anders KNUDBY*[1]**, Candace NEWMAN[1], Ellsworth LEDREW[1]

[1]Department of Geography, University of Waterloo, Waterloo, ON, Canada

The local spatial distribution of fishes on a coral reef show that reef fish biodiversity is influenced by habitat variables including coral cover, depth, rugosity, and the distance to the reef edge. Commercially available satellite imagery can be used to map these habitat variables, and fish biodiversity can be estimated using the resulting habitat maps. We present a case study from two reefs in Zanzibar, Tanzania, based on high-resolution IKONOS imagery acquired concurrently with habitat and fish survey data from 2007. The influence of additional habitat variables, difficult or impossible to measure in-situ but mappable using satellite imagery, such as substrate beta-diversity and depth variability at a range of spatial scales, are also explored. We illustrate how accurately each habitat variable can be estimated using remote sensing, and how predictive each variable is for the local spatial distribution of fish biodiversity. We show a strong influence of the mapped habitat variables on fish biodiversity, and also show that the derived fish-habitat relationships change substantially between protected and unprotected areas. High-resolution satellite imagery is shown to have substantial value for spatial studies of fish biodiversity on coral reefs. Further research and/or future data sources are expected to improve estimation of several habitat variables, and thereby the accuracy of fish biodiversity maps.

## 17-25

**A Novel Model Framework For Predicting Organismal Distributions Across The Seascape Using Gis Topographic Metrics And Benthic Habitat Associations.**

**Brian WALKER*[1]**

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL

Increased topographic complexity has been linked to increased species diversity and/or abundance in many ecological communities including coral reefs. Several topographic metrics can be measured remotely in GIS using high resolution bathymetry including elevation, surface rugosity, and seafloor volume within specified areas. Statistical relationships between these data and organismal distributions within mapped habitats can be used to make predictions across the entire bathymetric dataset. In this study a model framework is presented which determines statistically significant relationships between reef fish abundance and species richness and GIS topographic complexity measurements for samples within similar benthic habitats. Predictions from these relationships for each habitat were then projected to create GIS-based prediction maps of abundance and species richness for the entire seascape. Reef fish associations with GIS topographic metrics were significant and varied between habitats. Model evaluation showed that patterns in the measured data emerged in the prediction data. The results allow for viewing of data trends throughout the seascape, quantification of assemblages in non-sampled areas, and statistical comparisons of areas within the region to support and guide management related decisions. This model framework can be adapted to other communities (e.g. benthic organisms) and/or parameters (e.g. diversity) that relate to topographic complexity.

## 17-26

**An Investigation Of Reef Fish Community Modelling With Geostatistical Methods**

**Jeanne DE MAZIERES*[1]**, James COMLEY[2]

[1]School of Marine Studies, University of the South Pacific, Suva, Fiji, [2]Institute of Applied Science, University of the South Pacific, Suva, Fiji

The objective of this study was to determine the spatial distribution of reef fish communities according to the habitat types of the Coral Coast, Fiji Islands by using geostatistical analysis methods. The Coral Coast is located on the south coast of Viti Levu, Fiji's main island which is bordered by a fringing reef about 80 km long. The study area was divided into 22 geomorphological reef units where biological data were previously collected. Substrate cover and fish counts were obtained for a total of 312 transects. Data were processed and a spatial database was created including the location of the surveyed transects associated with quantitative and qualitative information on substrate cover, habitat type and fish family abundance. We worked with six classes of habitats (sand, rubble, bedrock, macroalgae, seagrass and live coral) which were distinguished according to thresholds of 20% for the biotic substrate and 50% for the abiotic. Nine fish families were selected due to their importance for the fisheries and as reef health indicators. We conducted batches of exploratory and multivariate statistical tests to identify distinct and significant patterns of fish assemblage distribution at both scales of the reef system and the reef unit. The overall results showed that sand, seagrass and live coral habitats hosted significantly different communities. We then determined the fish families which were characteristic of those habitats. Their distribution was predicted at the reef unit scale by using the cokriging geostatistical model which allowed multivariate interpolation and estimation of prediction error. It seemed that the quality of the estimations varied highly depending on the reef unit and the family. Used as a complement to the others available tools, this geostatistical model might provide a useful support for decision-making and management of the reef resources.

## 17-27

**Predictive Habitat Mapping Of Deep Or Turbid Coral Reefs Using An Ecological Modelling Approach With Multibeam Data**

**Ben RADFORD*[1]**, Kimberly VAN NIEL[1], Karen HOLMES[1,2], Gary KENDRICK[3], Jessica MEEUWIG[3], Euan HARVEY[3]

[1]School of Earth and Geographical Sciences, University of Western Australia, Perth, Australia, [2]Centre for Ecohydrology, University of Western Australia, Perth, Australia, [3]Botany, University of Western Australia, Perth, Australia

In the past coral reef mapping using forms of remotely sensed data (such as satellite imagery, aerial photography) has been largely been limited areas shallower 30 meters of water depth because of light availability. However in resent years this has changed with in the introduction of sensors that can collect high resolution "Multibeam" sonar data. Multibeam sonar provides the potential to map at broad scale by providing high resolution bathymetric and substrate information from water depths of 20 to over 60 meters, When combined with an ecological modelling approach, multibeam and towed video imagery provide the basis for mapping living coral on deep or turbid coral reefs.

Here we outline this approach integrating data capture with analysis methods and ecological theory. We demonstrate this mapping method using deeper coral reefs areas from the Abrolhos Islands, Western Australia. This mapping approach involved a number of stages: (1) collecting and processing of raw data, (2) extensive secondary modelling on primary data, such as bathymetry, to develop spatial surfaces which are relevant to both the physical (e.g. h) and biotic aspects of a site, (3) integrating spatial surfaces and in situ information, (4) the development of predictive habitat models, and (5) the spatial extension of the in situ data to the unknown areas using the predictive models. Each of these steps is essential to build realistic spatially explicit models of reef substrate and major biotic groups. Predictive modelling methods were used to explore the data and final predictions were developed using a novel approach of merging multiple biotic predictions. This framework facilitated development of high accuracy maps of hard coral distribution (and other important biotic groups) were traditional spectral remote sensing would fail.

## 17-28

**Seafloor Characterization Using Multibeam and Optical Data at French Frigate Shoals, Northwestern Hawaiian Islands**

**Jonathan WEISS*[1]**, Joyce MILLER[1], John ROONEY[1]

[1]Joint Institute for Marine and Atmospheric Research, University of Hawaii, and NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

Multibeam bathymetry, backscatter, and optical data collected by NOAA's Coral Reef Ecosystem Division are used to create maps of seafloor habitats on the bank top at French Frigate Shoals in water depths ranging from <10-100 m. Supervised classification of backscatter and optical data with user-defined classes results in seafloor maps such as hard (rock, rubble, etc.) and soft (sandy) bottom that are useful. However, they suffer from a dependence on the optical data. Uncertainties in camera sled positioning, difficulty maintaining consistent tow depths, and user bias in the optical classification and supervised class definitions suggest an alternate approach may be necessary. Unsupervised classification of different combinations of bathymetry and backscatter derivatives uses the statistical separability of the data to define unique seafloor types. The optical data are then used to define and evaluate the accuracy of the classes. Habitat mapping using multibeam data in coral reef ecosystems presents unique challenges compared to other settings. A variety of methods are being evaluated and the resulting maps are being used to improve sampling techniques for long-term ecosystem monitoring, to guide future groundtruthing operations, and to identify coral-rich and species specific environments in the NWHI.

## 17-29

**Semi-Automated Classification Of Acoustic & Optical Remotely Sensed Imagery in The U.s. Caribbean**

**Bryan COSTA*[1]**, Tim BATTISTA[1], Charles MENZA[1]

[1]Biogeography Branch, NOAA/NOS/NCCOS/CCMA, Silver Spring, MD

Benthic habitat mapping supports ecosystem-based management objectives by contributing to the development of detailed species utilization models linking physical habitats with biological information. Marine habitats deeper than 30 meters have been successfully characterized by conducting heads-up digitizing of acoustic and optical remotely sensed imagery. These resulting maps, however, are subjective and ultimately irreproducible because they depend on the accuracy and interpretation of the person that is digitizing. Here we semi-automate the seafloor feature extraction and classification process using high-resolution MBES and LiDAR data as well as underwater images collected off the coast of western Puerto Rico. Alternative approaches were used to identify and extract seafloor features at relevant spatial and thematic scales. The accuracy of these mid to deep-water benthic habitat maps were validated using georeferenced underwater imagery. The ability to quickly and objectively create benthic habitat maps would allow scientists and resource managers to better quantify and assess the changing health of mid to deep-water coral reef ecosystems.

## 17-30

**Mapping Marine Habitats in The Largest Reef Area Of Southern Atlantic: The Abrolhos Bank, Brazil**

Daniel KLEIN[1], Alex BASTOS[2], **Guilherme DUTRA*[3]**, John MUSINSKY[4], Ruy KIKUCHI[5], Rodrigo MOURA[6]

[1]Marine Management Areas Science Program, Conservation International / UFBA, Caravelas, Brazil, [2]Laboratório de Oceanografia Geológica, DERN, UFES, Vitória, Brazil, [3]Marine Program, Conservation International Brazil, Salvador, Brazil, [4]CABS, Conservation International, Arlington, VA, [5]Centro de Pesquisas em Geofísica e Geologia, UFBA, Salvador, Brazil, [6]Marine Program, Conservation International Brazil, Caravelas, Bahia, Brazil

The Abrolhos Bank is the largest and richest coral reef area in the South Atlantic, covering 46,000 km$^2$ of shallow waters (up to 100 m deep) in the Northeastern Brazilian Continental Shelf. The region bears a mosaic of estuaries, mangrove forests and coralline reefs, as well as rodolith, grass, algae and muddy beds. Despite its importance, most of the bank remains unmapped in terms of the extension and distribution of its habitats, with the exception of emergent coralline reefs mapped in coarse scale with remote sensing (TM Landsat). This situation represents a major impediment for effective conservation planning, zoning and monitoring of marine managed areas. The project described herein is producing finer scale maps covering Abrolhos' main marine habitats with use of side scan sonar (Edgetech) surveys at two different scales: 1) East-West transects from shallow areas (20 m) to the shelf break, each transect spaced by 10 km (100 kHz); 2) finer scale mapping between the initial transects, in areas with hard bottom structures and higher habitat heterogeneity (500 kHz). Subsequent ground truth with targeted SCUBA dives, ROV (Remotely Operated Vehicle) and bottom grabbers are assisting habitat classification. Preliminary results are showing extensive areas of unmapped reefs (hard structures), as well as a great habitat diversity in inter-reefal areas. Paleochannels and other more isolated depressions were also recorded and observed along the Bank's plains. Habitats' maps resulting from these surveys will be critical for developing strategies for the sustainable use of the region's unique seascape.

## 17-31

**Single Beam Acoustic Remote Sensing For Coral Reef Mapping**

**Arthur GLEASON*[1]**, Pamela REID[1], Todd KELLISON[2]

[1]Marine Geology and Geophysics, University of Miami / RSMAS, Miami, FL, [2]NOAA Southeast Fisheries Science Center, Miami, FL

Coral reef habitats that cannot be mapped with optical techniques are both extensive and ecologically important. For example, over 55% of the Florida Keys National Marine Sanctuary (about 1540 square nautical miles) has not been mapped due to water depth or clarity limitations. Acoustic mapping systems are the natural solution to mapping optically deep water, and inexpensive commercial single beam seabed mapping systems are available. Several studies have used commercial single beam systems to map coral reefs, but basic questions about what substrates can be reliably distinguished and how consistent classification schemes are in different areas have not been systematically explored. We have used one commercial system, the Quester Tangent Series V (QTCV) to begin answering such questions. QTCV datasets from the Florida Keys, USA, the Bahamas, and Navassa Island reveal that rock and sediment are almost always reliably distinguished and that sediment grain size and high seabed relief are other factors captured by classification results. Moderate resolution (~100 m transect spacing) surveys in the Florida Keys are sufficient to delineate the extent of outlier reefs and to differentiate two distinct outlier reef morphologies: patches and linear ridges. Due to their low cost and portability, single beam systems can play a valuable role in coral reef mapping efforts, efficiently providing rapid reconnaissance and moderate resolution habitat maps of large areas.

## 17-32

**Characterization And Monitoring Of Insular Shelf Reefs in Optically-Deep Waters**

**Roy ARMSTRONG*[1]**, Maria CARDONA[1], Hanumant SINGH[2], Sara RIVERO[1], Fernando GILBES[1]

[1]University of Puerto Rico, Mayaguez, Puerto Rico, [2]Woods Hole Oceanographic Institution, Woods Hole, MA

Although remote sensing technology is a useful tool for monitoring shallow (<20 m depth) coral reefs present in clear oligothrophic waters, the large-scale assessment of reefs present in optically-deep waters require other approaches such as indirect methods or the use of *in situ* platforms for high-resolution optical and acoustic imaging. Optically-deep waters as those where the upwelling radiance received by the airborne or satellite sensor originates from the water column without any bottom signal contribution. These waters could be relatively shallow but mostly turbid or clear waters at depths of 30 m or more. For shallow reefs in clear to turbid areas we developed an indirect approach to infer coral reef community parameters based on the attenuation coefficient of photosynthetically-active radiation (Kd $_{PAR}$) of surrounding waters. Water optical measurements and coral reef surveys at 19 study sites along the south and west coasts of Puerto Rico were obtained. An inverse relationship ($R^2$ = 0.92) between Kd $_{PAR}$ and percent cover of living corals was found.

We used the Seabed autonomous underwater vehicle (AUV) for imaging mesophotic reefs, those present between 30 to about 100 m depth, using digital photo transects. Each transect was approximately 1 km in length and produced over 800 images, each about 3.1 m wide by 2.5 m long. These AUV transects have provided the first comprehensive data set of the deep coral reef habitat of Puerto Rico and the U.S. Virgin Islands. We found high coral cover at depths of 40-47 m at several sites south of St. Thomas and St. John (USVI), and between 35-40 m at Black Jack Reef, Vieques Island. These healthy and structurally-complex mesophotic reefs appear to be an abundant and ecologically-important habitat within the Puerto Rico-USVI geological platform.

## 17-33

**Geospatial Analysis: An Effective Tool For Simulating The Spatial And Temporal Dynamics Of Tropical Cyclone Disturbance Of Coral Reef Communities Across The Great Barrier Reef Region**

**Marji PUOTINEN*[1]**, Katharina FABRICIUS[2], Glenn DE'ATH[2], Terry DONE[2]

[1]School of Earth and Environmental Sciences, University of Wollongong, Wollongong, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

Tropical cyclones (hurricanes, typhoons) can cause major mechanical damage to coral reefs, which when repeated over time, can significantly affect the structure and function of reef communities such as those of Australia's Great Barrier Reef (GBR). Understanding the timing and frequency of these events (disturbance regime) requires mapping both the energy generated by each of a representative set of cyclones and the subsequent reef damage. However, direct measurements like these are rare in the GBR. For this reason, a meteorological model adapted to run in a GIS was used to reconstruct maximum wind speeds (as a proxy for wave heights) for 85 cyclones that passed near the GBR from 1969 to 2003. A comparison with limited field data of damage from cyclones Ivor and Joy (1990) and Justin (1997) was used to establish thresholds of maximum winds capable of damaging reefs. From these, a disturbance history was constructed. In 2005, severe tropical cyclone Ingrid crossed the Far Northern GBR, a region that had not been affected by major disturbances of any kind for several decades, and where benthic data had been collected before the event. This provided a unique opportunity to test the skill of the model in predicting reef damage and to refine the damage thresholds. An extensive field survey (82 sites on 32 reefs along the modelled wind gradient) showed that the types and intensity of damage were well explained by modelled maximum wind speed, and by spatial and biotic factors. For example, maximum winds <28 cm $s^{-1}$ for <12 hours inflicted only minor damage on any reef, but winds >33 m $s^{-1}$ and >40 m $s^{-1}$ caused catastrophic damage on inshore and offshore reefs, respectively. These results are being used to better understand both current and future (possible greater frequency / intensity) cyclone disturbance regime dynamics.

## 17-34

**Marine Integrated Decision Analysis System (Midas)**

**Suchi GOPAL*[1]**, Les KAUFMANN[1], Hrishi PATEL[1]

[1]Boston University, Boston, MA

Marine areas are critical regions on the Earth's surface as nearly two-thirds of the world's people live within 150 km of a coastline and are dependent on marine resources. Marine conservation has become seminal in this context. We present a spatial decision support system framework called MIDAS - Marine Integrated Decision Analysis System that integrates spatial and nonspatial data for marine management. The components of MIDAS are: (1) JIM (Java Interface for Managers) a graphic interface and JAVA code (programming) that allows a MMA manager to change parameters or conditions as a thought experiment and see outputs or consequences of a user-driven change in parameter states; (2) a GIS database that appears in map form, called JIM-Mapper, implemented using ArcIMS, that allows for dynamic GIS displays and spatial analysis; 3) a Bayesian Belief Networks (BBNs) to provide an appropriate method for developing predictive models of marine management effectiveness. The marine BBN's general structure is that of an integrated knowledge extraction/expert system. Knowledge is extracted from scientific literature as well as from experts for representing concepts as well as their relationships. BBNs represent information in the form of probabilities, enabling many different sources of data to be integrated and analyzed according to a common framework. We discuss the implementation of the three components of MIDAS for Belize and Brazil marine coastal management.

## 17-35

**A Procedure To Target Coral Reef Deterioration Using Ikonos Satellite Imagery, Zone Boundaries, And Coral Reef Use**

**Candace NEWMAN*[1]**

[1]Geography, University of Waterloo, Waterloo, ON, Canada

We have developed a procedure to identify specific locations of coral habitat that have a 'high probability of acute deterioration' caused by human impact. The procedure uses satellite imagery, coral zonal boundaries, and coral reef use by dive operators and fishermen. The procedure involves development of a habitat map, then overlaying zonal boundaries and reef use data in a GIS. Using a set of criteria, sites with a 'high probability of acute deterioration' are identified, and then validated using in-situ field survey data. The potential for this procedure to address local coral reef management issues is significant, and relevant to current management projects on Bunaken Island, Indonesia.

It is increasingly evident that context-relevant maps are essential to address acute coral reef degradation concerns in developing nations. On Bunaken Island, specific coral reef management projects are consistently undertaken, and many projects are focused on conflict resolution between coral reef resource user groups – dive operators and fishermen. Therefore, a challenge is to utilize remotely sensed information, combined with context-specific information, to contribute relevant and useful management information to these projects.

In this study, we develop a procedure to address this challenge. IKONOS satellite imagery was captured in 2001 and 2004 and has been integrated with zonal boundary data of Bunaken Island, which recognizes different coral reef use activities and coral reef use data by dive operator and fishermen groups. Following integration and analysis in a GIS, sites of 'high probability of acute deterioration' have been identified. Results were validated using field survey data, as well as contributions from Universitas Sam Ratulangi and local NGOs.

## 17-36

**The Coral Reef Landscape: Spatial Patterns Of Water Quality in The Florida**

**Daniel WAGNER*[1]**, Eric MIELBRECHT[2], Robert VAN WOESIK[1]

[1]Department of Biology, Florida Institute of Technology, Melbourne, FL, [2]Emerald Coast Environmental Consulting, Washington, DC

While we have some peripheral understanding of water-quality 'weather', which includes nutrients, salinity, temperature and turbidity, we know little about the coral-reef landscape 'climate' and the influences of that climate on coral-community structure. Determining the scales of the inherent variability of key environmental variables is clearly necessary. We use landscape-ecology techniques coupled with Geographic Information Systems (GIS) technologies to examine the spatial dynamics of specific water-quality parameters along the Florida Keys reef tract. The spatial distance at which temperature variance stabilized throughout the region was dependent on whether the samples were from the surface or near-substrate. Greater homogeneity was found for near-substrate temperatures, with patches at ≤ 1.075 km compared to ≤ 0.893 km for the surface. Salinity was more homogeneous at the surface (≤ 1.662 km) than near the substrate (≤ 0.234 km). Surface chlorophyll a showed greater homogeneity at ≤ 0.592 km while DIN patches were more homogeneous near the substrate (≤ 2.873 km) than at the surface (≤ 0.151 km). The greater variability of other parameters, including turbidity and total nitrogen, precluded accurate predictions at the applied spatial scale of sampling. This is not to say turbidity for example is not important, because it is, but we need to re-evaluate the sampling strategy to capture the inherent scale at which these parameters vary. Moreover, temperature variance decreased across the shelf from inshore zones to offshore as a function of distance from the shoreline. The significant difference between surface and near-substrate temperatures seriously questions the commonplace use of sea surface temperature data in evaluating direct influence on reef corals because it ignores the variability of the system due to the stratification of the water column.

## 18-1

**Stony Coral Status And Trends in Dry Tortugas National Park (Florida, Usa): 1975-2007**

**Douglas MORRISON*[1]**, Walt JAAP[2], Carl BEAVER[2], Michael CALLAHAN[2], Dustin JOHNSON[2], Jim KIDNEY[2], Selena KUPFNER[2], Shannon WADE[2], Jennifer WHEATON[2]

[1]Dry Tortugas National Park, USNPS, Key Largo, FL, [2]Florida Fish and Wildlife Research Institute, FFWCC, St. Petersburg, FL

Coral reefs are arguably the most important natural resource in Dry Tortugas National Park (DTNP). Stony coral abundance in DTNP has been monitored periodically since the mid-1970's using multiple methods. Live coral percent cover has been measured using photo quadrats and video transects at fixed stations. Larger scale assessments of coral spatial extent have been conducted using aerial and in-water surveys. There has been a substantial decrease in stony corals, especially *Acropora spp*., over the last 30 years. There were 479 hectares of *Acropora* dominated reefs (mostly *A. cervicornis*) in the park in 1976; but, there are currently only about four hectares of live *Acropora* thickets, a 99% loss. Furthermore, *Acropora* live cover is ≤5% on these existing reefs. Reef forming *Montastrea, Siderastrea*, and *Colpophyllia* coral species also have declined in abundance. Mean coral cover at a long term monitoring site dominated by *Montastrea spp*. and *Colpophyllia* decreased from 45% in 1975 to 10% in 2006. Stony coral abundance declined 25% at seven monitoring sites from 2005 to 2006, based on pooled means (6.3% cover in 2005 and 4.7% in 2006; $p<0.004$, Wilcoxon paired sample test). Most coral loss in the 1970's and 1980's was caused by hypothermic events (strong cold fronts) and disease. More recent coral loss has been due to disease and bleaching; and five hurricanes in a 14 month period in 2004 and 2005, an unprecedented occurrence in the 130 year history of Tortugas science. Coral decline is the most significant and challenging DTNP resource stewardship issue. U.S. National Park Service science and stewardship strategies addressing this issue are discussed.

## 18-2

**Status Of Florida Keys Coral Reefs Based Upon Multiple-Scale Sampling**

**Mark CHIAPPONE*[1]**, Dione SWANSON[2], Leanne RUTTEN[1], Steven MILLER[1]

[1]Center for Marine Science, University of North Carolina-Wilmington, Key Largo, FL, [2]Division of Marine Biology and Fisheries, RSMAS-University of Miami, Miami, FL

Large-scale coral reef benthic surveys in the Florida Keys utilizing a two-stage stratified random sampling design provide context to smaller-scale monitoring and experimental studies, and reveal a complex spatial and temporal pattern of reef status. Shallow, offshore reefs historically dominated by Acropora palmata are now, depending upon regional location, dominated either by Palythoa and Porites astreoides or by gorgonians and Millepora. Stony coral cover is currently low (< 10%) for most reefs, except those with existing A. palmata stands, where coverage is upwards of 25%. Patch reefs further inshore reveal a different spatial pattern, with greater coral species richness, colony density, size, and cover, especially by mounding corals, even though the Florida Keys inner shelf margin is closer to shore and experiences considerable environmental variability. Low-relief hard-bottom areas interspersed between higher relief reefs continue to exhibit dominance by turf algae and gorgonians, with very low coral abundance (< 5%). Deeper fore reef slope areas are intermediate in terms of coral species richness and abundance between the patch reef and shallow fore reef environments. Temporal comparisons since 1999 reveal a pattern of relative stability at multiple scales. Comparisons between no-fishing zones and corresponding reference habitats illustrate the non-random placement of 23 of these relatively small zones, as they were selected because of factors such as coral species richness and cover. Diadema antillarum densities are still well under 1 individual/m2 compared to pre-1983 values, although there is some indication that densities and sizes increased since 1999. Scleractinian coral disease prevalence is upwards of 2% of the Florida Keys coral colonies. Coral bleaching was relatively mild until 2005, when a moderately severe event impacted most species and ~25% of colonies, followed by a less severe episode in 2007.

## 18-3

**Shifting Dominance And Diversity On A Florida Forereef: Is The Ripple Effect Gaining Momentum?**

**Stephen GITTINGS*[1]**, Mitchell TARTT[1], Steven MILLER[2], Sarah FANGMAN[3], Patrick GIBSON[4], Lad AKINS[5], Mark CHIAPPONE[2], Dionne SWANSON[6], Allison WHITE[2]

[1]National Marine Sanctuary Program, NOAA, Silver Spring, MD, [2]University of North Carolina at Wilmington, Key Largo, FL, [3]National Marine Sanctuary Program, NOAA, Savannah, GA, [4]University of North Carolina, Chapel Hill, NC, [5]Reef Environmental Education Foundation, Key Largo, FL, [6]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

Since 1994, benthic cover and fish populations have been monitored between 20 and 30 m depth on Conch Reef, Florida Keys, to assess change in a deep fore reef community on the reef tract. Surface and saturation divers collected repetitive and random photographic data during four expeditions between 1994 and 2007, and counted fish, brittle stars, and sea urchins beginning in 1998. They measured coral, sponge, and algae cover, brittle star and sea urchin abundance, and fish richness and relative abundance. Our findings suggest that changes and impacts from declining environmental quality pervade this coral reef community. Cover data reflect a trend of increasing dominance by algae on Conch Reef. Invertebrate surveys show a lack of recovery of the long-spined sea urchin, Diadema antillarum, following the 1983 mass mortality of the species. The loss of this important herbivore has been linked to the proliferation of algae on the reef. An unexpected finding was the near absence of brittle stars inhabiting Conch Reef in 2007. A total of 360 individual surveys (visual inspections of the underside of rocks at three depths; 6m, 20m, and 30m) yielded only three individuals. Data from research published in the 1970s suggested abundances 250 times higher. This raises the concern that there may be widespread biodiversity loss among other taxa for which information is lacking. This would have significant implications on ecosystem integrity in a community that depends heavily on multi-species interactions, and represents a formidable challenge for marine protected area management.

## 18-4

**Ten Years And Counting: The Coral Reef Monitoring Project in The Florida Keys**

**James W. PORTER*[1]**, and Coral Reef Monitoring Team -[2]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]-, -, FL

Coral reefs of the Florida Keys are the most studied, regulated, and protected tropical marine ecosystem in the world. Despite all of this attention, over the last decade, reefs of the Florida Keys have lost 50% of their living coral cover (falling from a survey-wide average of 12.1 % cover to 6.1%). In addition, 25% of all study sites have fewer species in them now than in 1996. Major reef-building corals, such as the iconic branching coral *Acropora palmata* and the massive monument coral *Montastraea annularis* have lost 85% and 33%, respectively, of their projected surface area. Coral loss (in terms of either reduced species number or coral cover) is greatest in the Upper Keys (off Key Largo) and in the Lower Keys (off Key West), and least in the Middle Keys (off Marathon). Bleaching and disease have contributed causally to these declines. *Diadema* density remains remarkably low, but has increased slightly from $0.0008/m^2$ in 1996 to $0.0033/m^2$ in 2006. Despite some inter-annual variation, neither octocoral nor marcolagal abundance has changed appreciably over the ten years of the project.

In the last half decade, coral loss in the Florida Keys has slowed considerably, perhaps providing a respite within which to enact stronger local (wastewater and stormwater master plans), state (wastewater treatment standards), federal (no-discharge zones, navigational aids, and tougher water quality standards), and international (green house gas) legislation to protect coral reefs.

## 18-5

**Coral Reef Habitat Around New Providence Island, Bahamas**

**Walter JAAP*[1]**, Jennifer DUPONT[2], Walter JAAP[1]

[1]Lithophyte & USF CMS, St. Petersburg, FL, [2]USF CMS, St. Petersburg, FL

In July 2006, the Academy of Natural Sciences of Philadelphia organized an expedition to New Providence Island, Bahamas. Sampling sites were based on the Böhlke and Chaplin's (1968) field notes and recollections of Gordon Chaplin (participant in the original studies). Coral species richness and cover, and reef surface rugosity were examined at three depth zones: 1.5 to 6.1 m (1), 6.2 to 7.6 m (2), 7.7 to 15.2 m (3) at Delaport Point (DP), Green Cay (GC), and Long Cay (LC). Greatest number of coral species (27) was observed at DP-2 and the fewest (14) at DP-3. Rugosity was greatest at GC-1 due to the spatial complexity of an *Acropora palmata* reef. Coral cover tracked well with rugosity index (RI); GC-1 with an average RI of 1.7 had coral cover (20.56%) superior to the other stations. Algae were the most abundant benthic cover component: mean= 50.99 ± 25.45% (SD) for all stations; stony coral cover ranged from 0.65 to 20.56%, and the mean was 6.72 ± 6.94%. Similarity (Bray Curtis coefficient) was greatest among GC stations and transects; weakest transect similarity occurred at DP-2. ANOSIM two-way crossed test documented that replicate transects at sampling stations were not different (Global R =0.066); however, site locations were different (Global R = -0.259). SIMPER analysis documented that when the algae genera were removed from the analysis, *Acropora palmata* contributed 20 to 30% of dissimilarity in setting GC-1 apart from other stations. Taxonomic Distinctness (□+) and Variation in Taxonomic Distinctness (Lambda+) evaluations reported that □+ is stable and Lambda+ shows strong variance.

## 18-6

**The Almost Total Loss Of Acropora Palmata From The Shallow Waters Off Barbados, West Indies, Initiated By Catastrophic Destruction Of A Major Bank-Barrier Reef Off The Southeast Coast**

**Ian MACINTYRE*[1]**, Peter GLYNN[2], Marguerite TOSCANO[1]

[1]Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC, [2]RSMAS - MBF, University of Miami, Miami, FL

The reef-building coral *Acropora palmata* has virtually disappeared from the shallow waters off the coast of Barbados. Only a few individual colonies are known to exist off the west coast. The abundance of *A. palmata*, which was a major reef-framework component of both Pleistocene and Holocene Barbados reefs, started to decline between 4,500 to 3,300 years ago as a result of the catastrophic destruction of a major bank-barrier reef off the southeast coast. This bank-barrier reef has never recovered to form reef framework since this period of destruction, and colonies of *A. palmata* have continued to disappear right up to modern times. Although the geologic loss of this coral was related to severe storm damage, in historic times stress factors related to human activity have brought this coral to a stage of almost total local extinction.

## 18-7

**Recent Regional Declines In Reef Relief Within The Caribbean**

**Lorenzo ALVAREZ-FILIP*[1]**, Jenny GILL[2], Nicholas DULVY[3], Andrew WATKINSON[1]

[1]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, [2]School of Biological Sciences, University of East Anglia, Norwich, United Kingdom, [3]Centre for Environment, Fisheries & Aquaculture Sciences, Lowestoft, United Kingdom

Habitat structure is a key factor influencing the abundance and diversity of organisms in all ecosystems. In tropical reefs, corals and other sessile organisms can provide a complex architecture that supports a wide array of species. The loss of this reef structure is therefore likely to result in a loss of biodiversity, with perhaps rapid loss of reef specialists and indirect, delayed consequences, for taxa with more generalist habitat preferences. Drastic declines in coral cover have been reported across the Caribbean in recent decades, as result of human activities, diseases outbreaks and climate change. Here we collate over 100 studies reporting reef rugosity (using the chain method) in the Caribbean Sea between 1969 and 2006, to explore the extent to which declines in coral cover have been mirrored by loss of reef structure, and the potential implications for reef biodiversity. There have been substantial changes in reef rugosity across the Caribbean throughout this time period, with studies in the 1970s reporting a wide range of values but recent studies consistently reporting low reef rugosity. These declines in habitat structure on reefs are likely to have very important implications for rates of change in reef biodiversity.

## 18-8

**Patterns Of Decline And Evidence For Resilience in Caribbean Coral Reefs**

**Virginia SCHUTTE*[1]**, Elizabeth SELIG[2], John BRUNO[1]

[1]Marine Sciences, UNC-Chapel Hill, Chapel Hill, NC, [2]Curriculum in Ecology and Marine Sciences, UNC-Chapel Hill, Chapel Hill, NC

Coral reefs are being degraded worldwide and the Caribbean basin is generally thought to include some of the world's most at-risk reefs. Building on several recent studies that described changes in Caribbean coral and macroalgal cover, we compiled and analyzed a database of quantitative reef surveys from eight Caribbean regions using data from peer-reviewed and grey literature and from several extensive monitoring programs. The database contains about 3,700 surveys from almost 2,000 reefs surveyed from 1971-2006. Yearly Caribbean-wide means show a 14.6% decline in absolute coral cover from 32% in 1971 to 17.4% in 2006. Most of this decline took place in the early 1980s. Coral cover has fluctuated between 12% and 18% since 1993, and has had an increasing trend from 2000 to 2006. There is significant variation in coral cover between regions, however. Average regional coral cover ranged from 6.9% to 50.3% in 2005. Some regions have even had a modest increase in coral cover from 2001 to 2005. In addition, most reefs have not undergone classic phase shifts. The majority of reefs have low coral and macroalgal cover, and only 5.6% of all surveys reported more than 50% macroalgal cover. Average macroalgal coverage on all reefs was only 12.9% in 2005, and ranged from a fraction of a percent to 71.9% on individual reefs. Our database yielded a much higher estimate of current coral cover and a much lower prevalence of phase shifts than previously reported. This suggests that Caribbean reefs are more resilient than expected, and that recovery may still be possible if we continue to invest in coral reef management.

## 18-9

**Long-Term And Large-Scale Trends in Caribbean Coral Reef Fish Populations**

**Michelle PADDACK*[1,2]**, Isabelle CÔTÉ[1], John REYNOLDS[1], Andrew WATKINSON[2]

[1]Biological Sciences, Simon Fraser University, Burnaby, BC, Canada, [2]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom

Coral reefs worldwide have become severely degraded within the past several decades. This is particularly so in the Caribbean, where live coral cover across the region has declined by 80%, resulting in reefs with dramatically changed benthic community structure. Despite awareness that a fundamental shift in ecosystem structure has occurred, there is currently no quantitative estimate of temporal trends for other aspects of the coral reef community. Consequently, we have little understanding of how these organisms are responding to changes driven by increasing stressors. The aims of this project were to: (1) assemble, for the first time, all available abundance data on Caribbean coral reef fish communities, and (2) analyze these data to test predictions about how abundance and community composition respond to variation in both natural and anthropogenic stressors. Data from over 30 published and unpublished scientific surveys, spanning the entire range of years in which fishery-independent surveys have been conducted (1973 – 2007), and over 80 sites across the Caribbean were compiled and analyzed using meta-analytic techniques. Overall, there has been surprisingly little change in abundance of coral reef fishes over the past 34 years. However finer-scale examination reveals a mixture of significant declines and increases within specific guilds. These findings suggest that Caribbean coral reef fish community assemblages are experiencing shifts concomitant with changes in benthic structure, but that some groups of fishes may be less resilient than others to ecosystem-wide stressors.

## 18-10

**Population Status Of The Long-Spined Sea Urchin Diadema Antillarum in The Florida Keys 25 Years After The Caribbean-Wide Mass Mortality**

**Mark CHIAPPONE*[1]**, Dione SWANSON[2], Leanne RUTTEN[1], Steven MILLER[1]

[1]Center for Marine Science, University of North Carolina-Wilmington, Key Largo, FL, [2]Division of Marine Biology and Fisheries, RSMAS-University of Miami, Miami, FL

The 1983-84 Caribbean-wide mortality of the long-spined sea urchin Diadema antillarum Philippi was followed by a second mortality event in the Florida Keys in 1991. The demise of this once ubiquitous urchin is considered a key factor responsible for the changes observed on Florida and Caribbean reefs during the past 25 years, including increases in algal cover and declines in crustose coralline algae, reef coral abundance, and coral recruitment. Over an 8-year period from 1999-2007, we examined densities and test sizes of D. antillarum at over 800 sites spanning ~350 km of the southeast Florida shelf encompassing Biscayne National Park, the Florida Keys National Marine Sanctuary, and Dry Tortugas National Park. Visual surveys along belt transects were used to enumerate the number of individuals and test sizes in a two-stage stratified random sampling design that incorporated benthic habitat types, geographic regions, and no-fishing management zones. While pre-1983 densities in the Florida Keys were reported to be as high as 5 individuals/m2, surveys since 1999 at over 850 sites in a variety of hard-bottom and coral reef environments from < 1 m to 27 m depth reveal that current densities are still well below 1 individual per m2. During seven different annual sampling periods, the maximum site-level density was only 0.33 individuals/m2, with the highest densities of large (> 5 cm test diameter) individuals reported from shallow-water hard-bottom and reef sites in the Dry Tortugas and the upper Florida Keys. While the relative importance of larval survivorship, predation pressure, suitable recruitment sites, and reduced fertilization success are poorly known, these surveys provide baseline information from which recovery can be monitored across multiple habitat types, geographic regions, and managed areas.

## 18-11

**Was The 1998 Coral Bleaching in The Southern Seychelles A Catastrophic Disturbance? -1999-2006 Reef Fish Responses To Coral Substrate Changes**

**Raymond BUCKLEY*[1,2]**, Nigel DOWNING[3], Ben STOBART[4], Kristian TELEKI[5]

[1]College of Ocean and Fishery Sciences, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, [2]Fish Program/Marine Resources, Washington Department of Fish and Wildlife, Olympia, [3]Cambridge Coastal Research Unit, Cambridge University, Cambridge, United Kingdom, [4]Marine Reserves, Spanish Institute of Oceanography, Mallorca, Spain, [5]International Coral Reef Action Network (ICRAN), Cambridge, United Kingdom

Responses of reef fish communities to massive losses of live coral habitat are influenced by pre-impact richness of corals and fishes, and by anthropogenic disturbances which can also confound determinations of natural responses. Aldabra Atoll, a protected UNESCO World Heritage site, and neighboring unprotected islands of Assomption, Astove and St Pierre, were coral-rich sites prior to the 1998 bleaching-event loss of up to 50% of live coral. Hard coral recovery has been minimal except for significant increases at St. Pierre. Multivariate comparisons are made of fish populations at 10m and 20m depths at Aldabra (1999-2006; Sites 1-8), Assomption (2002-2006), Astove (2002-2005), and St Pierre (2002-2005). Aldabra fish abundances by species were not different between years and sites, except at Sites 2 (10m), 4 (20m), and 7 (20m), where between year differences were driven by high annual variability in schooling, reef-resident planktivores (Serranidae 5 species, Labridae 1 species, Pommacentridae 5 species). Removing these species from analyses eliminated differences at Sites 2 and 4, but Site 7 remained different, likely due to storm-induced inundation by sand that caused habitat changes. Assomption, Astove and St. Pierre fish abundances by species were not different between years, and were similar to high fish counts at Aldabra Site 6. These results support earlier analyses that post-bleaching reef fishes at Aldabra represent pre-bleaching community structure, and abundance changes appear to be within the natural ecology of the system. Similar responses at neighboring unprotected islands suggest that any local harvest primarily affects non-reef-resident species. The massive1998 losses of live coral habitat in these rich coral and reef fish communities do not appear to represent catastrophic disturbances that changed the basic structure of the reef fish assemblages.

## 18-12

**Spatiotemporal Trends in Biodiversity And Coral Reef Communities Structure At A Decade Scale (Reunion Island; Southwest Indian Ocean)**

**Lionel BIGOT*[1]**, Bruce CAUVIN[2], Emmanuel TESSIER[2], Pascale CHABANET[3], Vianney DENIS[1]

[1]ECOMAR, University of Reunion Island, St Denis, Reunion, [2]APMR - Reunion Marine Reserve, St Leu, Reunion, [3]IRD La Réunion, Ste Clotilde, Reunion

Since 1998, the GCRMN standardised methodology (LIT) has been used to assess the coral reefs and fishes in Reunion Island through a monitoring survey realized each year. Fourteen stations have been surveyed on the reef flats and the outer reef slopes at St Gilles / La Saline, St-Leu, Etang Sale and St Pierre reef complexes. Spatio-temporal trends of benthic community structure and fishes were studied in the context of the BIOCOR and PAMPA scientific project related to the implementation of the new Marine Reserve. The first results on St Gilles / La saline reef show that 75 species of corals have been recorded during the 10 last years and highlight the dominance of the "habitat" factor on the time (year) factor. Main trends in benthic community structure show that algal coverage became dominant after 2000 on reef flat and reef slopes. On the outer reef slopes, temporal trend is associated with a decrease of coral cover (from 56 to 32 % in 2007) and coral diversity (from 29 in 1998 to 15 species in 2006), and a progressive shift of coral communities. St Leu outer reef slope are characterized by the highest live coral coverage and diversity and a moderate temporal changes in benthic communities between 1998 and 2007.

Overall, fish densities increase after 2002 on all sites that could be due to a massive recruitment. Moreover, results on trophic structure highlight important fluctuations through time of herbivore groups while carnivorous group remains at a very low level, results probably related to overfishing.

All these results displayed contrasting spatial and temporal situations of Reunion Island coral reef ecosystems that are subjected to several natural disturbances (cyclone, bleaching) surrounding the chronic anthropogenic pressures affecting coral reef communities according to their degree of resilience.

## 18-13

**Response Of High Latitude Hermatypic Coral To The Rising Sea Water Temperature At Daya Bay, South China's Guangdong Province**

**Hui HUANG*[1]**, Jiansheng LIAN[1], Jianhui YANG[2], Xiubao LI[1]

[1]LMB, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of, [2]South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of

Daya Bay is a semi-enclosed subtropical bay located in the southeast of the south China's Guangdong Province. Its latitude is 22.5°N-22.9°N, covering an area of about 550 km$^2$. The water exchange with the ocean is low and the residence time of seawater is about 1 or 2 months. Two Nuclear Power Stations, situated in the mid-part of west coast of the bay, began in commercial operation in the 1994 and 2003 respectively. The cooling water plume flows into the bay and accumulatively elevates the sea water temperature of the bay by about 1.1 degree Celsius, which is about the temperature rise of IPCC 2007's projection for 2050. This provides a unique "in situ experiments" to explore the response of hermatypic coral to the rising sea water temperature. Change of temperature scheme is very sensitive because the distribution of hermatypic corals in Daya Bay is near their north limit.

The percent cover and community structure of hermatypic corals in Daya Bay was surveyed using line transect methods in 2007. Comparing the historical survey records in 1983~84, 1991, and 2002, a great change was observed. The live coral cover was 70% in 1983~84, then stabilized at ~30% after 1991, and slightly increase to 33~35% after 2005. The dominant species was *Acropora* spp. in 1983~84 and theretofore, which was replaced by *Favia* spp. after 1991. The percent cover of *Acropora* spp. and the total species number was also increased after 2005.

The annual growth rates were estimated using X-radiography technique with coral samples of *Porites lutea*. We found that the growth rates of the coral influenced by the cooling water were 0.8mm/a greater than those unaffected.

Our results suggested that increasing sea water temperature may favor the growth and development of hermatypic corals in high latitude area like Daya Bay.

## 18-14

**A Ten-Year Study On Dynamical Structure Of A Sub-Tropical Coral Community in Hong Kong Sar, China**

**Tze-wai TAM*[1]**, Put O. ANG[1]

[1]Marine Science Laboratory, Department of Biology, The Chinese University of Hong Kong, Hong Kong, Hong Kong

A long term monitoring programme of a sub-tropical coral community has been set up in A Ma Wan, Tung Ping Chau Marine Park, Hong Kong and has been on going since May 1997 with nine fixed position 40 m long transects and 0.5 m x 0.5 m permanent quadrats laid at every 5 m interval along each transect. The study is to provide the first-hand information for understanding the natural variation of Hong Kong corals towards physical disturbances and to serve as an important baseline for objective assessment of human impacts on the local coral communities. At the beginning of the study, a total of 40 scleractinian coral species from 20 genera (12 families) was recorded. Over the ten-year study (1997 - 2006), the coral community was subject to repeated physical disturbances caused by tropical cyclones. Within the period from 1997 to 1999, the site experienced the highest frequency of severe tropical cyclones and the strongest cyclone to hit Hong Kong in the last 23 years (1984 - 2006). The coral cover was reduced significantly after the cyclone impacts and the community never recovered to its original state ever since. *Cyphastrea serailia*, *Goniopora lobata*, *Montipora peltiformis* and *Pavona decussata* were the dominant species most highly affected by the cyclone impacts. Significant shift in the coral community structure from *Platygyra-Goniopora* dominant community to *Pavona-Platygyra* dominant community was also observed after the cyclone impacts. Overall, the coral community was relatively stable and resistant towards short-term but not long-term repeated disturbances. The community may also have low resilience towards more severe disturbances in the future. Preserving the resilience of coral communities/species in Tung Ping Chau should be one of the main goals of coral conservation strategies for the island marine park.

## 18-15

**Decadal Scale Changes in Coral Reefs in Quintana Roo, Mexico**

**Thaddeus NICHOLLS*[1]**, W. David LIDDELL[1]

[1]Geology, Utah State University, Logan, UT

The east coast of Quintana Roo, Mexico is bordered by the barrier-fringing reefs of the Mesoamerican reef system. Spanning over 1126 km from the tip of the Yucatan Peninsula south to the Bay Islands off the Honduran coast, this reef system is the largest in the Atlantic, and the second largest in the world. The Caribbean coast of Quintana Roo was covered by semi-humid tropical rainforest until 1970, when coastal development including road and resort construction broke ground. Sixty percent of this area had been cleared by 1988 for the "megaproject" known as the "Cancun-Tulum Touristic Corridor," or "Mayan Riviera." The long term impact of this development on the coral reefs of this area had not been quantified. In 1992 data on community composition were collected from two areas, Akumal and Chemuyil, ranging from 4.8-33.5m depth. These areas were revisited in 2005 and data were collected in the same fashion and at the same depths as in 1922 to determine if coastal development has had a significant impact on the coastal reefs. Chi squared analysis determined that the community composition data collected in 1992 are significantly different from those data collected in 2005 (alpha value 0.05). Coral cover in Chemuyil at 33.5m declined from 44.1% to 33.3%. Algae (including macro algae, filamentous algae, and erect coralline algae) coverage at the same site increased from 29.1% to 46.7%. Similar trends are observed at accompanying sites. Anecdotal accounts suggest that the trends exhibited by the reefs are due to nutrification by septic water flowing through the highly porous karst limestone of the Yucatan Peninsula since there were few signs of damage to the reefs other than a very high percentage of algae coverage. Furthermore, fish populations appeared to be relatively healthy.

## 18-16

***pocillopora* Recovery At Devil's Crown, Galápagos Islands, Ecuador, Following Extirpation Associated With The 1982-83 El Niño-Southern Oscillation**

**Joshua FEINGOLD*[1]**, Peter GLYNN[2]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Fort Lauderdale, FL, [2]Department of Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

In 1982-83 a severe El Niño-Southern Oscillation (ENSO) event killed 95% of the scleractinian corals in the Galápagos archipelago. Over 99% coral mortality occurred at the Devil's Crown study site located within the flooded (2-4m depth) center of a small (156 x 100m), emergent, dormant volcanic cone off the north coast of Floreana Island. Also at this site, a structural reef composed primarily of the branching coral *Pocillopora* spp. was lost from contrary wave action combined with primary and secondary biological disturbances associated with ENSO. For the subsequent 11 years *Pocillopora* was not observed there, however 5 colonies were seen in May, 1995. Since then the number and size of colonies were monitored approximately annually. Coral colony surface areas were determined following two methods: direct measure during snorkel surveys to determine maximum width and length (1995-2003), and digital photography to obtain 2-D images (2004 & 2007). These images were converted to projected surface area using the program CPCe. The numbers of *Pocillopora* colonies increased from 5 in 1995 to 154 in 2007, with total colony surface area increasing from 849 cm2 to 37,772 cm2 (3.8m2) over the same period. Colonies initially appeared via sexual recruitment, probably from source populations located upcurrent, and now larger colonies are fragmenting and forming localized aggregations. This long term (25y) monitoring reveals slow initial recruitment from 1995 to 2002 followed by recent accelerated increases in *Pocillopora* colony number and surface area. This suggests that *Pocillopora* may once again attain population densities sufficient to form reef structures, an unusual prospect considering the widespread reports of coral loss worldwide.

## 18-17

**Status Of The Mesoamerican Reef System**

Miguel GARCIA SALGADO[1], Marydelene VASQUEZ[1], **Gabriela NAVA MARTÍNEZ*[2]**, Noel JACOBS[3]

[1]MBRS project, Belize City, Belize, [2]Oceanus, A.C., Chetumal, Quintana Roo, Mexico, [3]MBRS project, Belize city, Belize

A synoptic monitoring program was established in the Mesoamerican Barrier Reef System (MBRS) region since 2004, with the objective of gather information about the status of the reef ecosystems and other associated ecosystems such as seagrasses and mangroves. This MBRS project comprises a four countries initiative: Mexico, Belize, Guatemala and Honduras.

The establishment, operation and maintenance of this environmental monitoring program in the long term will provide a synoptic vision of de MBRS health. At the same time, a Regional Environmental Information System was created and uploaded to the www to facilitate the capture of the data on line and results analysis information in the regional level.

The information generated allowed the establishment of a baseline with data from 2004-2005.For Coral Reef Ecosystem, the MBRS region has an average of 23.47% live coral cover, and 35.38% of algal cover for the region. The main live components (sponges, octocorals, stony corals, encrusting coralline algae and Millepora) were compared to algae in order to develop a baseline that can be used by later studies to determine any trends in change to the benthic reef community. The baseline mean ratio of MLC to algae in the MBRS region was of 1.19 meaning that typical reefs in this region are not overrun with algae.

This information is now analyzed in a temporal trend at each site to determine changes in the Mesoamerican Reef. This tool has been useful for comparisons of impacts from human activities and natural disasters that influence directly in the sustainable use and conservation of the MBRS.

## 18-18

**The Decline Of Crinoids On The Reefs Of Curaçao And Bonaire, Netherlands Antilles**

**David L. MEYER*[1]**, Elizabeth A. DAME[1,2], Peter B. LASK[1]

[1]Geology, University of Cincinnati, Cincinnati, OH, [2]Geology, University of Cincinnati, Cincinnati

Comatulid crinoids were abundant on the leeward fringing reefs of Curaçao and Bonaire until the 1990s, but since 1996 have declined drastically in population size and diversity. Prior to this decline, five species inhabited the forereef slope from depths of 6 to over 30 m: *Nemaster grandis, Davidaster rubiginosa, D. discoidea*, an undescribed species of *Davidaster*, and *Ctenantedon kinziei*. Of these, *D. rubiginosa* and *D.* n. sp. were common along the edge of the forereef slope from about 6 to 15 m depth, and *D. discoidea* was common below about 15 m. *N. grandis* and *C. kinziei* were found in lower abundance at about 30 m depth. Transect data from Bonaire showed that a drastic decline in numbers of the *Davidaster* taxa occurred between 1989 and 1996. Transects in Curaçao in the late 1990s through 2001 documented a similar decline. In 2007, transects following the AGRRA protocol in Curaçao showed that sites where species of *Davidaster* were formerly common are now practically devoid of crinoids. In particular, *D. discoidea*, once the most numerous crinoid in these islands, has all but disappeared. The cause of this decline is unknown. It is noteworthy that the decline affected both Bonaire and Curaçao, even though Bonaire has about one-tenth the human population of Curaçao, very little industrialization, and protected reefs, while a much higher level of development impacts the reefs of Curaçao. It is possible that heating associated with the severe coral bleaching event of 1995 also affected the crinoids. As far as we are aware, reef crinoid populations elsewhere in the western Atlantic region have not shown a similar decline. However, the loss of these passive suspension-feeding echinoderms from one of the centers of high reef diversity of the region is a cause for concern and requires ongoing monitoring.

## 18-19

**Brazilian National Coral Reef Monitoring Program: Status And Perspectives.**

**Beatrice FERREIRA*[1]**, Mauro MAIDA[1], Ana Lidia GASPAR[2], Caroline FEITOSA[1], Sergio REZENDE[1], Eduardo MACEDO[1], Fabio NEGRAO[3], Ana Paula PRATES[4], Clóvis CASTRO[5], Débora PIRES[5], Andreza PACHECO[1], Iara SOMMER[6], Liana MENDES[7], Joao Marcello CAMARGO[2]

[1]Oceanography Department, Federal University of Pernambuco, Recife, Brazil, [2]Instituto Recifes Costeiros, Tamandare, Brazil, [3]Instituto Recifes Costeiros, Caravelas, Brazil, [4]NZCM, Ministry of Environment, Brazilia, Brazil, [5]UFRJ, Tamandare, Brazil, [6]APA Guadalupe, Tamandare, Brazil, [7]UFRN, Natal, Brazil

The coral reefs of Brazil represent the only coral reefs in the south Atlantic and include a large proportion of endemic species. Since 2002 the Ministry of Environment is funding an initiative to monitor Brazilian coral reefs using a methodology compatible with the global protocol Reef Check. Between 2002 and 2007, surveys were conducted in eight representative regions of Brazilian reefs, between latitudes 3° and 18°S, including reefs inside protected areas of both full protection (4) and sustainable use (5) categories as well as areas of general use (2) or protected areas with no enforcement (1). Those included coastal reefs, shelf reefs and reefs in oceanic waters. Analysis of data indicated that fishery indicators at all trophic levels are significantly more abundant on fully protected areas (no fishing). Sustainable use areas were no different of general use or protected areas without enforcement, except those that include special no take zones. Fishing has moved down the food chain and impacts are no longer restricted to large predatory groups (serranids, lutjanids and sharks) with larger scale fisheries now also directed to herbivorous fishes (scarids and acanthurids) as well as Haemulids. Within each region, abundance of indicators was related to fishing pressure directed over the specific resource. Higher hard coral cover was inversely related to land based pressures, mostly sedimentation, regardless of coral diversity or species composition. Low proportion large scale bleaching, across 2000 kms, was detected twice, in 2003 and 2005, with low effect on the apparently resilient Brazilian coral reef fauna. Conservation and recovery of Brazilian coral reefs depend on effective fishing regulation as well as protected areas establishment/ enforcement, but, in the case of the extensive coastal reef formations, also on coastal and riparian recovery and protection.

## 18-20

**Long-Term Changes in Taxonomic Distinctness And Trophic Structure Of The Reef Fishes At Cabo Pulmo Reef, Gulf Of California**

**Hector REYES-BONILLA*[1]**, Lorenzo ALVAREZ-FILIP[2]

[1]Departamento de Biología Marina, Universidad Autonoma de Baja California Sur, La Paz, Mexico, [2]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom

Cabo Pulmo is the most septentrional coral reef in the Tropical Eastern Pacific, and although many aspects of the reef have been described, there is a lack of the temporal studies that addresses the change that this marginal ecosystem has suffered in the last decades. In this context the present study evaluates the changes in community structure and average trophic level of the 13 most important reef families, from 1987 to 2006. In this period the reef has suffered several perturbations, such as ENSO events, hurricanes strikes and the increase of the coastal development, and at the same time the efforts for its protection has increased as the area was declared a National Park in 1995. In each year we performed at least 18 stationary censuses in observation cylinders of 5 m radius, and calculated the taxonomic distinctness index as well as the trophic level. The results show that community composition did not differ between seasons (warm and cold), in clear contrast to what occurs in other areas of the Gulf of California. However, when the comparison was made among years, the ordination analysis shows that ichtyofaunal composition differs between 1987 and the rest of surveys. The taxonomic distinctness gradually declined between 1987 and 2006 but at the same time, the trophic level of the assemblages increased through the years. In conclusion these results suggest that the establishment of the National Park might have had a positive effect on the fish community, as shown by the increase in the trophic level. However the simultaneous decrease in taxonomic distinctness probably indicates that a large number of carnivores has depleted the abundance of herbivores and omnivores; this way, the conservation efforts have reached a goal but at the same time produced unexpected consequences in the ecological function of the area.

## 18-21

**Socio-Economic Monitoring (Socmon) As A Tool In The Management Of Marine Protected Areas: Participatory Process And Initial Results In Palawan Province, Philippines**

**Michael PIDO*[1]**, Sheila VERGARA[2], Melissa MACASAET[3], John Francisco PONTILLAS[4], Marissa PONTILLAS[1], Eva Marie PONCE DE LEON[1], Delia MARTINEZ[3], Filomeno RACUYA[4]

[1]Palawan State University, Puerto Princesa City, Philippines, [2]Conservation International-Philippines, Quezon City, Philippines, [3]City Government of Puerto Princesa, Puerto Princesa City, Philippines, [4]Palawan Council for Sustainable Development Staff, Puerto Princesa City, Philippines

Methodological tools in the assessment of bio-physical parameters in marine protected areas (MPAs) have been fairly standardized. The same level of consensus is not yet reached in assessing the human dimension's socio-economic and governance variables. Socioeconomic Monitoring (SocMon) is a standardized set of guidelines on how to conduct socio-economic monitoring for collecting and analyzing basic socio-economic data useful for coastal management As a methodological tool, SocMon was employed to assess the awareness of people's dependence on marine resources, perceptions of resource conditions, threats to marine resources, use levels, and status of governance of two locally-managed MPAs in Puerto Princesa City, Palawan Province, Philippines. Preliminary results show that there is an almost equal number of male and female residents; almost half of the population are 20 years and below; few adults (barely 10%) belong to a stakeholder organization; a quarter reached high school level; and the migrant population now comprise nearly three quarters. They generally perceive the natural resources' status to be either good or very good. Male and female respondents share similar positive attitudes towards non-market and non-use values of resources. Coastal communities are aware of temporal benefits of marine resources and they would put a higher value on future benefits (such as bequest values) rather than on current needs. In the order of decreasing importance, threats to resources identified were: rampant cutting of mangroves; destructive fishing activities for corals; and pollution for beaches. Overall, the method was found very useful in providing basic socio-economic information and has huge potential for between and across sites comparison to better inform management decisions, including communication with stakeholders, and to form a baseline for current socio-economic conditions of MMAs and coral reef areas. Methodologically, SocMon has potential for large-scale use in the Philippines and Southeast Asia by virtue of its ease in field application and data analysis.

## 18-22

**Socio-Economic Status Of Communities Dependent On Coral Reefs in The Western Indian Ocean**

**Innocent WANYONYI*[1]**, David OBURA[2], Delphine MALLERET-KING[1]

[1]socmon Wio, Cordio Ea, Mombasa, Kenya, [2]corals, Cordio Ea, Mombasa, Kenya

Coral reefs form the basis of the livelihoods of hundreds of thousands of people in the region. Numerous poor coastal households depend very highly on marine resources often as a last economic resource for food and income, through extractive uses such as fishing. Climatic change, destructive fishing, sand mining, pollution etc threaten coral reefs in the Western Indian Ocean (WIO) region. To manage resources effectively, it is essential to understand the context within which marine resource users live, their livelihood constraints and opportunities. It is increasingly recognised in the region that for resource management to be effective in the long term, MPA and fisheries management need to adapt and respond to changes in marine resource users' socio-economic context. The Socio-economic Monitoring Initiative for Coastal Managers of the Western Indian Ocean (SocMon WIO) aims to increase coastal manager's capacity to understand and incorporate the socio-economic context into coastal management programmes. SocMon WIO is a regional programme that builds on local-level monitoring systems. SocMon approach is based on community members' participation, it is implemented locally at site level by relevant projects, marine protected area authorities, local area management authorities, fisheries officers or community groups. The SocMon WIO sites include eight managed as MPAs, three ICM/Co management sites and four are either fisheries management or co-management as well as Eco-region sites of regional importance within the East Africa Marine Eco-region (EAME). The SocMon WIO network expanded to 15 sites across the region in 2007. The Results are presented here for pioneer SocMon WIO sites as sample monitoring data collected by the various sites to address their respective management needs. Diani-Chale site had 66% of households that undertook marine related livelihood activities and 25% households involved in fisheries alone.

## 18-23

**Lessons Learned from Socio-economic Monitoring (SocMon) and Marine Protected Area Management Effectiveness (MPA-ME) Evaluation in the Caribbean**

**Maria PENA*[1]**, Patrick MCCONNEY[1]

[1]Centre for Resource Management and Environmental Studies (CERMES), The University of the West Indies, Cave Hill Campus, Barbados, Bridgetown, Barbados

*Socio-economic Monitoring at Negril Marine Park (NMP), Jamaica*, was implemented from 2004 to 2006 aimed at obtaining sound socio-economic information useful for decision-making. The assessment was linked to the simultaneous formulation of the first fisheries management plan for the NMP. The application of the *SocMon Caribbean* methodology to this project was informally evaluated by the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies (UWI) in Barbados. The project followed the SocMon methodology reasonably well, and the methods used were largely successful in achieving intended outcomes. The major deficiency in the project was lack of institutional capacity to undertake some tasks.

*CERMES Regional Project on Enhancing Management Effectiveness at Three Marine Protected Areas in St. Vincent and the Grenadines, Jamaica and Belize* was implemented from 2005 to 2007 to evaluate management effectiveness of MPAs at these sites. The project utilised methods set out in the guidebook *"How is your MPA doing?"* for evaluating management. The process of evaluating management effectiveness in order to implement adaptive management was new to all study sites and therefore was a learning process. Primary lessons learned included an appreciation for evaluating management; the need for management agencies to undertake evaluation tasks based on available resources; the need for stronger science training for evaluation; the importance of presentation and validation of results and an awareness of stakeholder perceptions of management efforts.

This paper reports on the practical lessons learned from applying the *SocMon Caribbean* methodology to socio-economic monitoring at the NMP; and biophysical, socio-economic and governance assessment outlined in *"How is your MPA doing?,"* for evaluating MPA management effectiveness at specific MPAs in the Caribbean.

## 18-24

**Status And Trends in Socioeconomic Factors Affecting The World's Coral Reefs**

**Christy LOPER*[1]**, Robert POMEROY[2], Patrick MCCONNEY[3], Arie SANDERS[4], Gaya SRISKANTHAN[5], Khulood TUBAISHAT[6], Innocent WANYONYI[7], Sheila VERGARA[8], Caroline VIEUX[9]

[1]NOAA, Washington, DC, [2]University of Connecticut, Groton, CT, [3]University of the West Indies, St. Michael, Barbados, [4]University of Zamorano, Tegucigalpa, Honduras, [5]IUCN- The World Conservation Union, Colombo, Sri Lanka, [6]PERSGA- Regional Organization for Conservation of the Environment of the Red Sea and Gulf of Aden, Amman, Jordan, [7]CORDIO East Africa, Mombasa, Kenya, [8]Conservation International- Philippines, Manila, Philippines, [9]SPREP- South Pacific Regional Environment Programme, Apia, Samoa

This presentation aims to address two primary questions: (1) What are the current status and trends in socioeconomic factors affecting the world's coral reefs? and (2) How have socioeconomic monitoring programs contributed to coral reef research, conservation and management? In coral reef conservation, understanding socioeconomic factors is critical to the success of management tools used to conserve coral reefs.

Since 2000, the Global Socioeconomic Monitoring Initiative for Coastal Management (SocMon) has facilitated socioeconomic monitoring in approximately 40 sites in six regions: Caribbean, Western Indian Ocean, Southeast Asia, Pacific, Red Sea, and South Asia. A critical gap in this data collection has been a coordinated review and analysis of socioeconomic information at the global and regional levels. Moreover, most of the data that has been collected has not previously been accessible to coastal managers, decision makers or donor agencies.

By working with global partners to synthesize individual SocMon site assessments, this study has delineated trends in factors such as regional and global awareness of people's dependence on coral reefs, perceptions of reef conditions, threats to coral reefs, use levels, and status of governance around the world. Access to all of this data is now provided through a Global Socioeconomic Database, a web-enabled resource developed by WorldFish Center in Malaysia.

This is a seminal study in the understanding of socioeconomic factors impacting coral reefs. Never before has a comprehensive survey of socioeconomic assessments of coral reef areas been undertaken. The results fill a critical need by advancing a global and regional understanding of human interactions with and dependence on coastal resources.

## 18-25

**Status Of Coral Reefs in South Asia (Bangladesh, India, Maldives, Pakistan, Sri Lanka And Chagos (Biot))**

Jerker TAMELANDER[1], **Arjan RAJASURIYA*[2]**, JK PATTERSON EDWARD[3], Sarang KULKARNI[4], Rohan ARTHUR[5], Alasdair HARRIS[6], Terney PRADEEP KUMARA[7], Vineeta HOON[8], Zahirul ISLAM[9], Hussein ZAHIR[10], M.F.M. FAIROZ[7], K. VENKATARAMAN[11]

[1]Global Marine Programme, IUCN - The World Conservation Union, Dar es salaam, Tanzania, [2]NARA, Colombo, Sri Lanka, [3]SDMRI, Tuticorin, India, [4]Oceaeco, Mumbai, India, [5]NCF, Mysore, India, [6]Blueventures, London, United Kingdom, [7]University of Ruhuna, Matara, Sri Lanka, [8]CARESS, Chennai, India, [9]Marinelife Alliance, Dhaka, Bangladesh, [10]MRC, Male, Maldives, [11]NBA, Chennai, India

Coral reef recovery in South Asia over ten years since the 1998 coral bleaching and mortality event has been highly variable. Some severely bleached reefs such as in the Chagos archipelago and at locations in the western atoll chain of the Maldives have returned to pre-bleaching coral cover and are making gradual progress towards pre-bleaching population structure. However, although coral cover is increasing at most sites in the Lakshadweep islands, recovery is limited on several atolls. Localized and seasonal bleaching has been observed annually in the region since 1998, but bleaching related mortality has been very low. For example, reefs on the Indian side of the Gulf of Mannar exhibited annual bleaching around May but usually with full recovery within weeks-months. The impact of the Indian Ocean tsunami 2004 was comparatively low, with the exception of areas affected by tectonic activity in the Andaman and Nicobar Islands, and recovery predictions are mostly good. However, direct anthropogenic stress hampers recovery and is the main driver behind reef degradation in many areas. Surveys show reef status and recovery is better in areas where human interference and anthropogenic stress is low. Direct anthropogenic stress and poor management of coral reef areas, including many MPAs, is further expected to reduce the ability of many areas to adapt to climate change, a synergistic effect that threatens to drastically change reefs in some parts of the region over the coming years to decades. Natural resource dependence and a shortage of livelihood options leaves many communities highly vulnerable. Efforts underway seek to address this through improved reef monitoring that increasingly incorporates social and economic aspects, strengthening the research agenda and supporting uptake into management and policy through development of tools and communication and capacity building initiatives.

## 18-26

**Patterns Of Coral Community Recovery in The Maldives Following Mass Bleaching in 1998**

**Hussein ZAHIR*[1]**

[1]Ministry of Fisheries Agriculture and Marine Resources, Marine Research Centre, Male, Maldives

The recovery in one of the world's largest oceanic atoll reef systems following a catastrophic coral bleaching is reported. Increased sea surface temperature during the 1998 El Niño Southern Oscillation event caused extensive coral bleaching and widespread coral mortality throughout the Indian Ocean including the reefs of the Maldives. Live coral cover was reduced from pre-bleaching estimates of 40-60% to less than 3% in shallow waters assessed soon after the bleaching. Virtually no living *Acropora* species were recorded at the study sites during these assessments in late 1998. Changes during the last 7 years at 15 selected reef sites throughout the Maldives from almost 7° N to almost 1° S are presented and discussed. Trends in coral cover both between sites within atolls and between atolls are presented, as is the generic diversity of the live coral community and its development since the bleaching. Patterns of coral settlement on tiles and recruitment to natural substrates were assessed at 6 sites in the central atolls to see whether recruitment rates were related to recovery. Same site comparisons using settlement plates to study potential availability of coral larvae and *in situ* monitoring of coral recruits to assess those surviving to a few mm in diameter provided useful information on the availability of coral larvae for recruitment and replenishment of denuded coral reefs. The recovery was very variable from site to site; coral taxa that were most susceptible to bleaching (acroporids and pocillorids) have shown the largest increase in cover since 1998; while the more resilient groups that survived the bleaching (e.g. agariciids and poritids) show a relative decrease in cover. The patterns and rates of coral recovery on these reefs suggest that recruitment was not a limiting factor for reef recovery in the Maldives.

## 18-27

**Status Of Coral Reefs in Southeast Asia – 2008**

Karenne TUN[1], Loke Ming CHOU[1], **Thamasak YEEMIN*[2]**, Nguyen VAN LONG[3], Dr SUHARSONO[4], Cleto NANOLA JR[5], David W LANE[6], Affendi YANG AMRI[7]

[1]Biological Sciences, National University of Singapore, Singapore, Singapore, [2]Faculty of Science, Ramkhamhaeng University, Bangkok, Thailand, [3]Institute of Oceanography, Nha Trang, Vietnam, [4]COREMAP, Jakarta, Indonesia, [5]College of Science, University of Philippines, Marine Science Institute, Diliman, Quezon City, Philippines, [6]Universiti Brunei Darussalam, Brunei Darussalam, Brunei Darussalam, [7]Marine Biology Unit, University of Malaya, Institute of Biological Sciences, Kuala Lumpur, Malaysia

The coral reefs of Southeast Asia have not seen major change in the past four years; many reefs continue to remain under threat, mainly from anthropogenic impacts, although encouraging signs of improvement are emerging in many areas resulting from better monitoring and management initiatives. The 2004 Asian Tsunami did not cause widespread damage to the coral reefs of Southeast Asia, with only localized impacts reported in Indonesia, Thailand and Malaysia. Long-term monitoring programmes are still ongoing in many countries, while expanding in Peninsular Malaysia with the formal establishment of Reef Check Malaysia. However, the status of coral reef monitoring in Cambodia and Myanmar remain largely unknown.

## 18-28

**Status of Coral Reefs in Post-Tsunami Period in Andaman & Nicobar Islands (India)**

**Alok SAXENA*[1]**

[1]Department of Environment & Forests, Government of India, Port Blair, India

Andaman & Nicobar Islands, located in the Bay of Bengal off the eastern coast of India, are one of the four major sites of coral reefs. Coral reefs found in these islands are mostly fringing types. The survey carried out by the UNDP team along with experts from India in 2001 recorded 197 species only in Andaman group of Islands as against 179 species reported earlier by Pillai (1983) for the entire Andaman & Nicobar Islands. The survey was based on satellite data interpretation and field survey of 13 sites. It also projected that the actual number of coral species may be as high as 400. The survey done by Kulkarni and Saxena (2002) for 21 coral reef sites identified under coral reef monitoring action plan showed not only the distribution of corals, but also the status of health and mortality. Tsunami that struck these islands on 26th December 2004 led to vast destruction of coral reefs mainly due to geo-morphological changes resulting in uplifting and exposure of reefs in the northern islands and submergence in the southern islands A rapid assessment done by the Reef Watch, an NGO in 2005 showed that there was overall 20% mortality in Andaman group of Islands while in Nicobar group of Islands, up to 80% mortality was observed. The report however indicated recovery processes in some coral reef sites particularly those in shallow reefs. The present study is based on the survey being carried out at different coral reef sites to monitor recovery processes. The initial results show not only recovery but also changes in the distribution pattern of corals at the selected sites.

## 18-29

**Extent And Timing Of Disturbances: Comparison Between Australia's Great Barrier Reef And The Caribbean Region**

**Hugh SWEATMAN*[1]**

[1]Australian Institute of Marine Science, Townsville, Qld 4810, Australia

Australia's Great Barrier Reef (GBR) province and the greater Caribbean region include similar areas of coral reef. In recent decades, the major cause of losses of coral cover on the GBR has been *Acanthaster planci*, the crown-of-thorns starfish. Three well-documented waves of outbreaks have passed southwards along the central GBR in the past 40 years, with an independent pattern of outbreaks on the Swain Reefs in the south and less-well documented waves of outbreaks travelling northward in the remote northern region. At any point in time, 1-3 discreet regions are affected, each adjoining areas where the reefs are recovering or are yet to be affected. Published reports from the Caribbean suggest that impacts on coral in the Caribbean, notably coral diseases, are much more widespread at any time. One salient example is the fatal disease of *Diadema* that spread through the entire region in 1983 and 1984. Such differences in the extent and timing of major disturbances may influence replenishment and hence the processes of recovery.

## 18-30

**Patterns Of Reef Fish Utilization And The Consequence Of Human Population Growth On Fish Density And Community Composition in American Samoa**

**Marlowe SABATER*[1]**

[1]Department of Marine and Wildlife Resources, American Samoa Government, Pago Pago, American Samoa

Long-term time-series data from fishery-independent underwater surveys and fishery-dependent surveys were examined and analyzed alongside prehistoric and current utilization patterns of reef fish populations in order to assess the status of coral reef fish populations and the fishery. Underwater surveys showed overall density of coral reef fish has been increasing over the past three decades due largely to a significant increase in parrotfish populations. Concurrent with this increase in fish density was a significant decrease in subsistence fishing effort and a non-significant decrease in commercial effort over time. Catch landings showed no long-term trend with highs recorded from 1994-2001 and lows prior to and after these years. Rapid population growth on the main island of Tutuila is seen as a threat to coral reef resources. One major impact that is often assumed is that increases in human population will lead to increases in fishing pressure. However, despite the rapid significant increase in human population on Tutuila, fishing effort has continually decreased over the last three decades. Population growth had a negative relationship with fishing effort (subsistence and commercial) due possibly to the society's shift from subsistence to a cash-based economy since the early 1900's. Present catch composition and reef fish assemblage is statistically similar to prehistoric periods dating 1500-3000 years ago. Recent interviews of 425 respondents in Tutuila has shown preference for surgeonfish, groupers, squirrelfish, and parrotfish which again follows the same proportion as the prehistoric records and significantly correlates with the present day fish assemblage. This preference may have existed since prehistoric times despite advances in fishing technology or may have been driven by what was abundant and easily available in the fishery. These findings indicate that the fishery was sustainable from the prehistoric times and the fish population shows signs of improvement in the recent past.

## 18-31

**Ten Years Of Volunteer Science**

**Gregor HODGSON*[1]**, Cori KANE[1], Craig SHUMAN[1]

[1]Reef Check Foundation, Pacific Palisades, CA

In 1997, Reef Check began as the first attempt to survey the world's coral reefs using a standard method, carried out by volunteer recreational divers trained and led by marine biologists. Reef Check has expanded into an international non-profit organization, the Reef Check Foundation, with thousands of volunteers in 90 countries and territories and with a mission of protection and rehabilitation of reefs (including temperate reef ecosystems in California). The initial assumption was that trained volunteers could collect reliable data and catalyze marine conservation activities. The ten-year coral reef database shows that overfishing remains the most important problem affecting coral reefs, with most high-value indicator species missing from most coral reefs. The results show that on a global scale, both reef corals and reef fish are relatively resistant to perturbation from bleaching events and recovered during the period. The rapid declines in coral reefs during the 1980s and 1990s have not continued. Numerous conservation projects have been triggered by the actions of volunteer Reef Check teams in all tropical seas including the creation and improvement of several Marine Protected Areas. By involving recreational divers in scientific monitoring, Reef Check has helped build a better educated constituency that will support coral reef conservation activities throughout the world.

## 18-32

**The Response Of Caribbean Coral Reefs To Repeated Stress Events.**

**Loureene JONES*[1]**

[1]Integrated Watersheds and Coastal Zone Management Branch, National Environment and Planning Agency, Kingston 5, Jamaica

In recent times, coastal ecosystems and specifically coral reefs have been experiencing varying degrees of stress from several sources. The incidence of natural phenomenons such as hurricanes and bleaching events has increased to the point where one or both of these events are guaranteed to occur annually. Coupled with terreginous run-off and poorly planned coastal developments, the reefs of the region are constantly bombarded with less than ideal conditions. At present coral cover is still low at most sites assessed and has been for a long while.

In Jamaica Reef Check assessments indicated coverage ranging between 2% and 37% were recorded between 2001 and 2006. Results from bleaching assessments conducted during and after the 2005 event depicted up to 75% bleaching in some countries and varied levels of recovery. Data from long-term monitoring sites in Jamaica also produced results, which indicate that the reefs are to an extent able to survive and recover from the stress events. Given the increased frequency of stress events it is still unsure what level of recovery will be realized and the duration.

## 18-33

**Agrra Data Can Distinguish Chronic From Acute Impacts To Wider Caribbean Reef Communities And Provide Baselines To Assess Future Changes**

Robert GINSBURG[1,2], Philip KRAMER[3], Judith LANG[2,4], **Kenneth MARKS*[2,5]**, Patricia RICHARDS KRAMER[6], Robert STENECK[7]

[1]Marine Geology & Geophysics, RSMAS, University of Miami, Miami, FL, [2]Ocean Research and Education Foundation, Coral Gables, [3]The Nature Conservancy, Sugarloaf Key, FL, [4]Independent, Ophelia, VA, [5]Independent, Boca Raton, FL, [6]Perigee Environmental, Big Pine Key, FL, [7]School of Marine Sciences, Darling Marine Center, University of Maine, Walpole, ME

Standardised AGRRA coral health indicators *(e.g.,* >5% recent mortality of outer colony surfaces) have quantified the immediate impacts of acute perturbations like mass bleaching and outbreaks of disease. The program's reef-community condition indicators *(e.g.,* old mortality of coral colony surfaces, live coral cover, abundance of benthic algae, AGRRA fish data) have assessed the effects of chronic stressors acting on longer (multi-months to multi-annual) time scales. Collectively the AGRRA data are a regional baseline of reef community status for the early 21st Century against which future changes can be compared. This baseline augments previous evidence for widespread reef decline at <20 m in much of the wider Caribbean, even though the average live coral cover of 19% on 468 surveyed fore reefs was higher than expected. For example, at some sites small, non-framework building corals have replaced large, massive species in a change that may not be evidenced in coral cover. Macroalgae have clearly increased in abundance and biomass on many reefs. Given their regional importance as reef framework constructors, significant declines in the *Montastraea annularis* complex after both the 1998 and 2005 mass bleaching events are cause for much concern.

The online database (www.agrra.org) has data on the benthos at some 812 sites spread over the Caribbean, Gulf of Mexico, Florida and the Bahamas and, for the AGRRA fishes, at 689 of the same sites. It is the only comprehensive, standardized dataset for the wider Caribbean. However, because the collection of data spanned almost a decade, there is a need to revisit representative areas in a shorter period to determine changes that have occurred since the initial assessments.

## 18-34

**The Status Of Coral Reefs Of The World: 2008**

**David SOUTER*[1]**, Clive WILKINSON[1]

[1]Global Coral Reef Monitoring Network, Townsville, Australia

The condition of coral reefs in most regions of the world has progressively declined during the past 3 to 4 decades. Initial damage was largely caused by human activities, such as over- and destructive fishing, inappropriate coastal developments and land-use causing sedimentation and nutrient pollution, and outbreaks of coral and fish diseases and predators such as the crown-of-thorns starfish; all of which might have been exacerbated by human activities. However, since the first recognised mass bleaching event in 1982/83, there has been growing concern about the influence of climate on coral reefs. Unfortunately, these concerns have been vindicated by the increasing frequency and intensity of mass coral bleaching events, particularly in 1998 when approximately 16% of the world's reefs were functionally destroyed, in 2002 when reefs across the western Pacific were affected, and in 2005 when severe bleaching and coral disease caused up to 50% mortality in many areas of the Caribbean. Caribbean reefs were also subjected to 26 named storms, including 13 hurricanes in 2005. There is also growing recognition that increasing concentrations of atmospheric $CO_2$ threaten the structural integrity of reefs by reducing the rate of calcification in corals. Assessments by the GCRMN, WRI, Reef Check, CORDIO, AGRRA, ReefBase and many NGOs show considerable damage to reefs in Eastern Africa, mainland South Asia, Southeast Asia and the wider Caribbean, although there are signs that the condition of reefs is improving in well managed areas and where there are major national, and international initiatives by governments and NGOs to conserve coral reefs, particularly when the community and stakeholders are deeply involved. The results of 80 national status reports highlight that the events of the past decade clearly indicate that there must be unified action to halt and reverse the impacts of climate change on the world's coral reefs.

## 18-35

**Coral Reef Monitoring in The South West Pacific 2007**

**Kenneth MACKAY*[1]**, Cherie WHIPPY-MORRIS[2]

[1]Institute of Marine Resources, University of the South Pacific, Suva, Fiji, [2]Institute of Marine Resources, University of South Pacific, Suva, Fiji

The GCRMN Southwest Pacific Node of Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu, is coordinated by the Institute of Marine Resources, University of the South Pacific.

Monitoring is carried out by scientists, students, dive guides and communities. Country monitoring sites have been mapped and will feature in the WorldFish Center Reebase Pacific online database. Results show reefs are in good condition but under increasing pressure from anthropogenic impacts (over-fishing, sedimentation, and coastal development) as well as climate events (cyclones, tsunamis and coral bleaching). Coral cover has recovered in Fiji since the bleaching events of 2000 and 2002. Solomon Islands experienced an earthquake and tsunami in 2007 with deep sites damaged by underwater landslides while one island was uplifted 3m. Recent monitoring there shows little impact on the fish assemblage but future monitoring will determine the long-term impacts. Recognition of anthropogenic impacts has led to establishment of Marine Protected Areas (MPA) by communities. Coral health and fish populations are increasing in some MPAs.

A network of temperature loggers has been established in Fiji and is being expanded to other countries to collect long-term data and its relationship to bleaching. A reef crisis framework has been developed to provide information on reef recovery and resilience.

IMR has coordinated workshops: on monitoring, in-country networking and data analysis and report preparation to increase in-country capacity. Priority for future work will be specific in-country database and measuring effectiveness of MPAs.

A report on the 2004 Status *has* just been published while the 2007 report will be less inclusive but published more timely. .

The value of long-term monitoring has been shown but on-going resources are required to allow predictions of responses of coral reefs to anthropogenic and climate change stresses.

## 18-36

**Rapid Recovery From Bleaching Events -Fiji Global Coral Reef Monitoring Network Assessment Of Hard Coral Cover From 1999-2007**

**Edward LOVELL*[1]**, Helen SYKES[2]

[1]School of Marine Studies, University of the South Pacific, Suva, Fiji, [2]Marine Ecology Consulting Fiji, Suva, Fiji

Long-term biological and water temperature monitoring of reef sites across the Fiji Islands was carried out over an eight year period which included mass coral bleaching events. Data was contributed by many organisations, including scientists, tourism operators, non-governmental and community members. All used point intercept transects from which the percentage of hard coral cover was used for regional comparisons over-time. Benthic data was generally recorded as coral life-form categories. In-situ temperature loggers were placed on sites where biological surveys were made, and compared with NOAA sea surface temperature (SST) records. High SST's in 2000 and 2002 led to large-scale coral bleaching events with hard coral mortality of 40 – 80%. In both cases, temperatures remained above the observed bleaching threshold (29ºC) for over 3 months. Though variable, substantial recovery to pre-bleaching levels was seen within 5 years in many areas. Fiji's reefs show great diversity, and are spread over a large geographical area. Though mass bleaching events were expansive, they did not affect the entire country's reef systems at one time. Some habitats appear to be conducive to minimising the effects of bleaching. This allowed for the repopulating of affected areas more swiftly than may occur in more isolated reefs. A high level of resiliency of the Fiji reef system as a whole is indicated, and is a cause for optimism.

## 18-37

**It Depends On Where You Look: The Status Of Coral Reef Ecosystems in The United States And Pacific Freely Associated States**

**Alicia CLARKE*[1]**, Jeannette WADDELL[1]

[1]Center for Coastal Monitoring and Assessment, Biogeography Branch, National Oceanic and Atmospheric Administration, Silver Spring, MD

U.S. states, territories, commonwealths and affiliated states that contain coral reef ecosystems span more than half the globe from the U.S. Virgin Islands to Palau. T*he State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008,* a NOAA publication, pools monitoring data from 15 jurisdictions to provide a comprehensive assessment of the condition of the nation's coral reefs in an effort to broadly summarize key threats, present monitoring activity results in three primary categories, and describe current management actions taken at both local and national levels to conserve coral reefs. Data from the U.S. Virgin Islands, Puerto Rico, Navassa Island, Southeast Florida and the Florida Keys, the Flower Garden Banks and other banks of the NW Gulf of Mexico, Hawaii, the Northwestern Hawaiian Islands, American Samoa, the Pacific Remote Island Areas, the Commonwealth of the Northern Marianas, Guam, the Republic of the Marshall Islands, the Federated States of Micronesia and the Republic of Palau are presented. Information from jurisdictional chapters written by teams of scientists, academics, coastal managers, and state and federal agencies is used to develop the National Summary chapter which describes trends in ecosystem condition. This chapter of the report also presents key biotic and abiotic variables that are currently the focus of monitoring efforts, spatial and topical data gaps, and a qualitative assessment of the perceived impact of 13 key threats identified in the U.S. Coral Reef Task Force's National Coral Reef Action Strategy. The 2008 report is the third in a series of reports intended to deliver the most comprehensive and up-to-date information to a wide audience, including members of the U.S. Congress, scientists, managers and the general public. Results from the 2008 report will be released and presented during the ICRS.

## 18-38

**The Status And Trends Of Coral Reef Ecosystems in The Hawaiian Archipelago**

**Eric BROWN*[1]**, Greta AEBY[2], Russell BRAINARD[3], Kathy CHASTON[4], Athline CLARK[5], Alan FRIEDLANDER[6], Jean KENYON[3], Petra MCGOWAN[7], Tony MONTGOMERY[5], William WALSH[8], Ivor WILLIAMS[8], Wendy WILTSE[9]

[1]Kalaupapa NHP, U.S. National Park Service, Kalaupapa, HI, [2]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, [3]Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division, NOAA, Honolulu, HI, [4]Dept. of Natural Resources & Environmental Management, University of Hawaii at Manoa, Honolulu, HI, [5]Division of Aquatic Resources, Hawaii Department of Land and Natural Resources, Honolulu, HI, [6]Biogeography Branch and The Oceanic Institute, NOAA, Waimanalo, HI, [7]Division of Aquatic Resources, NOAA, Honolulu, HI, [8]Division of Aquatic Resources, Hawaii Department of Land and Natural Resources, Kailua-Kona, HI, [9]Pacific Islands Contact Office, U.S. Environmental Protection Agency, Honolulu, HI

Coral ecosystems in the Hawaiian archipelago range from poor to excellent condition and are geographically split into the remote Northwestern Hawaiian Islands (NWHI) and the populated Main Hawaiian islands (MHI) in the southeast. Archipelago-wide stressors include large waves, increasing temperature (0.8°C since 1956), diseases, ship groundings, and marine debris. MHI-specific stressors add coastal development, pollution, increasing tourism, shifting fisheries, the commercial aquarium fishery, and invasive species.

Resource condition assessment indicated that overall quality of Hawaii's waters is good with impaired coastal waters in the MHI around harbors and protected embayments. Benthic habitats had moderate coral coverage (20.0%) across 1746 sites in the archipelago. Coral cover was highest in the southern portion of the archipelago and lowest in the north. Trends at long-term (>10 yrs) MHI sites showed that the majority (70%) experienced a decline in percent coral cover. Fish biomass was highest on islands with low human populations and this pattern appears consistent since 2000. Oahu with the highest human population had the lowest overall fish biomass and apex predators were virtually absent. Assessments for 55 fish species targeted in all fisheries found that nearly three-quarters of the species are depleted.

In 2006, the NWHI were designated a Marine National Monument, the largest fully protected marine conservation area in the world, encompassing nearly 3,626,000 $km^2$ (100%). In the MHI no-take MPAs comprise only 2.2 $km^2$ (0.4%) of nearshore waters with an additional 19.4 $km^2$ (3.6%) in partially protected areas, and 35.0 $km^2$ (6.5%) in areas with no or restricted access. Studies have shown that the MHI are in poor condition compared with the NWHI and even small protected areas in the MHI do not adequately protect the full complement of species or interactions found in the NWHI.

## 18-39

**Healthy Algal-Dominated Reefs On Remote Pacific Islands?**

**Peter VROOM*[1]**, Kimberly PAGE[1], Jean KENYON[1], Russell BRAINARD[1]

[1]Coral Reef Ecosystem Division, NOAA Pacific Island Fisheries Science Center, Honolulu, HI

Reefs surrounding remote, uninhabited islands in the central Pacific Ocean have been regarded as "predominantly healthy and at low threat risk" by leaders of tropical reef research. To gain multidisciplinary understanding of such healthy reefs under U.S. jurisdiction, NOAA, PIFSC's Coral Reef Ecosystem Division began synergistic surveys of fish, coral, macroinvertebrates, and algae coupled with oceanographic surveys in 2000. Baseline research presented here showcases percent cover of benthic organisms at a functional group level from eight of the most isolated islands monitored, including reefs from the Northwestern Hawaiian Islands (NWHI), the U.S. Phoenix Islands (USPI), the U.S. Line Islands, American Samoa, and the Commonwealth of the Mariana Islands. Although localized patches of dense coral cover occurred in select habitats at all of these top-predator-dominated islands, average coral cover ranged from 7.1% to 32.7%. Algal functional groups (macroalgae, turf algae, and crustose coralline red algae) were 2.0 to 12.0 times more abundant than corals around islands when all habitat types were considered together, with fleshy macroalgae occupying more substrate than corals at 46% of sites examined. This unexpected finding is forcing scientists to reevaluate the definition of reef health at remote tropical Pacific islands. Can the same parameters used to gauge reef health in one ecosystem be transferred to other ecosystems in different geographic areas? For instance, the subtropical NWHI are dominated by turf algae and the meadow-forming green alga, Microdictyon, whereas the USPI contain very little turf algae but high abundances of crustose coralline red algae. Should low coral cover automatically be considered alarming if no evidence of a recent phase-shift is evident? Is a high abundance of macroalgae always indicative of decreased reef health?

## 18-40

**Pacific Reef Assessment And Monitoring Program (Ramp): Integrated Ecosystem Observations Of Coral Reef Ecosystems Of The U.s. Pacific Islands**

**Russell BRAINARD*[1]**, and Research COLLEAGUES[1,2]

[1]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu

In an effort to provide scientific information needed to support ecosystem approaches to management of coral reefs in the U.S. Pacific Islands region, a multi-institutional team of scientists led by NOAA's Coral Reef Ecosystem Division has been collaborating to implement the Pacific Reef Assessment and Monitoring Program (RAMP): an integrated ecosystem observing system to map, assess, and monitor the coral reef ecosystems across the Pacific region. With support from NOAA's Coral Reef Conservation Program, Pacific RAMP has conducted multidisciplinary baseline assessments and biennial monitoring around 50 island/atoll ecosystems in the Hawaiian and Marianas Archipelagos, American Samoa, and the remote U.S. Line and Phoenix Islands. Monitoring efforts include rapid ecological assessments of corals, other invertebrates, fish, and algae to species or genus level using multiple methods; spatial towed-diver surveys of benthic composition and the abundance and distribution of ecologically and economically important macroinvertebrate taxa and large fish; mapping of shallow and moderate depth benthic habitats using multibeam acoustic systems, optical systems, and satellite imagery; passive acoustic monitoring of biotic and anthropogenic sounds; and multi-platform oceanographic and water quality monitoring using shipboard surveys, moored instrument arrays, drifters, and satellite remote sensing. A subset of these multidisciplinary ecosystem observations have been integrated into the *Coral Reef Ecosystem Monitoring Report for American Samoa: 2002 – 2006*, the first in a series of comprehensive reports for each of the four U.S. Pacific Island regions. Use of consistent multidisciplinary methods across this vast region allows an unprecedented opportunity to perform biogeographic and ecological comparative analyses across diverse ecological, environmental, oceanographic, and socioeconomic gradients. Patterns of variability of reef fish biomass, coral cover and disease prevalence, and other reef metrics across the Pacific Islands are examined.

## 18-41

**Observer Variability And Deployment Effect With Reef Check Data In Australia: Implications For Management**

**Jos HILL*[1]**, Andrew HARVEY[1], Laura FANTOZZI[2], Craig SYMS[3]

[1]Reef Check Australia, Townsville, Australia, [2]James Cook University, Townsville, Australia, [3]Marine Biology and Aquaculture, James Cook University, Townsville, Australia

In Australia there is a role for community-based coral reef monitoring programs to supplement government datasets. Reef Check Australia (RCA) volunteers have surveyed 48 sites in the GBR Marine Park since 2001. A well-documented limitation of community-collected data is lack of precision due to the use of multiple observers who have limited levels of training and experience in coral reef monitoring. A key question for reef managers is how well do the data reflect real patterns, and is data resolution sufficient to reveal important changes in reef status? The objective of this study was to determine the level of precision of data collected by RCA participants in order to better inform managers on how the data should be interpreted and where RCA can best value-add to other datasets on coral reef status and trends. We compared data from randomly deployed transects that were surveyed by a sample of trained RCA volunteers. Precision was high for hard corals, with only 6.7% of the random variation due to observer effects. Precision was lower for less abundant substratum types including rubble and recently killed coral. Differences in precision were due to a combination of the percent cover of different substratum types, and the level of substratum categorisation. These results suggest that RCA data can identify temporal trends in cover of important substrata such as hard coral, and that between-observer variability can be minimised in volunteer divers. This enables RCA to make informed recommendations to managers and other stakeholders, with a clear confidence interval on the RCA results. We will discuss the relevance of this study for a successful marriage between the general community and coral reef managers in Australia.

## 18-42

**Assessment Of Resilience in *montastrea Faveolata* Inside And Outside Of A Marine Park**

**Erich MUELLER*[1]**

[1]Perry Institute for Marine Science, Jupiter, FL

Wound healing was used as a proxy for assessing organismal resilience in the coral, *Montastrea faveolata*. In addition, potential effects of wounding on quantum yield determined by PAM fluorometry were examined. Cores (2.5 cm diameter) were extracted from parent colonies cultured at least two years in an open seawater system at Lee Stocking Island (Exumas, Bahamas). In a mesocosm experiment, surface lesions (~0.5 cm2 x 2 mm deep) were imaged daily over 15 days to develop healing curves. Quantum yields were obtained daily using a PAM fluorometer (2 mm fiberoptic) at four locations 5 mm away from the lesion and 10 mm away. Results demonstrated that 50% healing occurred in 5-6 days. To examine whether wound healing (i.e. resilience) differed in the Exuma Cays Land and Sea Park from a control location near Lee Stocking, additional cores were removed from parent colonies (N=6) and deployed to one of three field arrays at each site. Lesions, images and PAM measurements were made on day 0 and again 5-7 days later. These procedures were repeated in the winter, spring and summer of 2007. There were no seasonal differences in healing rates or between genotypes. No consistent effects of site, time of year or wounding were seen on quantum yields of surrounding tissue, however, newly formed tissues had significantly lower yields than measured in undamaged tissues. Healing was significantly greater at the Park site in the winter of 2007 but there were no site differences in spring or summer. This Marine Management Area Science (Conservation International) study has developed a simple and inexpensive method to assess coral resilience. It will be further developed examining known stressors and with colonies *in situ* to provide researchers and resource managers with a tool to identify colonies and reef areas particularly susceptible to decline.

## 18-43

**Occupancy Models For Estimating The Size Of Reef Fish Communities**

**M. Aaron MACNEIL*[1]**, Timothy R. MCCLANAHAN[2]

[1]National Research Council, NOAA Panama City Laboratory, Panama City Beach, FL, [2]Wildlife Conservation Society, Bronx, NY

Reef fish surveys conducted using underwater visual census (UVC) have the potential to introduce substantial downward bias in species richness estimates when cryptic, mobile, or rare species are prevalent. In particular, heterogeneity in the detection of reef fish species can inflate or distort trends in community composition through time, compromising the quality of data collected and degrading our ability to link observations with processes. Using a suite of models for repeated observations through time, we develop a framework for estimating the number and composition of species in a reef fish community that can be readily applied to conventional survey data. Estimation of community-level quantities are made from model-based estimates of occurrence that incorporate imperfect detection of individual species. We suggest that occupancy models should be routinely used in monitoring programs, particularly in threatened or recovering areas.

## 18-44

**Evaluating The Health Of The Mesoamerican Reef**

**Melanie MCFIELD*[1]**, Nadia BOOD[2], Ana FONSECA[3], Alejandro ARRIVILLAGA[4], Albert FRANQUESA RINOS[5], Rosa María LORETO VIRUEL[6]

[1]Smithsonian Institution, Belize City, Belize, [2]Worls Wildlife Fund, Belize City, Belize, [3]Universidad de Costa Rica, San Jose, Costa Rica, [4]The Nature Conservancy, Guatemala City, Guatemala, [5]Amigos de Sian Kaan, Puerto Morelos, Mexico, [6]CONAP, Cancun, Mexico

Like most of the world's reefs, the health of the Mesoamerican Reef (MAR) has declined in the last decades. The1998 coral bleaching event and Hurricane Mitch caused widespread bleaching and significant coral mortality, particularly in Belize. Large-scale bleaching affected most reefs within the MAR in late 2005, although resulting coral mortality was lower than in previous bleaching years. The active 2005 storm season damaged reefs, mainly in Mexico, but may have also contributed to greater mixing of oceanic waters and prevented 'doldrum conditions' associated with more severe bleaching events. The bleaching and hurricanes in 2005 may have further delayed potential recovery from the bleaching-related losses of 1995 and 1998, as coral cover throughout the region remains moderately low (just over 10%), with little to no overall recovery from the 1998 losses. The 2006 Rapid Reef Assessment sponsored by TNC and WWF was the largest reef study ever conducted in the MAR and aimed to evaluate reef recovery from these disturbances and provide a comprehensive, representative assessment of reef health throughout the region. The results are also being used by a variety of partners for different management and research purposes. These data are also being combined into an Integrated Reef Health Index, as one component of a new ecosystem report card for the Mesoamerican Reef being developed by the Healthy Mesoamerican Reef Ecosystem Initiative. The findings from Belize are similar to the other countries: Only 3.7% of over 5000 colonies assessed showed any signs of coral bleaching by summer 2006. Average disease infestation was also low (<2% of colonies). Mean recent coral mortality for was less than 1.5%, with no difference among habitats. Although the 2005 bleaching event did not cause significant mortality it may have contributed to the continued lack of recovery recorded on these reefs.

## 18-45

**New Insights Into The Exposure And Sensitivity Of Coral Reefs To Ocean Warming**

**Patrick BOYLAN*[1]**, Joanie KLEYPAS[1]

[1]Institute for the Study of Society and Environment, National Center for Atmospheric Research, Boulder, CO

Increases in coral bleaching events over the past 20 years are correlated with increases in sea surface temperature (SST). While SSTs have increased everywhere in the tropics, and coral bleaching events have occurred in all coral reef provinces, the frequency and intensity of coral bleaching events have varied considerably from region to region. Unless these patterns are random, we can derive useful information about why some reefs have been less vulnerable to increasing SST, and use this information to guide conservation efforts. Coral reef vulnerability to bleaching is a function of exposure to some stress (elevated SST), sensitivity to that stress, and the capacity of the reef to adapt to the exposure. To better characterize differences in coral reef vulnerability to increases in SST, we analyze temperature and coral bleaching records from reefs in select regions for differences in exposure (nature of the SST increase at multiple temporal scales) and sensitivity to the SST increase. These refined relationships between temperature and bleaching allow us to create region-based bleaching thresholds that allow better predictions of future bleaching events.

## 18-46

**Mesophotic Reefs Of The Puerto Rican Shelf: Physical Processes, Resistance To Climate Change, Cryptic Mortality, And Future Trajectories**

**Tyler SMITH*[1]**, Richard NEMETH[1], Jeremiah BLONDEAU[1], Jacqulyn CALNAN[1], Elizabeth KADISON[1]

[1]Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Mesophotic coral reefs (MPR) are some of the least studied and most poorly understood reefs systems in the world. Available data for the Caribbean and extrapolation from bathymetric data suggest that these environments are extensive between 30 and 100 m. MPR south of St. Thomas (US Virgin Islands) have been under investigation for the last five years. A study to understand the resources within a full no-take marine reserve, the Red Hind Marine Conservation District (MCD, 41 $km^2$), using technical SCUBA and closed circuit rebreather, has revealed 25 $km^2$ of coral reefs, and expanded estimates of coral reef structure from multi-beam/side-scan data by ~110%. Surveys show that coral cover is unusually high for modern Caribbean reefs, and often surpasses 40%. Furthermore, a community of commercially important fish species, including rare high trophic level carnivores, is both abundant and in large biomass. Both exploratory dives and inspection of regional bathymetry strongly suggest that similar MPR are extant in a large (300 $km^2$+) region near St. Thomas, a fact that has not been previously appreciated. Studies on the health of these coral reefs have revealed important information on their potential to withstand climate related thermal disturbance. During a mass bleaching event (2005) MPR suffered relatively little bleaching compared to all shallow reefs (5% bleaching prevalence vs. 70%), but still experienced high mortality (27% cover lost vs. 36%). Surveys in 2007 revealed that within the matrix of the MCD a large (8 $km^2$), spatially explicit cryptic coral mortality event occurred (42% of sites at 45% prevalence), that was decoupled from trends in shallow reefs. The spatial extent of mortality suggests a large common driver. Clearly, further ecological, geological and oceanographic investigations are needed to fully understand the role that MPR play within the interconnected reefs systems of the Caribbean and the world.

## 18-47

**Recurrent Large-Scale Disturbances, Recovery Trajectories, And Resilience Of Coral Assemblages On A Coral Reef in The South-Central Pacific**

**Mehdi ADJEROUD*[1]**, François MICHONNEAU[1], Peter J. EDMUNDS[2], Yannick CHANCERELLE[3], Lucie PENIN[1], Jérémie VIDAL-DUPIOL[1], Bernard SALVAT[1], René GALZIN[1]

[1]Biologie et Ecologie Tropicale et Méditerranéenne, Université de Perpignan, Ecole Pratique des Hautes Etudes, UMR 5244 CNRS-EPHE-UPVD, Perpignan, France, [2]Department of Biology, California State University, Northridge, CA, [3]Centre de Recherches Insulaires et Observatoire de l'Environnement, Moorea, French Polynesia

Temporal variability in coral community structure on the outer reef at Tiahura, Moorea (French Polynesia) was investigated between 1991 and 2006 to test for the effects of major disturbances. During the study, the reef was impacted by one cyclone (1991) and four bleaching events (1991, 1994, 2002, 2003). The cyclone and bleaching of 1991 had the greatest impact, and caused a rapid decline in coral cover from 51.0 % in 1991 to 24.2 % in 1992. In contrast, the three successive bleaching events had little effect on coral cover, even though the thermal anomalies causing these events were similar to the conditions leading to the 1991 bleaching. By 2001, coral cover returned to the 'pre-disturbance' levels of early 1991, but the trajectories of change differed among genera. *Acropora* was affected by the disturbances of 1991, but subsequently showed a high rate of recovery; *Montipora* was affected by most disturbances and showed no sign of recovery; *Pocillopora* was affected by the disturbances of 1991, and showed a partial recovery by 1995; and *Porites* was not affected by any disturbances, but increased in cover throughout the study. Our results demonstrate that large-scale disturbances are not always associated with a phase-shift from coral- to algal-dominated communities, but instead show that coral cover can recover rapidly after dramatic declines. To our knowledge, our study is the first contemporary analysis to demonstrate rapid recovery of coral cover, despite the effects of ongoing disturbances, although importantly this trend was achieved through a shift in the relative abundance of coral genera. Thus, coral communities at Tiahura appear to be characterized by ecological resilience to disturbances in terms of coral cover, but fragility in terms of generic composition.

## 18-48

**Multiple States Of Coral Reefs In Human Shaped Environments**

**Albert NORSTRÖM*[1,2]**, Magnus NYSTRÖM[1,2], Jerker LOKRANTZ[1,2], Carl FOLKE[2,3]

[1]Systems Ecology, Stockholm University, Stockholm, Sweden, [2]Stockholm Resilience Centre, Stockholm, Sweden, [3]The Beijer Institute, Royal Swedish Academy of Sciences, Stockholm, Sweden

Coral ecosystems worldwide are facing large-scale degradation that is often associated with phase shifts: modifications of their functions and feedback mechanisms to a new regime. The most well documented type of phase shift on coral reefs involves a decrease in the abundance of scleractinians coupled with an increased abundance of large, fleshy macroalgae. However, there are numerous reports of coral reefs becoming dominated by other organisms following a disturbance but they have largely been ignored in coral phase shift literature. An ISI search with the keywords "phase shifts AND coral" revealed that only 2 out of 152 research articles mention other possible regimes. We search the literature for evidence of transitions from coral dominance to community assemblages other than macroalgae and argue that four other types of phase shifts seem to occur on coral ecosystems: coral to soft coral, coral to corallimorpharian, coral to sponge and coral to urchin barrens. We place our findings in the context of the current phase shift discourse, and discuss whether these transitions constitute alternative states, as opposed to transient alterations in local community structure. We assess processes and mechanisms behind their manifestation, emphasizing human induced drivers. We conclude that the mix of different human-induced drivers (like excess nutrient runoff, sedimentation, overexploitation) in different coastal and marine contexts create attractors of reef development that lead to the existence of a multiple set of alternative regimes.

## 18-49

**A Global Assessment Of The Threat Of Extinction For Reef-Building Corals**

**Kent CARPENTER*[1]**, Suzanne LIVINGSTONE[1], Muhammad ABRAR[2], Greta AEBY[3], Richard ARONSON[4], Andy BRUCKNER[5], Charles DELBEEK[6], Lyndon DEVANTIER[7], Graham EDGAR[8], Alasdair EDWARDS[9], Doug FENNER[10], Hector GUZMAN[11], Bert HOEKSEMA[12], Gregor HODGSON[13], Danwei HUANG[14], Ofri JOHAN[15], Al LICUANAN[16], Edward LOVELL[17], Jennifer MOORE[18], David OBURA[19], Domingo OCHAVILLO[20], Bill PRECHT[21], Miledel QUIBILAN[22], Clarissa REBOTON[23], Zoe RICHARDS[24], Alex ROGERS[25], Jonnell SANCIANGCO[1], Anne SHEPPARD[26], Charles SHEPPARD[26], Jennifer SMITH[1], Muhammad SYAHRIR[2], Emre TURAK[27], Ernesto WEIL[28], Elizabeth WOOD[29], Dana ZEBROWSKI[1]

[1]Global Marine Species Assessment, IUCN - World Conservation Union, Norfolk, VA, [2]The Indonesian Coral Reef Foundation, Jakarta, Indonesia, [3]Hawaii Institute of Marine Biology, Honolulu, HI, [4]Dauphin Island sea lab, Dauphin, AL, [5]NOAA, Boston, ME, [6]Waikiki Aquarium, University of Hawaii at Manoa, Honolulu, HI, [7]Australian Institute of Marine Science, Brisbane, Australia, [8]Conservation International, Perth, Australia, [9]Newcastle University, Newcastle, United Kingdom, [10]Dept Marine & Wildlife Resources, American Samoa, United States Minor Outlying Islands, [11]Smithsonian Institute, Panama City, Panama, [12]Naturalis, Amsterdam, Netherlands, [13]Reef Check, Los Angles, CA, [14]National University of Singapore, Singapore, Malaysia, [15]Research Center for Aquaculture, Jakarta, Indonesia, [16]DeLa Salle University, Manilla, Philippines, [17]University of the South Pacific, Fiji, Fiji, [18]NOAA, Tampa, FL, [19]CORDIO East Africa, Nairobi, Kenya, [20]Reef Check Philippines, Manilla, Philippines, [21]Reef Resources, Miami, FL, [22]Conservation International, Manilla, Philippines, [23]Marine Laboratory Silliman University, Manilla, Philippines, [24]James Cook University, Townsvillle, Australia, [25]Institute of Zoology, Zoological Society of London, London, United Kingdom, [26]University of Warwick, Warwick, United Kingdom, [27]AIMS, Paris, France, [28]University of Puerto Rico, Mayagüez, Puerto Rico, [29]Marine Conservation Society, Peterbourgh, United Kingdom

The continuing decline and growing threat facing the world's coral reefs motivated the IUCN Species Survival Commission to conduct a series of workshops under the Global Marine Species Assessment initiative to evaluate the zooxanthellate scleractinian coral species of the world against the categories and criteria of the IUCN's Red List of Threatened Species. This is the first attempt to globally assess the threat of extinction for reef-building corals at the species level. A high proportion of species were listed in threatened categories based on habitat decline of recently destroyed and critically declining reefs and life history traits related to species resilience to threats. In addition to habitat loss estimated from published reef assessments and monitoring data, major threats were identified as bleaching, disease, acidification and other climate-related phenomenon, coastal destruction, over-harvesting for the curio and aquarium trade and other human disturbance. This global taxonomic group represents one of the richest and most important ecosystems in the ocean, and the IUCN Red List assessment highlights that the threat off loss of marine biodiversity is comparable to that of terrestrial environments.

## 19-1

**Nutritional Exchange in The Anemonefish/anemone Symbiosis: Photosynthetically-Fixed Carbon Is Translocated To Host Fish**

**Ann CLEVELAND*[1]**, Alan VERDE[1], Raymond LEE[2]

[1]Corning School of Ocean Studies, Maine Maritime Academy, Castine, ME, [2]School of Biological Sciences, Washington State University, Pullman, WA

The relationship between anemones and anemonefish is an oft-cited and endearing example of a mutualistic symbiosis. Current research on mutualistic symbioses suggests these relationships are more commonplace and have greater import at the ecosystem level on nutrient dynamics and evolutionary processes than previously thought. Our research examines the flow of nutrients between resident anemonefishes *Amphiprion clarkii* and *A. perideraion* and their host anemone *Heteractis crispa*; this study provides the first direct evidence of nutritional transfer from zooxanthellae to resident fish. Specifically we traced 1) the flow of photosynthetically-fixed carbon from zooxanthellae to resident fish and 2) the flow of ingested carbon and nitrogen from anemones to resident fish. In the photosynthetic study, anemones were incubated in seawater with 13CO2; in the carbon/nnitrogen study, anemones were fed pellets containing both 13C and 15N. After isotopic exposures, anemones were transferred to individual aquaria equipped with running seawater and paired with a resident fish. Prior to placing each fish in an aquarium and at 2, 4, 8, 16, and 24 hr after exposure to labeled anemones, the epidermis of each fish was wiped with GFC filters; after a 12 d exposure to the labeled anemones, tissue samples were collected from each fish. Filters and fish tissues were analyzed for 13C and 15N using a mass spectrometer. 13C was detected in the filters at the 2 hr timepoint and both 13C and 15N were present in fish tissue samples. Although isotopic label is transferred directly from anemone to fish epidermis via direct contact, the only mechanism for the fish tissues to accumulate the labels is by ingestion. The data suggest that fish are directly ingesting zooxanthellae expelled by the anemone and that photosynthetically-fixed carbon may be an important supplement to anemonefishes.

## 19-2

**Continuous Measurements Of Productivity Over An Algal Reef Flat Using A Modified Eulerian Approach**

**James FALTER*[1]**, Ryan LOWE[2], Marlin ATKINSON[1], Stephen MONISMITH[3], Daniel SCHAR[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]School of Environmental Systems Engineering, University of Western Australia, Perth, Australia, [3]Civil and Environmental Engineering, Stanford University, Stanford, CA

We made continuous measurements of the flux of dissolved oxygen over an algal-dominated reef flat community on the Kaneohe Bay Barrier Reef, Hawaii as a proxy for the instantaneous net community production (NP) of organic carbon. Fluxes were calculated from measurements of dissolved oxygen and current profiles taken from moored oxygen sensors and acoustic Doppler current profilers (ADCPs) located at points defining the vertices of a triangular control volume 250 m in length on each side. We also used conventional Lagrangian methods of estimating NP by following drifters and dye patches. Comparison with conventional Lagrangian methods of estimating NP were excellent when tracking water with dye patches, however, the use of surface drogues over-predicted NP. Continuous measurement of daily integrated Production (P) and integrated community Respiration (R) reveal that R varies with P on short time scales in response to changing light conditions; thus indicating the predominance of autotrophic respiration in this plant-dominated reef community. At seasonal time scales, P and R are well matched in late fall and winter, however, P:R become significantly greater than 1 in summer. In addition, light utilization efficiencies were significantly greater in summer than late fall.

## 19-3

**Nitrogen Dynamics on a Post-bleaching Reef**

**Glen HOLMES*[1]**, Ron JOHNSTONE[1]

[1]The University of Queensland, St Lucia, Australia

Understanding the dynamics of coral reef nutrients, particularly nitrogen, following a coral mortality event is imperative for the prediction of further possible changes on the impacted reef as well as for the identification of potential management interventions. This is particularly pertinent in view of the continued trend towards the increased frequency and geographic extent of coral mortality events. This study investigated the dynamics of nitrogen associated with microbial communities that develop on coral skeletons following bleaching induced mortality using both the acetylene reduction and isotopic nitrogen techniques. The results show that nitrogen fixation activity increases dramatically in the initial three months following coral mortality with fixation rates as much as an order of magnitude higher than those observed on hard substrate material throughout the study sites. Rates of ethylene conversion up to 705 µmol.m-2.hr-1 were observed on *Montastrea faveolata* skeletons while nitrogen fixation rates using 15N of up to 144 µmol N2.m-2.hr-1 were observed on *Acropora aspera* skeletons. These rates are higher than previously reported for coral reefs. Nitrogen fixation activity was found to be influenced by environmental parameters such as nutrient loading and light levels. The results also suggest that the microbes persisting from the pre-bleached coral may influence the dynamics of the microbial community developing on the newly dead coral skeletons. The observed rates of nitrogen fixation following bleaching induced coral mortality may potentially be sufficient to singularly direct an affected ecosystem towards a phase change from a coral to algal dominance.

## 19-4

**Nitrogen Fixation in Coral Reef Environments**

**Beatriz CASARETO*[1,2]**, Loic CHARPY[3], Marie Jose LANGLADE[4], Yoshimi SUZUKI[1]

[1]Graduate School of Science and Technology, Shizuoka University, Shizuoka, Japan, [2]Laboratory of Aquatic Science, Tokyo, Japan, [3]IRD, CENTRE D fOCEANOLOGIE DE MARSEILLE, Marseille, France, [4]IRD CENTRE D fOCEANOLOGIE DE MARSEILLE, Marseille, France

Coral reefs are sites of high nitrogen fixation activity. Marine cyanobacteria are major contributors of nitrogen fixation in coral reefs. In coral reefs cyanobacteria can be found in very diverse environments: in the water column, in the sandy bottom, on coral gravels as endolithic and epilithic forms, or forming microbial mats. The high diversity of cyanobacteria in coral reefs shows their adaptative capacity to live in these nutrient limited environments. The purpose of the present research is to evaluate N2 fixation rates in different environments of the coral reefs and their contribution to the primary production of the total ecosystem. Two different fringing coral reef sites were studied: Sesoko at Okinawa, Japan and La Reunion at the Indian Ocean. N2 fixation and primary production rates were measured using 13C and 15N fixation techniques. Time series incubations were done in order to asses N2 fixation during the night (dark period) and day time. Measurements were done in sandy bottom, coral gravels and cyanobacteria mats. N2 fixation in sandy bottom varied from 2 to 8 µmol N/mg Chl-a with 2.5 to 12% contribution to the primary production. In coral gravels it ranged from 0.5 to 12 µmol N/mg Chl-a with 6 to 26% contribution to primary production, while in cyanobacteria mats it varied between 9 to 240 µmol N/mg Chl-a with contributions of 5 to 21% to the primary production. Differences in N2 fixation rates between daytime and nighttime were found in all the studied environments. Moreover the presence of both heterocystous possessing and non-heterocystous possessing cyanobacteria indicates that N2 fixation and primary production were separated in time (day and night) and space (presence of heterocystous) due to oxygen sensitivity of the nitrogenase enzyme.

## 19-5

**Cyanobacteria Mats in Two Shallow Coral Reef Ecosystems: La Reunion (Sw Indian Ocan) And Sesoko (Okinawa, Nw Pacific Ocean)**

**Charpy LOIC*[1]**, Casareto BEATRIZ[2], Langlade MARIE JOSÉ[3], Suzuki YOSHIMI[4], Palinska KATARZYNA[5], Golubic STJEPKO[6]

[1]IRD, Marseille, France, [2]Laboratory of Aquatic Science and Consultan, Tokyo, Japan, [3]IRD, Marseille, France, Metropolitan, [4]Shizuoka University, Shizuoka, Japan, [5]University of Oldenburg, Oldenburg, Germany, [6]Boston University, Boston, MA

Various types of microbial mats are present in Okinawa and La Reunion coral reef ecosystems. The heterocystous Nodularia and non-heterocystous Leptolyngbya cyanobacteria were present in the two ecosystems. Many mats contained a mixture of different morphotypes. Using the acetylene reduction technique, nitrogenase activity was observed in all the tested mats. The conversion ratio of ethylene to N (C2H2:N2) calculated from 15N2 method ranged between 1.1 and 5.8. Nitrogen fixation by Nodularia, Hydrocoleum lyngbyaceum and Hydrocoleum cantharidosmum mats were particularly high at Sesoko compared with literature data. Nitrogen fixation represented between 5% (Leptolyngbya ) to 21% (Hydrocoleum cantharidosmum ) of that required for primary production measured using 13C uptake and C:N ratio.

## 19-6

**Functional Role Of Crustose Coralline Algae in Nutrient Dynamics Of Coral Reef Ecosystem**

**Yeong Shyan YUEN*[1]**, Seitaro S. YAMAZAKI[1], Takashi NAKAMURA[1,2], Hideo YAMASAKI[1]

[1]Faculty of Science, University of the Ryukyus, Okinawa, Japan, [2]Amakusa Mar. Biol. Lab., Kyushu University, Kumamoto, Japan

Coral reefs worldwide, especially those located near the coastline are constantly being subjected to anthropogenic nutrient input. This anthropogenic nutrient input generally increases the nitrogenous compound concentrations in seawater. This is in contrast with the paradigm that coral reefs thrive best in oligotrophic waters. Accordingly, the study of biogeochemical of nitrogen cycle in reef ecosystems should consider this increasing eutrophication phenomenon. In addition, crustose coralline algae (CCA), a main reef-builder, have been overlooked when it comes to the study of organisms involved in the major nitrogen cycle processes. CCA is well known for its important role in reef-building, inducer for invertebrates' larval settlement and metamorphosis as well as primary producer. In this study, we consider CCA as a combination of the algal component and its calcium carbonate substratum. Here, we report the $NH_4^+$ and $NO_3^-$ uptake activities by CCA and the organisms involved in these activities. Laboratory experiments on the nutrients uptake involved the incubation of CCA in seawater containing a spike of nutrient and monitor its depletion. Organisms involved in nutrients uptake was identified using molecular biological approach. Our results show that microbial consortium residing in the substratum plays a major role in nitrogen cycle processes in the CCA system. The substratum covered by CCA would create a low oxygen concentration environment as well as anoxic environment, which is ideal for the growth of various microbes. Our finding leads us to conclude that CCA is an important functional group involved in the nutrient dynamics in coral reef ecosystems.

## 19-7

**Nitrogen Dynamics in Symbiotic Relationships in Corals**

**Kazuyo SHIROMA*[1]**, Yoshimi SUZUKI[1], Kazuhiro DAIGO[1], Sylvain AGOSTINI[1], M.F. M. FAIROZ[1], Beatriz E. CASARETO[1,2]

[1]Shizuoka University, Shizuoka, Japan, [2]Laboratory of Aquatic Science, Tokyo, Japan

Symbiotic systems in corals are found to be complex and diverse today. The components are not only corals and zooxanthellae but algae and bacteria also have important roles in/on corals. The systems sustain coral symbiosis with nitrogen cycling in oligotrophic environment.

Empirical data have demonstrated imbalance of nitrogen budget that contributed in the symbiotic relationships with measurement such as nutrients in seawater and nitrogen isotope in corals. These studies found that besides external resources, internal resources are used in coral symbiosis.

Isotope technique enables determination of external resource usage or translocation of nitrogen from symbionts to corals without facing to nitrogen conservation issues. However, the calculation used today overestimate uptake rate by coral symbiosis since only uptake but not excrete rates are considered. If the assimilation of ammonium only contribute 10 % of nitrogen required by zooxanthellae, nitrogen cycle in corals are underestimated. Here, we propose possible methods to evaluate internal and external nitrogen cycles found in symbiotic systems in corals.

By introducing C and N stable isotopes into seawater simultaneously, we found that uptake ratios fluctuate, possibly caused by variation in internal resource availability to coral symbiosis. In the future, mathematical model is built to develop as a tool to predict nitrogen dynamics in coral reefs with environmental data. Construction of mathematical model of the symbiosis become useful tool to predict fluctuations of symbiotic relationships in corals those are vulnerable to environmental changes.

## 19-8

**Dissolved Organic Carbon Dynamics and Microbial activity in Tropical and Sub-tropical Coral Reefs**

**Fairoz M F M *[1]**, Forest ROHWER[2], Yoshimi SUZUKI[1], Beatriz CASARETO [3]

[1]Global Biogeochemistry Lab, Shizuoka University, Japan, Shizuoka, Japan, [2]Biology Department, San Diego State University, U.S.A., San Diego, CA, [3]Laboratory of Aquatic Research and Consultants (Pvt) Ltd., Tokyo, Japan, Tokyo, Japan

The marine microbial food web is supported by dissolved organic carbon (DOC). Yet very few measurements of DOC have been made on coral reefs and the relationship between DOC, microbial activity, and macro-organisms in reef environment is not well understood. In previous studies we have shown that additions of labile DOC kill corals. In this study, DOC, nutrients and coral reef characters were measured on Sri Lankan reefs and compared with similar measurements from the Caribbean, Line Islands, Bermuda, and Japan. The water chemistry analysis and reefs surveys were performed using JGOFS and Reef Check protocols, respectively. On the northern Sri Lanka coral reef, the DOC levels were high with low nutrient levels. These conditions correlated with higher coral and lower algae cover. DOC levels were lower and nutrient levels were higher at reefs in southern region, which had low live coral and higher algae cover. However, this is significant variation in the general trends. We suggest that the biogeochemical origin and fate of labile fraction of DOC in coral reef will be important to describe the interactions between microbial activity and coral stress.

## 19-9

**A Role Of Organic Matter In Chemical Symbiosis At Coral Reef**

**Yoshimi SUZUKI*[1]**, Beatriz CASARETO[1], Sylvain AGOSTINI[1], M.F.M FARIOZ[1], Kazuyo SHIROMA[1], Loic CHARPY[2]

[1]Graduate School of Science and Tecnology, Shizuoka University, Shizuoka, Japan, [2]Cyanobacteria Lab., IRD, Marseille, France

Bleaching of corals and damages of the symbiotic zooxanthellae are presently believed to result largely from elevated temperature of the seawater and the increase of UV radiation. Mild or moderate bleaching is commonly followed by recovery, but the long-term effects of high temperature of seawater will end in an irreversible bleaching and massive death of corals. Due to the impact of rising up seawater temperature, corals receive a strong stress, and as a result, corals release high amounts of organic matters (mucus) and ammonia. This means that organic matters in dissolved (DOM) and particulate (POM) forms might play an important role for the fate of corals and coral ecosystem, especially in the food web. The production of organic matters by corals can act as a mechanism for defence but also it is used in feeding for particles capture strategy. High amount of ammonia in the reefs surrounding waters can enhance the growth of pico-phytoplankton, which acts as main food source for benthic community. However organic matters may enhance the growth of certain bacteria, which are known to infect corals and induce bleaching and diseases. Therefore the understanding of organic matters dynamics is of extremely importance for the evaluation of coral health. In this paper, the behaviour of dissolved and particulate organic matters such as concentration, distribution and changes in its characteristics (composition such as amino acids, carbohydrate and molecular weight) at the field and during incubation experiments are reported.

We discuss also the significance of chemical symbiosis in coral reef communities.

## 19-10

**Stimulation Of Coral-Derived Organic Matter Release During Bleaching**

**Wolfgang NIGGL*[1]**, Martin GLAS[1], Christoph MAYR[2], Christian LAFORSCH[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, Munich, Germany, [2]GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-Universität München, Munich, Germany, [3]Department Biology II, Ludwig-Maximilians-Universität München, Munich, Germany

Corals continuously release mucoid exudates in order to clean their surfaces. But recent research also showed that this coral-derived organic matter acts as an energy carrier and particle trap, thus plays an important ecological role for recycling of matter and conservation of nutrients for the oligotrophic reef ecosystem. Some environmental stressors such as air exposure, high sediment loads and turbidity are known to increase mucus production. But although it is a common statement in the literature, scientific data verifying increased mucus release rates during temperature-induced bleaching events (loss of symbiotic zooxanthellae from the coral host) are lacking. This is critical as coral bleaching is the most extensive coral disease world-wide, and bleaching-induced changes in organic matter release potentially have far reaching consequences for reef functioning. In this study, we induced a bleaching event and determined release of particulate organic carbon (POC) and particulate nitrogen (PN) by corals. A new methodology involving several centrifugation steps was introduced in order to separate released zooxanthellae from the coral-derived organic matter. Microscopical counting revealed that at least 99 % of released zooxanthellae could be removed. Our results show that during bleaching on average 50 % more POC is released whereas PN release rates almost doubled compared to the unstressed controls. This is the first experimental evidence that coral bleaching has consequences for organic matter release and ensuing element cycles in tropical reef ecosystems.

## 19-11

**Bacterial Degradability Of The Organic Matter Released From Symbiotic Coral Colonies**

**Yasuaki TANAKA*[1]**, Toshihiro MIYAJIMA[1], Yu UMEZAWA[2], Isao KOIKE[3], Takeshi HAYASHIBARA[4], Hiroshi OGAWA[1]

[1]The University of Tokyo, Tokyo, Japan, [2]Research Institute for Humanity and Nature, Kyoto, Japan, [3]University of the Ryukyus, Naha, Japan, [4]Seikai National Fisheries Research Institute, Ishigaki, Japan

The organic matter released from corals is well known to be utilized by bacteria and stimulate the bacterial growth. However, degradability of the organic matter has not been investigated in a long-term perspective and therefore it is still not understood what % of the released organic matter can actually be mineralized by bacteria. To investigate the long-term degradability, the reef-building corals *Acropora pulchra* and *Porites cylindrica* were first incubated in a normal submerged condition or a stressful condition (air exposure), and released organic matter to the ambient seawater. After taking out of the corals, the incubation seawater containing organic matter was put under dark over 1 year to follow bacterial decomposition of dissolved and particulate organic matter (DOM and POM). The results showed that the concentrations of DOM and POM rapidly decreased within the first 1 week and the remaining organic matter was gradually decomposed much more slowly, suggesting that the coral-derived organic matter had two different fractions in bacterial degradability. The labile organic matter (L-OM) had turnover time of 3.2-9.1 d (average 6.2 d) for DOM and 5.6-9.1 d (average 7.4 d) for POM. The L-OM could be easily mineralized within or around the reef ecosystem. The stressful condition increased the ratio of degradable to bulk organic matter. On the other hand, a part of the coral-derived organic matter was not mineralized even after 1 year, suggesting that it was very recalcitrant to bacterial decomposition. The corals might routinely release such refractory organic matter to the ambient seawater for defense against pathogens.

## 19-12

**Uptake Of Dissolved Organic Matter By The Scleractinian Coral Stylophora Pistillata**

**Renaud GROVER*[1]**, Jean-François MAGUER[2], Denis ALLEMAND[1], Christine FERRIER-PAGÈS[1]

[1]Centre Scientifique de Monaco, Monaco, Monaco, [2]Laboratoire de Chimie Marine, Institut Universitaire Européen de la Mer, PLOUZANE, France

In this work, we investigated the importance of dissolved free amino acids (DFAA) as an organic nitrogen source for the scleractinian coral *Stylophora pistillata*. For this purpose, 15N-enriched DFAAs were used and %15N enrichments were measured separately in both symbiotic zooxanthellae and animal tissue after incubation of the entire coral colonies at different DFAA concentrations and light levels. As previously observed for urea, which is another organic nitrogen source for corals, DFAA uptake is carrier mediated for concentrations below 3 µM and diffusive for higher concentrations. Our results showed that corals are well adapted to in situ DFAA concentrations, since they are able to take up DFAAs at very low concentrations (ca. 0.5 µM) and their Km, that represents the carrier affinity for the substrate was also very low. When normalized to skeletal surface area, uptake rates were ca. twice higher in the animal tissue than in the zooxanthellae and were enhanced by light exposure. The contribution of DFAA as a nitrogen source for tissue growth in the coral *Stylophora Pistillata* was compared to other nitrogen sources such as ammonia and nitrate for the inorganic part, as well as urea for the organic part. It ensues that inorganic sources constitute 75% of the daily nitrogen needs against 24% for the organic sources, and that all dissolved nitrogen sources can supply almost 100% of the nitrogen needed for tissue growth.

## 19-13

**Water Quality Monitoring Along The Florida Reef Tract: Assessment Of Dissolved Organic Matter Sources And Compositional Variations**

**Youhei YAMASHITA*[1]**, Joseph BOYER[1], Diane WILLIAMS[1], Rudolf JAFFE[1]

[1]Southeast Environmental Research Center, Florida International University, Miami, FL

The characterization of DOM can contribute to understanding its ecological roles in diverse aquatic environments. This carbon pool is highly reactive and influences ecosystem function through many biogeochemical reactions and is known to fuel the microbial loop, particularly in oligotrophic environments. Thus in addition to its quantity it is important to determine its source and characteristics (i.e. quality) in large scale and long term water quality monitoring programs. DOM in coastal regions is derived from a variety of sources, including autochthonous planktonic as well as allochthonous terrestrial and anthropogenic sources and its quality has been found to strongly depend on sources and physical and biological processes. This study reports on preliminary data on DOM quality along the Florida Keys reef tract. The concentration of dissolved organic carbon (TOC) and dissolved organic nitrogen (DON) in addition to optical properties of DOM were determined at over 100 field stations ranging from the upper Florida Keys to the Dry Tortugas National Park in the Gulf of Mexico on a quarterly schedule. DOM quality was determined through excitation emission matrix (EEM) fluorescence in combination with parallel factor analysis (PARAFAC). Results show that the DOM associated with the South Florida coral reef community is derived from a combination of sources including autochthonous microbial sources as well as terrestrial and anthropogenic sources, both from the Florida Keys as well as through water exchange with Florida Bay and the Florida Shelf. The spatial variability confirmed potential source assignments of the DOM.

## 19-14

**Organic Matter Cycling in Tropical Coral Reef Ecosystems: The Role Of The Reef Framework And Its Biota, Dominated By Encrusting Sponges.**

**Jasper M. DE GOEIJ*[1,2]**, Joost W. VAN DAM[1,2], Hubèrt EIJKELENBOOM[1,2], Eric H.G. EPPING[3], Fleur C. VAN DUYL[1]

[1]Department of Biological Oceanography, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands, [2]Caribbean Research & Management of Biodiversity, The CARMABI Foundation, Willemstad, Netherlands Antilles, [3]Department of Marine Chemistry & Geology, Royal Netherlands Institute for Sea Research, Den Burg, Netherlands

The coral reef framework is a major sink of organic matter. The removal of organic carbon by framework cavities, with volumes ranging from 50-250 $dm^3$, in reefs of the Berau area, East-Kalimantan, Indonesia and in the reefs of Curaçao, Netherlands Antilles were in the range, or even exceeded the estimated average gross primary production of a coral reef ecosystem. Dissolved organic carbon removal rates by coral cavities were on average 1 to 2 orders of magnitude higher than particulate organic carbon removal rates. A mass balance for carbon (C), nitrogen (N) and phosphorus (P) was constructed for Curaçaoan coral reef framework cavities. The major fate of C was assimilation, suggesting a rapid turnover of matter for a net increase in biomass close to zero. Relative to C and N, P was selectively retained from the reef water flushing the coral cavities. To directly link the nutrient cycling within the reef framework with the cryptic biota, the organic carbon fluxes were determined for the four dominant communities: (1) Sponge, (2) calcareous algae, (3) sediment, and (4) bare substrate – together accounting for, on average, 88% of the surface of the cavities. Evidently, sponges play a key role in the carbon cycling within the reef framework. Sponges, with an average cavity surface cover of approximately 25%, represented approximately 75% of the total organic carbon flux by coral cavities. Dissolved organic carbon accounted for more than 90% of the total organic carbon removal rate by encrusting sponges. We conclude that the coral reef framework is an important habitat for decomposition and (re)cycling of - to large extent dissolved - organic matter within the coral reef ecosystem. The nutrient cycling is mainly accounted for by a thin veneer of, mostly encrusting, sponges.

## 19-15

**Seasonal Carbon Production And Topographic Features in Sesoko Beach Reef, Okinawa, Japan**

**Hiroyuki FUJIMURA*[1]**, Takashi FUKUNAGA[1], Kyouhei ISHIKAWA[1], Koujiro SHIMADA[1], Tomihiko HIGUCHI[1], Tamotsu OOMORI[1], Yoshikatsu NAKANO[2], Tatsuo NAKAI[3], Beatoriz CASARETO[4], Yoshimi SUZUKI[5], Takuji ITO[6]

[1]Department of Chemistry, Biology and Marine Science, University of the Ryukyus, Okinawa, Japan, [2]Sesoko Station Tropical Biosphere Research Center, University of the Ryukyus, Okinawa, Japan, [3]Kokushikan University, Tokyo, Japan, [4]Laboratory of aquatic science consultant (LASC), Tokyo, Japan, [5]Shizuoka University, Shizuoka, Japan, [6]Mitsubishi corporation, Tokyo, Japan

Owing to the global warming and environmental change, coral reefs have been under a serious threat of degradation in the world. In order to understand the present state of coral reefs and predict the future changes, it is important to study a seasonal variation of community carbon metabolism and topographic features in coral reefs. We observed the community carbon metabolism of photosynthesis and calcification every month in Sesoko Beech reef in northwestern part of Sesoko Island, Okinawa, Japan. Most of the corals damaged by mass coral bleaching in 1998 and has not recovered yet. Topographically and biologically different sites were selected as representatives of the reef community in Sesoko. We took water samples every 30min for pH, dissolved oxygen and total alkalinity during slack water periods when the shallow lagoon water (< 80cm) was isolated from offshore. Only two narrow channels is existed and small portion of inside water is flowing out to offshore during low tide. Organic and inorganic carbon productions were estimated from the change in total alkalinity ($A_T$) and total dissolved inorganic carbon ($C_T$) with time. $C_T$ was calculated from pH and total alkalinity using a carbonate equilibrium in seawater. Gross primary production was 300-400 $mmol/m^2/d$ and respiration was 150-300 $mmol/m^2/d$. P/R ratio varied 1.3-1.9, indicating the high photosynthesis rate of fringing reef in Ryukyu Islands. While the high organic carbon production, inorganic carbon production of calcification was 45-55 $mmol/m^2/d$ which is lower value than the other reefs of Okinawa reported before the bleaching. This suggests that the Sesoko coral reef has significantly degraded since coral bleaching in 1998. Further observations are needed to detect the early change in recovery or more additional degradation in the future.

## 19-16

**Temporal Variations in Dissolved Inorganic Nitrogen, Dissolved Gas And Volatile Organic Matter Fluxes Resulting From Sponge Respiration And Microbial Transformations On Conch Reef, Florida Keys (Usa)**

**Christopher MARTENS*[1]**, Niels LINDQUIST[2], Howard MENDLOVITZ[3], James HENCH[4], Richard CAMILLI[5], Anthony DURYEA[6], Brian POPP[7], Patrick GIBSON[3], Melissa SOUTHWELL[3,8], Jeremy WEISZ[9], Nyssa SILBIGER[3]

[1]Marine Sciences, UNC-Chapel Hill, Chapel Hill, NC, [2]Institute of Marine Sciences, UNC-Chapel Hill, Morehead City, NC, [3]UNC-Chapel Hill, Chapel Hill, NC, [4]Stanford University, Stanford, CA, [5]Woods Hole Oceanographic Institution, Woods Hole, MA, [6]Monitor Instruments Company, Cheswick, PA, [7]University of Hawaii at Manoa, Honolulu, HI, [8]UNC-Wilmington, Wilmington, [9]Old Dominion University, Norfolk, VA

High nutrient element fluxes from sponges resulting from rapid respiration rates of dissolved and particulate organic matter likely dominate dissolved inorganic nitrogen (DIN) cycling on the Florida Keys reefs and should be dominant in coral reef ecosystems around the world featuring significant sponge biomass. The barrel sponge *Xestospongia muta* accounts for approximately 60% of sponge biomass in a 600m2 area on Conch Reef off Key Largo, and generates net DIN fluxes exceeding 10 mmol/m2/day, far greater than fluxes from coral substrate and sediments. Respiration by *X. muta* generally results in a 5-15% oxygen drawdown in the huge volumes of ambient water pumped through its tissues. This sponge and many other plentiful species have a single exit point for all exhaled water, allowing for rigorous in situ quantification of filtration rates and net chemical fluxes utilizing a variety of underwater instrumentation. During two 2007 missions utilizing the NURC/UNCW Aquarius Reef Base undersea observatory, chemical transformations and fluxes resulting from *X. muta* respiration were quantified continuously for periods of hours to weeks by coupling chemical sensor measurements with acoustic Doppler velocimetry (ADV) pumping rate measurements. Three different instrument arrays, including a newly designed, in situ membrane inlet mass spectrometer (MIMS), were utilized to continuously measure dissolved gases including O2 (mass 32), N2 (28), Ar (40) and CO2 (44,45) plus a variety of volatile dissolved organic molecules. The stoichiometries of O2 consumption, CO2 production and DIN release were utilized to quantify the role of barrel sponges in reef respiration and C and N cycling and to identify potential biogeochemical transformations such as the uptake of dissolved organic matter, N2 fixation and denitrification. The new capability to measure fluxes of volatile organic molecules from sponges using MIMS should provide novel insights into the chemical interactions of sponges with other reef ecosystem inhabitants.

## 19-17

**Biochemical Symbiotic System in Corals : Role Of The Vitamin $B_{12}$ Produced By Coelenteric Bacteria**

**Sylvain AGOSTINI*[1]**, Yoshimi SUZUKI[1], Beatriz CASARETO[2], Kazuyo SHIROMA[1], Kazuhiro DAIGO[1], Hiroyuki FUJIMURA[3], M. F. M. FAIROZ[1]

[1]Shizuoka University, Shizuoka, Japan, [2]Laboratory of Aquatic Science, Shizuoka, Japan, [3]University of the Ryukyus, Shizuoka, Japan

Vitamin B12, cyanocobalamin and other analogues, is an essential factor for numerous phytoplankton. Croft et al., Nature 2005, showed that 25 species of Dinoflagellates were vitamin B12 dependent out of 30 studied . Until now all Animalia were found vitamin B12 dependent. Even if Cnidaria were not specifically studied we can suppose that they require it too. Vitamin B12 is known to be only produce by bacteria and is found at very low level in seawater. Thus it is controlling the primary production in some oceanic area. Unfortunately the levels, the role of vitamin B12 in Coral Reefs and the requirement of the genus *Symbiodium* were never studied. The source of vitamin B12 in coral reefs was investigated in Sesoko, Okinawa, JAPAN. Vitamin levels were measured in surface water, pore water and coelenteric fluid of *Galaxea fascicularis*, sampled using a novel technique. The measurement was done using radioassay (SimulTrac SNB) which was optimized for analysis in seawater and in some case by HPLC. The highest concentrations were found in the coelenteric fluid : 200-400 pmol l-1 against 10-20 pmol l-1 for the surface water and the pore water. On the other hands high bacteria abundances (108 cells l-1) were found in the coelenteric fluid. Thus the hypothesis that vitamin B12 required by the zooxanthella was acquired through a symbiotic relation with the coelenteric bacteria was made. In order to confirm this hypothesis, the impact of an enrichment of vitamin B12, the requirement of zooxanthella and the possibility of a translocation of the vitamin between the bacteria and the zooxanthella were investigated. The different results precised the integration of the coelenteric bacteria in a biochemical symbiosis with corals and zooxanthella.

## 19-18

**Terrestrial Organic Matter Contribution in Surface Sediment Of Northern Mid Reef, Ishigaki Island, Japan**

Yumi KOTAKE[1], **Yutaka TATEDA*[2]**

[1]Tokyo College of Medico-Pharmaco Technology, Tokyo, Japan, [2]Environmental Science Research Laboratory, CRIEPI, Abiko Chiba, Japan

To evaluate the origin of organic matter being sedimented in the fringing reef environment, normal alkanes from $C_{12}$ to $C_{36}$ were analyzed in the reef surface sediments to identified the origin of the end member of organic matter loading from adjacent mangrove ecosystem. Marine biota originated $C_{15,17}$-alkanes peaks were obvious in the reef sediment, while the common signal of the terrestrial vegetation $C_{31}$ alkane peak were also detected, indicating some reef areas receive significant organic matter loading from terrestrial organic matter especially of mangrove. The straight chain n-alkanes detected in reef surface sediments at Ishigaki northern mid reef area, Okinawa, Japan were estimated to reflect the input of marine biota originated organic matter to be 39 -64 %, mangrove leaf originated organic matter to be 31 - 61 %, upstream riverside soil originated organic matter to be 3 - 9 %. The result of field decomposition experiment using terrestrial leaf indicated that turn over rates of terrestrial organic matter in reef sediment environment were within a range of 3 - 12 months. The overall result indicated that n-alkanes ratio of the end members: marine, mangrove, upstream soil n-alkanes are regarded as a good fingerprints to estimate the contributions of organic matter loading into the reef sediment, suggesting its usefulness for estimate how the stability of coral reefs linked to the biogeochemical cycles keeping the health of coral reef ecosystem, and also for the estimation of upstream land-derived soil loading to reef area under future land use planning.

## 19-19

**The Role Of Mucus Flocs in The Biogeochemical Cycle On Intertidal Coral Reef**

**Yu TAMURA*[1]**, Makoto TSUCHIYA[2]

[1]Graduate school of Engineering and Science, University of the Ryukyus, Ginowan-shi Okinawa-ken, Japan, [2]Faculty of Science, University of the Ryukyus, Naha-shi Okinawa-ken, Japan

On intertidal reef flats, thin films consisting of fine sand, algae and detritus often form on the water's surface during the flooding tide. When drifted by wind, these films develop into thick mucus flocs (MF). MF are transfered by the flooding tide, and are either deposited to the sediments after the gas bubbles inside it disappear, or are dispersed in the water. The organic matter, lipid and carbon hydrate content were higher in MF than in surrounding sediments. These substances seem to be produced by microorganisms like benthic diatoms that are abundant in MF. Therefore, migration of MF may affect the spatial and temporal distribution of nutrients in the oligotrophic coral reef environment.

The objectives of this study were to evaluate the contribution of MF as a food source for deposit feeders and to assess the role of MF in the biogeochemical cycle within the coral reef. We show that MF occur in sandy, exposed areas at the lagoon's edge, and are then carried down wind to the reef flat. The developmental process of MF were classified into 4 to 6 stages based on observations. Then, weight per unit area of each stage was determined, and the occurrence areas of each stage were measured to estimate total MF amount in one tidal cycle within the study area. As MF were produced in larger quantities in July, the amount of nutrients supplied to the reef flat from the lagoon's edge may fluctuate depending on the season. In addition, to investigate the contribution of MF as a food source for deposit feeders, we estimated the food consumption of the *Ophiocoma scolopendrina* population, which is one of the most dominant deposit and MF feeders in the intertidal.

## 19-20

**Coral Mucus Creates A Short-Linked Energy And Nutrient Cycle Via Particle Trapping in Fringing Reefs Of The Northern Red Sea**

**Florian MAYER*[1]**, Andreas HAAS[1], Malik NAUMANN[1], Riyad MANASRAH[2], Jonathan M JESCHKE[3], Christoph MAYR[4], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]Marine Science Station, Yarmouk University, Jordan, Aqaba, Jordan, [3]Dept. Biology II, Evolutionary Ecology, Ludwig-Maximilians-Universität München, Martinsried-Planegg, Germany, [4]Department of Earth and Environment, GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany

Mucoid exudates of hermatypic corals are known to play an essential role as energy carrier and particle trap in reef ecosystems. The mucus trap mechanism prevents loss of essential elements and facilitates fast recycling of organic matter within the oligotrophic system. Compared to platform and atoll reefs where mucus is quickly detached from the coral due to strong tidal currents, coral mucus produced in Red Sea fringing reefs remains significantly longer attached to the coral. Therefore, the mucus trap mechanism is increasingly initiated on the coral surface. Consequently, this suggests the existence of a short-linked nutrient cycle via coral-derived organic matter in fringing reefs. We conducted a series of interconnected investigations during two expeditions to the Northern Red Sea to understand the relevant processes underlying this potential cycle. Highly contaminated mucus strings were attached to 14.6 % of all inspected coral colonies (n= 733). Organic matter enrichment in mucus strings was determined by high temporal resolution sampling. This revealed mean enrichment rates for particulate organic carbon (POC) of up to 5.0 g $h^{-1}$ $L^{-1}$ of exuded mucus. After detachment from the coral, more than 95 % of the highly contaminated mucus aggregates descended to the reef floor within a distance of less than 5 m to the originating coral colony. In-situ and laboratory investigations for planktonic and benthic microbial degradation of collected mucus aggregates showed high organic C turnover rates. This confirms fast recycling of this material and a concomitant release of regenerated nutrients essential for reef productivity. This study therefore indicates that short-linked nutrient cycles via coral mucus importantly contribute to reef ecosystem functioning in the Red Sea.

## 19-21

**Coral Mucus Stable Isotope Composition And Labelling**

**Malik NAUMANN*[1]**, Christoph MAYR[2], Ulrich STRUCK[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-Universität München, München, Germany, [3]Museum für Naturkunde, Humboldt Universität zu Berlin, Berlin, Germany

Recent research showed that mucus released by reef corals functions as a carrier of energy and nutrients to the reef community, thereby importantly contributing to the conservation and fast recycling of organic matter and nutrients in oligotrophic reef ecosystems. However, food web processes involved in the uptake, assimilation and degradation of this material are poorly understood. Staining techniques involving different dyes proved to be inefficient tools in order to label coral mucus. This study now aims to elucidate the usefulness of stable isotopes in order to study the fate of coral mucus. Natural C stable isotope signatures (δ13C) of coral mucus (-25.5 ± 1.0 ‰) were similar to those of particulate organic matter (POM) suspended in reef waters (-23.6 ± 0.4 ‰), whereas N stable isotope signatures (δ15N) of coral mucus (+1.2 ± 0.3 ‰) were comparably lower than those of POM (+15.9 ± 4.1 ‰). For experimental investigations, where larger differences in δ13C and δ15N are required, a technique involving label addition to the coral incubation water was developed. This produced δ13C values of up to +122 ‰ and δ15N values of up to +2280 ‰ for mucus exuded by hermatypic corals of the genera *Fungia* and *Acropora*, indicating fast transfer of assimilated C and N as labelled compounds from the endosymbiotic dinoflagellates to the coral host under light conditions. The usefulness of this technique was demonstrated by laboratory experiments with labelled coral mucus addition. Another potential advantage of stable isotope labelling is that such a non-noxious methodology can be used in-situ. This was confirmed by benthic chamber experiments on coral reef sands revealing fast advective transport of labelled coral mucus from the water column into the sediment surface layer.

## 19-22

**Biogeochemical Constraints On Ecology Of Coral Reefs**

**Marlin J ATKINSON*[1]**

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI

Biogeochemistry is the study of rates of input, production and consumption of compounds that are involved in biological and geological processes. The fluxes and chemical kinetics of these compounds often set limits to ecosystem-metabolism and directly control organism-metabolism. The biogeochemistry of coral reefs is sufficiently well understood that we can delimit a number of basic rate processes, but we are just beginning to link biogeochemistry with ecological processes. Basic parameters in biogeochemistry are light, temperature, concentration (hence water residence time), water motion, waves, surface roughness or bottom drag, and community structure. The combinations of these variables often set limits for biomass accumulation, nutrient input, community metabolism, zonation of metabolism, herbivory, and food chain dynamics. This talk review will briefly review the concepts and approaches for biogeochemical constraints for the above ecological processes.

## 19-23

**Diurnal And Seasonal Nutrient Dynamics Associated With A Nuisance Macroalgae Bloom in The Permeable Coastal Margin Of Kihei, South Maui**

**Iuri HERZFELD*[1]**, Francis J. SANSONE[1], Celia M. SMITH[2]

[1]Department of Oceanography, University of Hawaii, Honolulu, HI, [2]Botany Department, University of Hawaii, Honolulu, HI

Nutrient regimes on coral reefs are dynamic and driven by forces acting on multiple spatial and temporal scales. We explored nutrient dynamics over time-scales ranging from days to seasons associated with a coastal fringing reef on the island of Maui, Hawaii. Studies were performed at Waipuilani Beach Park, Kihei, a site that is experiencing chronic nuisance blooms of the macroalgae Ulva fasciata and Hypnea musciformis. In an attempt to elucidate the mechanisms affecting nutrient concentrations in the water column, multiple 48-hour diurnal multi-parameter surveys of reef water-column and sediment porewater dissolved nutrients (N, P, Si, and Fe) and carbonate chemistry, water physics (tides, waves, currents), and wind speed were performed in 2005-2007 during both dry and wet seasons. Sampling was conducted over different tidal phases and amplitudes in order to decouple the effects of light and tides on nutrient supply and demand. Preliminary results indicate that diurnal nutrient concentrations in the water column and sediment porewater are affected by changes in the kinetic energy being dissipated by the system (wave height and near bottom current velocity), indicating an enhanced remineralization of organic matter. Over seasonal time-scales, nutrient concentrations in the water column are affected by a combination of fresh groundwater inputs, and recirculated brackish groundwater that is actively being altered by sediment diagenesis. We conclude that water column nutrient dynamics at our study site are the result of an intricate interplay between the hydrologic cycle and the atmospheric and gravitational forces that enhance porefluid flow in this permeable coastal margin.

## 19-24

**Dual-Carbon Sources Fuel The Deep Reef Community, A Stable Isotope Investigation**

**Kenneth SULAK*[1]**, James BERG[2], Michael RANDALL[1], George DENNIS III[3], Robert BROOKS[4]

[1]Florida Integrated Science Center, U.S. Geological Survey, Gainesville, FL, [2]ENSR International, Westford, MA, [3]Vero Beach Ecological Services Office, U.S. Fish and Wildlife Service, Vero Beach, FL, [4]ENSR International, St. Petersburg, FL

Surface marine phytoplankton is considered the sole carbon source for the OCS deep reef community (>60 m), the endpoint of one vertically-intergrated, surface to substrate ecosystem. Accordingly, community structure on deep reefs may be directly tied to phytoplankton carbon, channeled via benthic particulate consumers. We tested the hypothesis that phytoplankton carbon is the sole fuel of the deep-reef community, and an alternative hypothesis that terrestrial carbon may contribute secondarily. Our objective was to define trophic structure on, off, and above, northeastern Gulf of Mexico deep reefs via analysis of carbon and nitrogen stable isotopes. We analyzed 114 entities (carbon sources, sediment, fishes, and invertebrates). Carbon signatures supported surface phytoplankton as the primary fuel for the deep-reef community. However, unexpectedly, a second non-terrestrial carbon source was identified as important to the reef food web. This is the pelagic macroalgae Sargassum and the associated macroalgal epiphyte Cladophora liniformis. Macroalgal carbon signatures were detected among 23 consumer species. Most notably, macroalgae contributed 45 % of total carbon to the 13C isotopic spectrum of the particulate-feeding reef-crest gorgonian Nicella. Terrestrial carbon from coastal rivers was not detected. Nitrogen signatures revealed a 4-step trophic chain from particulate organic matter through apex macrovores. Eleven trophic guilds fell into four 15N-defined trophic levels, and three 13C consumer groups. Trophic enrichment in d15N per trophic step was 1.67 ‰, in d13C, 2.0 ‰, both departing from the classical 3.0-3.4 ‰, and 1.0% per step, respectively. In contrast to ubiquitous phytoplankton, the secondary macroalgal carbon source is spatially heterogeneous in surface waters. The spatial distribution of some key particulate-feeding sessile reef invertebrates may depend on carbon fallout from spatially discontinuous surface macroalgae, providing novel insight into the spatial heterogeneity of key colonial reef invertebrates.

## 19-25

**Mangrove-Exported Nutrient Incorporation By Sessile Invertebrates On Adjacent Coral Reefs**

**Elise GRANEK*[1]**

[1]Environmental Sciences and Resources, Portland State University, Portland, OR

Understanding the consequences of the declining global cover of mangroves necessitates consideration of how mangrove-derived nutrients contribute to threatened coral reef systems. We sampled potential sources of organic matter and a suite of sessile reef invertebrate consumers from six sites in Bocas del Toro, Panama in the Caribbean Sea to conduct stable isotope analyses using $\delta^{34}S$ or $\delta^{13}C$. Using IsoSource mixing models we determined the range of potential contributions to consumers from the various organic matter sources in the system. Mangrove organic matter contributed substantially to most filter feeders ranging across sites from 11-53% for sponges, 18-44% for file clams, and 29-51% for feather duster worms. Mangroves contributed 7-31% of the organic matter to coral species. To examine how mangrove contribution varied with distance from mangrove source we conducted a transplant experiment. Results indicated that the mangrove contribution to invertebrate species declined with increasing distance from shore. These results provide the first evidence that mangrove inputs of organic matter to sessile invertebrate species are substantial and offer an indication of the magnitude of incorporation. Thus, removal of mangroves from tropical shores can potentially generate a deficit in the organic inputs to reef organisms, with as yet unknown ecological consequences for the integrity and persistence of reefs.

## 19-26

**Habitat-Dependent Diet in Zooplanktivorous Fishes: Implications For Trophic Connections With Coral Reef And Oceanic Food Webs**

**Kate HANSON*[1]**, James LEICHTER[1]

[1]Scripps Institution of Oceanography, La Jolla, CA

The import and export of zooplankton from reef systems is an important pathway by which coral reefs exchange organic matter, energy and nutrients with adjacent open ocean ecosystems. Understanding the dynamics of this exchange requires knowledge of the trophic pathways through which zooplankton enter the reef system. This study examines the relative importance of oceanic versus reef-associated resources for site-attached reef planktivores. We utilize gut-content and stable isotope analyses to examine intra-specific spatial variability in the diet of zooplanktivorous reef fishes. Muscle tissue was collected from individuals of the damselfish species *Dascyllus flavicaudus* inhabiting three reef zones at 6 sites surrounding the island of Moorea, French Polynesia. Carbon isotope values measured from fish inhabiting deep forereef sites are depleted relative to values measured from shallow lagoon and fringing reef conspecifics by ~ 3 ‰, with corresponding differences in nitrogen isotope values of up to 1.5 ‰. Similar results were found for a second planktivorous species, *Chromis viridis*. Isotope values of forereef *Dascyllus flavicaudus* are less variable through time than are values of fringing reef individuals. Together with the results of gut-content analysis, comparison of isotope values sampled from fish with those obtained from bulk zooplankton tows suggests that forereef individuals rely on oceanic zooplankton while lagoon and fringing reef individuals may be increasingly dependent on reef-associated zooplankton such as larval decapods.

## 20-1

**The Comparative Demographic Of Two Scleractinian Corals On A Shallow Caribbean Reef**

**Peter EDMUNDS*[1]**

[1]California State University, Northridge, Northridge, CA

In light of the consequences of anthropogenic disturbances for coral reefs, considerable effort has been expended to understand the mechanisms by which such phenomena result in coral death, and how affected populations change over time. There has been less attention however, to the question of which corals might endure the adverse conditions, and to what extent might their populations increase in size? This study focused on two Caribbean corals that have survived better than most on shallow reefs (<8 m) in St. John, US Virgin Islands, and the objectives were to use demographic models to explore the responses of these species to disturbance, and elucidate their trajectories of change over the next 25 years. The study species were Porites astreoides, which is well known for its weedy life-history characteristics, and Diploria strigosa, and the approach utilized population censuses from 1994 to 2007, and a tag-and-resurvey procedure repeated annually between 1999 and 2007. The empirical data were used to parameterize size-based matrix models, and bootstrap resampling was used to attach confidence intervals to population parameters and projections. In contrast to the population trajectories of the historically dominant corals in St. John and elsewhere in the Caribbean, the intrinsic rate of population increase (?) rose gradually for both species between 1999 and 2007, and ended the study >1 showing that the populations were growing independent of the input from recruitment. Over the next 25 years, population projections suggest that both species will increase in abundance, regardless of the effects of catastrophic disturbances or periodic recruitment failure. Both P. astreoides and D. strigosa appear to have characteristics favoring high adult survival and successful fission under contemporary environmental conditions, both of which contribute to population growth in an era when most corals are declining in abundance.

## 20-2

**Simulating the Growth and Spread of Key Macroalgae in Florida Reefs**

**Aletta YÑIGUEZ*[1]**, John MCMANUS[2]

[1]National Center for Coral Reef Research (NCORE)/ Marine Biology & Fisheries (MBF), RSMAS, University of Miami, Muntinlupa City, Philippines, [2]National Center for Coral Reef Research (NCORE)/ Marine Biology & Fisheries (MBF), RSMAS, University of Miami, Key Biscayne, FL

The growth patterns of macroalgae can provide important information regarding the environments in which they live, and insights into changes that may occur when those environments shift. To decipher these patterns and their attendant mechanisms and influencing factors, a spatially-explicit model was developed. Using the three-dimensional agent-based model SPREAD (SPatially-explicit REef Algae Dynamics), which incorporates key morphogenetic characteristics of clonality and morphological plasticity, the influences of light, temperature, nutrients and disturbance on how the dominant macroalgae in the Florida Reef Tract grow and occupy space were investigated. At the individual level, SPREAD yielded several morphological types for *Halimeda tuna*, *Halimeda opuntia*, and *Dictyota* sp. under a large range of light, temperature, nutrient and disturbance levels. These morphological types approximated those measured for individuals in two inshore patch reefs and two offshore spur and groove reefs, and were formed in conditions similar to the environmental (light, nutrient and disturbance) conditions in the field sites. At the macroalgal population level, increasing disturbance in SPREAD such that the fragment pool was increased, but not enough so that fragments could not survive, led to the highest potential for space capture. Enabling fragmentation also allowed for comparable abundances in the three species between the model and the actual study sites, and, for *Halimeda* spp., captured the observed disparity in abundances between the sites. The variation in growth and disturbance conditions, as well as each species' capacity for success with fragmentation, seemed to play a strong role in the distinct differences in macroalgal abundances between inshore patch and offshore reef study sites. These mosaics of scenario-running and empirical studies have enabled us to tease out potential mechanisms and factors responsible for the growth patterns observed in reality at different levels.

## 20-3

**Recovery Dynamics Of *diadema Antillarum* And The Potential For Active Rebuilding Measures**

**Alice ROGERS*[1]**, Kai LORENZEN[1]

[1]Biology, Imperial College London, London, United Kingdom

In recent decades, Caribbean coral reefs have suffered a shift in community structure from a healthy coral-dominated state to a less resilient and less productive macroalgae-dominated state. This shift is believed to be related in part to the functional extinction of the previously dominant grazer of macroalgae, the sea urchin *Diadema antillarum* following a mass mortality event in 1983.

*Diadema antillarum* has failed to recover to pre-mortality densities in many locations. In light of recent studies suggesting that large scale recovery of *Diadema antillarum* could reverse community change and improve the health of Caribbean coral reefs, interest has arisen around the potential for active rebuilding measures such as hatchery enhancement to aid and increase population recovery.

We developed a size- and spatially structured, combined population dynamics and grazing impact model for *D. antillarum*. The model accounts for compensatory density-dependence in recruitment and individual growth, and depensatory density effects mediated by fertilization success, the possible refuge function of adults for juveniles, and 'cultivation' of settlement habitat by grazing. Results show that the population can exist in two distinct states, i.e. a low-abundance equilibrium associated with high macroalgal cover, and a high-abundance equilibrium associated with low macroalgal cover.

In order to 'kick start' recovery and switch from the low to the high abundance state the population needs to overcome multiple depensatory processes. This may require both, prior reduction in algal cover by other herbivores or human intervention, and a high recruitment event based on dispersal from recovered populations or the stocking of hatchery-reared *D. antillarum*. Hatchery releases could contribute effectively to recovery, but this would require stocking densities that are high relative to the natural population and may result in substantial ecological and genetic interactions with the natural population.

## 20-4

**Spatial Dynamics Of Herbivory And Coral Growth: Implications For Reef Conservation And Recovery**

Dylan MCNAMARA[1], **Stuart SANDIN*[2]**

[1]Duke University, Atlantic Beach, NC, [2]Scripps Institution of Oceanography, La Jolla, CA

Competition for space is a critical dynamic affecting patterns and rates of growth of sedentary organisms both on land and in the sea. Understanding the aggregate impact of spatial dynamics on competitive hierarchies along shared margins is important for gaining insight into large-scale systematic shifts, such as catastrophic phase shifts within coral reefs. Predictive insights are fundamental for both understanding conditions leading to coral loss and, perhaps more importantly, for designing strategies for restoring coral populations.

To explore this question, we have constructed a cellular automata model for coral reefs to mimic the dominant dynamics of coral reefs. State transitions are governed by probability-driven rules based on dynamics of growth, death, succession and recruitment. Explicit spatial dynamics are depicted both through size-dependent patterns of growth in corals and autocorrelated patterns of foraging for some herbivores. These assumptions are based on two main field observations: (i) small corals are more susceptible to overgrowth by macroalgae than larger colonies, and (ii) patterns of herbivory are distinct between fishes and urchins, especially in reference to the level of spatial autocorrelation of foraging. We find that algal dominated reefs are particularly stable because coral recruitment is severely reduced in the presence of macroalgae. Although clonal growth allows adult corals to increase in size even in the presence of high macroalgal cover, only in the presence of significant herbivory is coral recruitment facilitated. Additionally, because urchins open larger contiguous sections of benthos from algal coverage than do fishes, coral recruitment will be particularly facilitated in the presence of herbivorous urchins. The wide-spread mortality of both fast-growing corals (e.g., acroporids) and herbivorous urchins in the Caribbean, the dynamic attractor of macroalgal domination is particularly stable. These model predictions mimic closely a growing number of empirical observations from across the Caribbean.

## 20-5

**Agent-based Simulation of a Recreational Coral Reef Fishery: Linking Ecological and Social Dynamics**

**Jennifer SHAFER*[1]**

[1]University of Hawaii, Honolulu, HI

In this agent-based simulation, the ecological dynamics of a simple coral reef ecosystem are linked to the social dynamics of a recreational fisher community. The simulation captures the interaction and dynamic feedback between the ecological and social systems and how these affect fish stocks and fisher behavior. The analysis reveals the complex nature of how system-level dynamics emerge from localized individual-level behaviors. Empirically based parameter estimates and behaviors drive the energetics and ecology of the reef's three trophic levels from the bottom-up through individual-based mechanistic rule-sets: photosynthetic turf algae grows, herbivorous fish graze while schooling and avoiding predation, and roaming piscivores hunt herbivores and patrol the reef edge. These simple individual behaviors give rise to the more complex ecological phenomena of fish schooling, carrying capacity, and population cycles. At the same time, a community of recreational fishers interacts with each other and the physical and biological components of the reef. Individual fishers assess risk and pay-off in deciding when to go fishing, find appropriate locations on the reef to set gear, and attempt to catch fish. Simple individual choices made in the dynamic reef environment result in the emergent sociological phenomena of localized resource depletion, diffusion of information and cooperation. Under a community-based management scenario where fishers have the choice to form self-organized coalitions to establish and enforce catch restrictions, the resource dilemma associated with overfishing can be overcome under certain conditions. This research provides proof-of-concept for using agent-based simulation as a versatile and powerful modeling tool for coupling biophysical and sociological processes and evaluating alternative management scenarios.

## 20-6

**Models of Coral Reefs with And without Macroalgae Indicate Differential Resilience to Fishing And Anthropogenic Nutrients**

**Tak FUNG*[1]**, Robert SEYMOUR[1], Craig JOHNSON[2]

[1]Department of Mathematics, University College London, London, United Kingdom, [2]School of Zoology, University of Tasmania, Hobart, Australia

A dynamic model of a generic coral reef ecosystem is constructed using differential equations. Three benthic groups (corals, turf algae and macroalgae), three fish groups (herbivorous and small and large piscivorous fish) and one invertebrate group (sea urchins) are modeled.

The model is parameterized for a pristine (no fishing) generic reef with and without macroalgae using data from the Caribbean and Indo-Pacific. Three scenarios are examined, *viz*. increased a) fishing pressure, b) nutrients, and c) fishing and nutrients. Nutrients increase the growth rates of both macroalgae and turf, but can have a much bigger impact on reefs with macroalgae, since macroalgal patches grow laterally over other benthic groups.

For the reef without macroalgae, increased fishing pressure can give a continuous phase shift from high coral cover to high cover of turf algae. The reef with macroalgae can exhibit both continuous and discontinuous phase shifts to dominance by algae (turf and macroalgae) as fishing pressure increases. Increased nutrients also promotes algal cover, and for reefs which exhibit a discontinuous phase shift as grazer biomass decreases, nutrients can increase both the hysteresis effect (which slows recovery of coral cover) and the grazer biomass at which such a phase shift occurs. Fishing and nutrients can interact synergistically, such that a heavily fished reef with high nutrients can have high algal cover where in the presence of either factor alone, it would have low algal cover. However, in some cases, either decreased grazing or increased nutrients alone can result in high algal cover.

The results suggest the need for different management strategies for mitigating the effects of fishing and nutrients on reefs with macroalgae (such as many in the Caribbean) and without macroalgae (such as typical offshore Indo-Pacific reefs).

## 20-7

**Managing Uncertainties in The Development Of An Agent-Based Model Of A Complex Coral Reef Ecosystem**

**Felimon GAYANILO*[1]**, John MCMANUS[1]

[1]National Center for Coral Reef Research, RSMAS, University of Miami, Key Biscayne, FL

Agent-based modeling (ABM), an element of the Science of Complexity, is gaining acceptance in main stream ecological science as a viable tool to model complex coral reef ecosystems. Current approaches in agent-based modeling to simulate ecological changes due to anthropogenic and/or natural disturbances in a complex system, such as coral reef ecosystems, rely heavily on our ontological and epistemological understanding of the ecological network. Initialization of the model is inductive and generally, environment and rules are modified and the emergent behavior of the global system is analyzed. Coral reef science is just beginning to understand the linkages and taxonomic attributes of the elements of this diverse and complex ecosystem. These uncertainties and information gaps force researchers to rely heavily on assumed biophysical, temporal, physiological, and sociological rules. This paper addresses the effects of some of these uncertainties by comparing results of simulated scenarios executed by an ABM simulation tool, GAMET (Geographic Agent-based Marine Eco-forecasting Tool). Moreover, options are presented as to how to minimize the effects of these uncertainties, including the strengthening of a global interdisciplinary program, CARRUS (Comparative Analysis of Reef Resilience Under Stress).

## 20-8

**Thresholds And The Resilience Of Caribbean Reefs Under Climate Change**

**Peter MUMBY*[1]**

[1]School of BioSciences, University of Exeter, Exeter, United Kingdom

The deteriorating health of the World's coral reefs threatens global biodiversity, ecosystem function, and the livelihoods of millions of people living in tropical coastal regions. Reefs in the Caribbean are among the most heavily-impacted, having experienced mass disease-induced mortality of the herbivorous urchin Diadema antillarum in 1983 and two framework-building species of coral. Declining reef health is characterised by increases in macroalgae. A critical question is whether the observed macroalgal bloom on Caribbean reefs is easily reversible. To answer this question, we must resolve whether algal-dominated reefs are an alternative stable state of the ecosystem or simply the readily reversible result of a phase change along a gradient of some environmental or ecological parameter. Here, using a fully-parameterised simulation model, we show that Caribbean reefs became susceptible to alternative stable states once the urchin mortality event of 1983 confined the majority of grazing to parrotfishes. We reveal dramatic hysteresis in a natural system and define critical thresholds of grazing and coral cover beyond which resilience is lost. Most grazing thresholds lie near the upper level observed for parrotfishes in nature suggesting that reefs are highly sensitive to parrotfish exploitation. Ecosystem thresholds can be combined with stochastic models of disturbance to identify targets for the restoration of ecosystem processes. We illustrate this principle by estimating the relationship between current reef state (coral cover and grazing) and the probability that the reef will withstand moderate hurricane intensity for two decades without becoming entrained in a shift towards a stable macroalgal-dominated state. Such targets may help reef managers face the challenge of addressing global disturbance at local scales.

## 20-9

**Resilience in A Small Coral World: Disturbance in Networks**

**Stuart KININMONTH*[1]**, Glenn DE'ATH[1], Hugh POSSINGHAM[2]

[1]Australian Institute of Marine Science, Townsville, Australia, [2]University of Queensland, Brisbane, Australia

Coral reefs are declining worldwide due to increasing local and regional stress from fishing, coastal development, run-off and climate change. While disturbance is an essential part of coral reef dynamics, its frequency and intensity has increased. As the health of a reef changes due to stress and disturbance its capacity to recover is partly determined by the connectivity through larval transport. This exchange of larvae between reefs creates a complex system of interactions that can be modelled. Using graph theory models, we discover that ecological connectivity patterns are highly clustered and well connected. This gives rise to the description of the connectivity pattern of coral reefs as 'small world' where individual reefs appear to be improbably well connected. We examine the hydrological and genetic patterns of the central section of the Great Barrier Reef to find a mesoscale small world. We examine the history of disturbance from cyclones, Crown-of-Thorns starfish and bleaching within the coral reef network and discover that the spatial and temporal character of the disturbance differentially affects the network connectivity. Long term monitoring records of reef decline, stasis, or recovery cycles are incorporated into the graphical model. Our model demonstrates the need to understand the functional aspects of coral reefs in order to adequately provide conservation measures.

## 20-10

**Models Of Coral Community Structure, Environmental Variation, And Connectivity**

**Carrie KAPPEL*[1]**, Daniel BRUMBAUGH[2,3], Craig DAHLGREN[4], Alastair HARBORNE[5], Katherine HOLMES[2], Fiorenza MICHELI[6], Peter MUMBY[5], Claire PARIS[7]

[1]National Center for Ecological Analysis and Synthesis, University of California Santa Barbara, Santa Barbara, CA, [2]Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, [3]4Marine Protected Areas Science Institute, National MPA Center, Santa Cruz, [4]Perry Institute for Marine Science, Jupiter, FL, [5]Marine Spatial Ecology Lab, School of BioSciences, University of Exeter, Exeter, United Kingdom, [6]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [7]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

A suite of physical and biological environmental factors and processes have been shown to structure coral reef communities at local scales. Recently, studies have begun to address the role that other factors, such as temperature, pH, and dispersal potential, play in shaping communities at global and regional scales. Conservation planning and implementation typically take place at the seascape scale (10s – 100s km), creating a need to understand what drives variation in communities at intermediate scales and a demand for easily measured surrogates for biodiversity. We used distance-based redundancy analysis (dbRDA) to assess the role of physical and biological factors in explaining patterns of coral community structure at the seascape level. We examined the relationship between community structure, as measured in detailed field surveys of coral species distributions at nested spatial scales across the Bahamas archipelago, and the measured or modeled environmental variables: depth, vertical relief, wave exposure, grazing intensity by herbivorous parrotfishes, connectivity (based on simulations of larval dispersal for typical spawning and brooding corals), history of hurricane and bleaching disturbances, macroalgal cover and total coral cover, local human population density and tourism intensity. Several of these factors, including incoming coral larval supply (i.e. subsidies) and macroalgal cover were significant predictors of coral community structure. We also examined species-specific patterns of abundance across the archipelago. We used linear mixed-effect models to explain variation in common individual coral species from the genera *Montastraea* and *Agaricia*, relating their abundance to physical and biological variation and connectivity among our sites. For individual species, number of retained larvae (i.e. self-recruitment) was often a significant predictor of abundance. Together these analyses highlight the importance of connectivity, the history of disturbance, and physical and biological processes like grazing and wave exposure in explaining patterns of coral abundance and community structure across the Bahamian seascape.

## 20-11

**Exploring Past And Future Human Impacts On Reef Fish Ranges Via Distribution Models**

**Jana MCPHERSON*[1]**, Julia BAUM[2], Derek TITTENSOR[1]

[1]Biology Department, Dalhousie University, Halifax, NS, Canada, [2]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla, CA

Our study uses species distribution models to identify human-induced changes in the composition of reef fish communities. Species distribution models traditionally combine spatial information on species' occurrence with measures of environmental conditions to delineate individual species' ranges. They are widely used in terrestrial ecology to predict shifts in species' distributions in response to habitat alterations and climate change. We apply these models to coral reefs using data compiled by the Pacific Reef Fish Collaboration (PaReFiCo), an international effort to study humanity's impacts on reef ecosystems. PaReFiCo's data consist of underwater visual sightings of reef fish species from more than 8000 transects conducted at 83 islands across the Pacific Ocean. In order to determine both natural and human-induced constraints on individual species' ranges, potential explanatory variables in the models include not only traditionally used environmental predictors (e.g. temperature, habitat type) but also indicators of anthropogenic stressors (e.g. coastal population density). We are thus able to explore past as well as future human impacts on individual species' occurrence. Layering of individual species' models provides insight into human-caused changes in community composition.

## 20-12

**The New Commons: Why Coral Reef Scientists Should Get Out More**

**robert SEYMOUR*[1]**, Roger BRADBURY[2]

[1]mathematics, UCL, London, United Kingdom, [2]ANU, Canberra, Australia

How do we understand complex ecosystems such as coral reefs? More importantly, what do we understand them for? The current "big idea" in the Life Sciences is Systems Biology, a movement that aims to reverse the paradigm of reductionist research in which more-and-more-detailed properties of smaller-and-smaller components of biological systems are isolated and dissected. Systems Biology aims to pursue a reverse, integrationist agenda, in which whole system properties "emerge" from component processes. It is these emergent properties that promise significant payoffs to humans. Ecology is stuck in a rut with the classical "systems analysis" paradigm: ecosystems are conceived as assemblages that just "do what they do", and we try to understand this "doing" through a description of local interactions between components. Can we develop a Systems Biology paradigm for ecosystems? This talk will argue that we can, and should. Thus, in the absence of obvious naturally evolved ecosystem "functions", we should develop views as to what the "function(s)" of such an ecosystem might mean. Taking such a view forms a high-level conceptual basis for modelling, and can be used to provide a conceptual bridge between high-level functional properties and low-level mechanistic processes. This greatly facilitates modelling and analysis. Such "functions" cannot, and should not, avoid being related to human activity. We must escape from the guilt paradigm in which ecosystems would revert to a harmonious state if only humans would leave them alone. Instead, management should aim to buffer homeostatic properties associated with these functional properties (to maintain "health"). In this endeavour we should think more like medical physiologists and agricultural scientists, using manipulative techniques where necessary. Thus, the future of the Commons must be that of a highly managed landscape, subject to controlled development.

## 20-13

**Foodwebs Of Coral Reef Seascapes Across The Bahamian Archipelago: Network Structure, Biodiversity, Robustness And The Effect Of Rugosity**

**Steven LITVIN*[1]**, Fiorenza MICHELI[1], Jennifer DUNNE[2,3], Peter MUMBY[4]

[1]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [2]Santa Fe Institute, Santa Fe, NM, [3]Pacific Ecoinformatics and Computational Ecology Lab, Berkeley, [4]Marine Spatial Ecology Lab, University of Exeter, Exeter, United Kingdom

Do changes in the diversity of fish assemblages across the Bahamian archipelago lead to significant variability in the structure of coral reef foodwebs and their associated properties? To address these questions we assembled empirical foodwebs for coral reef seascapes surveyed by the Bahamian Biocomplexity Project. This dataset incorporates over 160 species of reef fish censused throughout the archipelago at locations separated by scales of tens to hundreds of kilometers. Differences in foodweb structure associated with factors including the level of fishing pressure, extent of mangroves and the presence of an established marine protected area were determined using ecological network approaches. In addition to the direct comparison of measures of foodweb complexity we estimated the potential effect of species loss among coral reef foodwebs by simulating both the directed and random loss of species and then measuring robustness in terms of secondary extinctions. Further comparisons were carried out utilizing the niche model approach, based on the empirically observed variation in species diversity and connectance across the locations surveyed. To access the role of rugosity on foodweb structure we first calculated the probability individual fish species surveyed in hard bottom habitats were present within a given range of rugosity. Subsequently, foodwebs containing all species likely present within a rugosity range were assembled and the above mentioned network approaches applied. Together, these results provide insight into the drivers of foodweb structure in coral reef seascapes and the degree which perturbations, human induced and otherwise, are transmitted throughout fish communities.

## 20-14

**Predicting Reef Futures Using A Multi-Scale Coral Reef Ecosystem Model**

**Jessica MELBOURNE-THOMAS*[1]**, Craig JOHNSON[1], Tak FUNG[2], Robert SEYMOUR[2]

[1]School of Zoology, University of Tasmania, Hobart, Australia, [2]CoMPLEX, University College London, London, United Kingdom

Models can be effective tools to assess tradeoffs that arise in the exploitation and protection of coral reef systems. The importance of a regional-scale approach to modelling and management is clear, given that reefs are highly connected across regions by ocean currents, social structures, regional economies and global markets. However, there are few regional-scale coral reef models useful to stakeholders for decision support in management and policy development.

We present a spatially explicit regional-scale model of a coral reef system which has been developed as a decision support tool. The model couples a fundamental, local-scale ecosystem-dynamic model to the regional scale by incorporating inter-reef connectivities for larvae, sediments and pollutants. Initial parameterisation is for the Meso-American Barrier Reef system (MBRS). Our approach is generic, so that the model can be transferred between global regions (e.g. Indo-Pacific, East Africa, and other areas in the Caribbean), with flexibility in parameterisation for differing data availabilities.

Despite its conceptual simplicity, the regional model demonstrates complex, non-linear responses to external forcings that have important management implications. We will present examples of several important behaviours for the MBRS, and show how the model can be used to visualise and assess possible reef futures under alternative management scenarios.

## 20-15

**One Fish, Two Fish, Red Fish, Blue Fish: The Use Of Simple Agent-Based Models And Role-Play Games To Communicate Key Messages To Community Groups**

**Deborah CLELAND*[1]**, Rollan GERONIMO[2], Anne DRAY[3], Pascal PEREZ[3], Abigail TRINIDAD[4]

[1]Fenner School of Environment and Society, Australian National University, Canberra, Australia, [2]University of the Philippines, Manila, Philippines, [3]Australian National University, Canberra, Australia, [4]Foundation for the Alternative Management of the Environment, Manila, Philippines

The principal anthropogenic factors driving reef degradation have been known for years, if not decades. Overfishing, sedimentation and nutrient loads are just some of the key impacts of human activities in and around reef communities. Therefore, the future of reefs does not rely on generating new knowledge, but rather on implementing and integrating the knowledge we already have. This will require creating effective links between researchers, managers and communities to promote mutual learning, negotiation and collaborative action for reef management. Combining agent-based models and role-play games, through a technique known as Companion Modelling (ComMod), creates a dynamic and interactive setting that can contribute to research, education and participatory goals across diverse stakeholders. Incorporating the decision-making processes of individuals into each time step, through the role-play game, means that socio-economic rationalities are seamlessly integrated with the bio-physical dynamics embedded in the models. ComMod has been used successfully as a communication and learning tool in participatory workshops in both the Mesoamerican Reef (Mexico) and the Bolinao-Anda reef complex (Philippines). These experiences demonstrate that simple, generic ecological dynamics are very effective in communicating key conservation messages to a lay audience. However, a comprehensive understanding of local cultural, economic and social characteristics is crucial to develop a coupled model/role-play game that can successfully engage stakeholders.

## 20-16

**Noaa Coral Reef Watch Experimental Coral Bleaching Forecast Tool**

**Gang LIU*[1]**, Ludmila E. MATROSOVA[2], M. Cécile PENLAND[3], Dwight K. GLEDHILL[1], C. Mark EAKIN[4], Robert S. WEBB[3], Tyler R. L. CHRISTENSEN[1], Scott F. HERON[4], Jessica A. MORGAN[1], William J. SKIRVING[4], Alan E. STRONG[4]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]CIRES/NOAA Earth System Research Laboratory Physical Science Division, Boulder, CO, [3]NOAA Earth System Research Laboratory Physical Science Division, Boulder, CO, [4]NOAA Coral Reef Watch, Silver Spring, MD

While NOAA Coral Reef Watch (CRW) near-real-time satellite monitoring of the thermal stress conducive to coral bleaching provides critical and timely information to coral reef managers and scientists, the outlook of potential thermal stress during the future months would be very useful for strategic planning and management. A new prediction tool is being developed by NOAA that seeks to provide a seasonal outlook of thermal stress conducive to coral bleaching. NOAA CRW has teamed up with the Physical Sciences Division of the NOAA Earth System Research Laboratory in developing thermal stress forecast model to provide coral bleaching HotSpot and Degree Heating Weeks forecasts ranging from two-weeks to seasons in advance. HotSpot and Degree Heating Weeks are two parameters that link the anomalously high sea surface temperature (SST) to the onset and intensity of mass coral bleaching and have been used successfully in providing near-real-time satellite bleaching monitoring. The SST forecast model is developed based on NOAA's Linear Inverse Model (LIM) that has successfully produced predictions of tropical Pacific and Atlantic SST anomalies. This presentation will introduce this new tool developed for coral reef managers and scientists.

## 21-3

**Recreational Fishers' Perceptions Of The Costs And Benefits Of The 2004 Rezoning Of Australia's Great Barrier Reef Marine Park**

**Stephen SUTTON*[1]**

[1]Fishing and Fisheries Research Centre, James Cook University, Townsville, Australia

Recreational fishing is a popular use of Australia's Great Barrier Reef Marine Park (GBRMP). In 2004, the Great Barrier Reef Marine Park Authority (GBRMPA) implemented a new zoning plan for the GBRMP that increased no-fishing zones within the Park from 5% to 33% of the total Park area. Anecdotal evidence suggested a high level of opposition towards the rezoning among recreational fishers before and after implementation of the new zoning plan. This study reports on a recent survey of 800 GBRMP recreational fishers that was aimed at understanding fishers' perceptions of the costs and benefits of the 2004 zoning plan and the rezoning process. Results revealed that a majority (70%) of recreational fishers support the new zoning plan and believe it will enhance the sustainability of the Great Barrier Reef and the fisheries it supports. In general, the effects of the new zoning plan on recreational fishing activity appear to be less severe than fishers had expected with most fishers (73%) reporting that the rezoning has had little negative impact on their fishing activity. However, most fishers did not believe that the concerns of recreational fishers were adequately considered in the rezoning process, and trust in the GBRMPA among recreational fishers is low. Results suggest that opposition towards the zoning plan among recreational fishers is due to dissatisfaction with the rezoning and consultation processes rather than dissatisfaction with the outcomes of the new zoning plan. Support for marine protected areas and coral reef conservation among recreational fishers could be enhanced by developing more effective methods of engaging the recreational fishing community in the decision making process.

## 21-4

**New Eco-Development Initiatives Involving Local People in The Conservation Of Coral Reefs in Mahatma Gandhi Marine National Park, Wandoor (India)**

Alok SAXENA[1], **Mani SAXENA*[2]**

[1]Department of Environment & Forests, Government of India, Port Blair, India, [2]Biotechnology, Central Agriculture Research Institute, Port Blair, India

Mahatma Gandhi Marine National Park situated at Wandoor about 29 km from Port Blair is among the first three Marine National Parks in India. It was established in 1983 with the objective of conserving the unique marine diversity particularly the coral reefs found in this area. There are 15 islands within MGMNP but there is no habitation inside the park area. There are 11 villages in the adjoining area having more than 1000 families. The main occupation is fishing. Though no rights are allowed within the Marine National Park but fishing routes are demarcated for providing safe passage to local fishermen. MGMNP is an important eco-tourist site because of its unique marine biodiversity and provides livelihood means to the people living around. In order to involve the local people in the conservation efforts, the Park authorities initiated action at a small level in 2003-04.Tsunami that struck these islands in 2004 affected not only tourism but also the efforts of Park authorities in people's participation. However there has been a significant increase in tourist inflow to these islands in last two years and the park authorities have also recently revived their eco-development initiatives. In a series of meetings by the administration with local people, new initiatives are being taken for providing livelihood means to locals and involving them in the conservation efforts. The present study shows results based on surveys with local people and representatives of administration on the new initiatives, expectations of locals, their increasing awareness and changing attitude towards Park authorities.

## 21-5

**Global Study Of Management Effectiveness Of Marine Protected Areas**

Robert POMEROY[1], **Tammy CAMPSON*[2,3]**

[1]Agricultural and Resource Economics, University of Connecticut, Avery Point, CT, [2]University of Connecticut, Simsbury, CT, [3]University of Connecticut, Storrs

Marine Protected Areas have been established all over the world for the purposes of conservation, fisheries management, or both. While site-specific or regional studies on the management effectiveness of MPAs in meeting one or both of these objectives abound, there are relatively fewer studies that rigorously examine the simultaneous achievement of ecological, socioeconomic and/or governance objectives, and none that attempt to do so on a global scale. Moreover, no prior research has investigated the effects of the timing of management interventions and exogenous or discrete biophysical events on the effectiveness of Marine Protected Areas.

This paper presents research results from a Global Management Effectiveness (GME) evaluation study of Marine Protected Areas. The main objectives of this study are to: 1) determine the socioeconomic, governance and ecological effects (outcomes and outputs) of MPAs; and 2)determine the critical factors (ecological, socioeconomic and governance) affecting MPA outcomes and outputs, as well as the impact of the timing of those factors on the outcomes and outputs of the MPA. The analysis integrates primary data derived from household surveys with extant ecological and control data. This paper will report the findings from the first round of GME study sites, including results from Asia, Africa, and the Caribbean.

## 21-8

**Assessing Economic And Ecological Thresholds in Artisanal Reef Fisheries**

**Louise TEH*[1]**, Lydia TEH[1], Ussif Rashid SUMAILA[1]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

Conventional fisheries management approaches are generally considered to be inadequate for managing coral reef fisheries. As an alternative, we apply the resilience concept to examine 'thresholds' of a reef fishery system in order to identify areas where management can enhance socio-economic and ecological sustainability. We use the unmanaged artisanal reef fisheries of Pulau Banggi, Malaysia, as our case study. We find that reef fisheries resources have declined from the past, but have been maintained at a consistent level in the past 3 years. Fish catch composition and fishing effort have also remained stable, and fishing strategies are adapted to seasonal fluctuations. A significant economic perturbation – an increase in fuel price by 20 to 50% - did not cause any noticeable change in fishing behaviour after 11 months, suggesting that the reef fishery is still within economic profitability thresholds. On the other hand, this could also reflect that fishers have a low capacity to adapt due to lack of alternative livelihood options, and limited non-fishing skills and market access. The ecological system might be at a more precarious threshold due to intense fishing for the live reef fish trade, and increasing intrusion of purse seine vessels into artisanal fishing grounds. These pressures are likely to drive down ecological productivity and economic benefits from the fisheries in the future. However, fishers' willingness and capacity to change this downward trajectory is impeded by their economic reliance on the live fish trade, and a general lack of community organization and an attitude of indifference to confront the purse seine fleet. Strategies to strengthen the resilience of Banggi's reef fisheries can include: 1) diversifying economic options for fishers; and 2) developing community capacity and/or community-institutional partnerships to address wider scale pressures such as purse seine intrusions.

## 21-9

**Integrated Economic Valuation in Coral Reef Management: Demonstration, Appropriation And Utilization Of Coral Reef Economic Values For Sustainability And Conservation**

**Rodelio SUBADE*[1]**

[1]Division of Social Sciences, University of the Philippines - Visayas, Miagao, Iloilo, Philippines

A major problem in the utilization of coral reef resources in developing countries like the Philippines is that the full value of these resources is not properly reflected in the market. A big portion of these resources' economic values are not sold in the market and are therefore not accounted for in society's policy and development decision-making

This paper aims to highlight the vital need to integrate economic valuation in coral reef management and in integrated coastal zone management. It uses the total economic value framework, and argues that much of the economic values of coral reef resources have not been properly demonstrated and expressed in the market and policy making, thereby resulting to their over exploitation and damage. Mechanisms on how to demonstrate such economic values (like entrance fees, conservation fees and others) and policies towards capturing them are crucial aspects of integrated economic valuation. A few cases in the Philippines show that this is possible and can provide a good framework in helping attain sustainability and conservation of such national treasures.

## 21-10

**Examining The Persistence Of Coral Reefs Destruction**

**Rijal IDRUS*[1]**, Deirdre HART[1], Eric PAWSON[1]

[1]Geography, University of Canterbury, Christchurch, New Zealand

Despite efforts to eliminate destructive fishing and improve coral reef management such as the multi-donor funded COREMAP Project and other capacity building programs, the state of coral reefs in Indonesia remains under threat and is continuously deteriorating. As in many developing countries, Indonesian coastal communities are often resource rich but income poor. With these paradoxes as a backdrop, this study examines why coastal resources are being continuously degraded, and apparently by the people whose livelihoods depend on them.

We explore the motives and consequences of destructive methods of resource utilisation, and examine the potential for sustainable livelihoods based on coastal resources currently under threat from destructive use patterns via fieldwork in nine coastal communities within the Sulawesi Region of Indonesia.

Field evidence indicates that blast and poison fishing were the most widespread destructive practices. Findings reveal that an array of competing demands and conflicting interests, coupled with inefficient institutional arrangements, have rendered inadequate many resource management institutions and efforts, allowing destructive patterns of resource utilization to persist. Local communities are disempowered when confronted with the intricate network of destructive-fishing actors targeting coral reefs. The existence of this collusive network must be considered in any effort to address problems of effective management.

Our findings also suggest that when a coastal community manages to overcome problems with managing common-pool resources, to establish reciprocal trust and to collectively pursue self-governance, conservation measures can be implemented and a degree of resource sustainability attained. The outcomes provide insight into the dynamic couplings of human and natural aspects of coastal resource systems and, as such, can help improve the decision making process and policies affecting coastal communities in developing nations.

## 21-11

**Ethnographic Studies of Marine-Based Livelihoods in Punta Cana, Dominican Republic**

**Megan STONE*[1]**, Liana TALAUE-MCMANUS[2], Benjamin KUSHNER[3]

[1]Marine Affairs and Policy, University of Miami Rosentiel School of Marine and Atmospheric Sciences, Key Biscayne, FL, [2]Marine Affairs and Policy, University of Miami Rosentiel School of Marine and Atmospheric Sciences, Miami, FL, [3]Punta Cana Ecological Foundation, Punta Cana, Dominican Republic

PESCA (a Partnership for Ecologically Sustainable Coastal Areas) has been initiated by a joint effort between the University of Miami and the Punta Cana Ecological Foundation to evaluate the current state of the coral reef environment in the Punta Cana region and to develop tools to promote sustainable decision-making in the future. We developed an interview questionnaire to guide our ethnographic studies in examining marine-based livelihoods and the social dynamics associated with large-scale coastal development adjacent to coral reef systems.

Preliminary results of studies around fishing and tourism-based employment indicate the critical role of mass domestic migration in both sectors, and where fishing is often an interim occupation in between tourism-based jobs. Migration has widened the networks of livelihood dependence to include workers living with their nuclear family members or extended clan, to others who send remittances to families and dependents residing in different towns. Among fishers, the displacement of coastal villages to locations inland have resulted in a unique structure of owner-crew relations because of the new need for transportation from inland communities to fishing grounds. For tourism workers, separation from nuclear households is common, and "gold-rush" towns forming out of migrant families and individuals with no shared heritage have begun to crowd coastal communities.

Through analyzing life histories, we have examined changes in quality of life over time. Tourism development along the coast has brought higher commodity prices and fragmented communities within the Punta Cana region. It has also brought benefits such as a larger job market, higher wages and better access to basic services. Subsequent analysis will allow us to use the socioeconomic data in identifying management practices to help make coastal tourism evolve as a socially and ecologically viable development sector.

## 21-12

**Towards A Framework For Integrated Conservation Planning in Coastal Catchments And Nearshore Marine Waters**

**Bob PRESSEY*[1]**

[1]Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

In broad terms, the problem of integrated coastal planning can be stated simply: decision-makers with limited funds for natural resource management must balance the local (within-catchment) benefits arising from their actions with the downstream benefits for freshwater and marine systems. The reality is less simple. The difficulty of resolving choices between local and downstream benefits can be illustrated by listing the main kinds of technical information that managers need. For terrestrial, freshwater and marine environments, they need spatially explicit data on: biodiversity (both depictions of pattern and models of process); ecosystem services (related to soil, water, salinity, acidity and carbon); models of likely expansion or contraction of extractive activities in the absence of management intervention; and the cost, feasibility and relative effectiveness of alternative management actions, including models of downstream effects. They also need to refine qualitative goals into a complex set of quantitative objectives, understand the socio-economic implications of management actions, and develop strategies for involving stakeholders, managing uncertainty and adapting their approaches as new information becomes available. There is presently no framework available for integrating all of this information, although some partial frameworks have been proposed and some organisations have developed specific components. A new research program at James Cook University is coordinating a multidisciplinary project on conservation planning in coastal catchments affecting the Great Barrier Reef. The first stage, reported here, is developing the conceptual and technical framework for integrated planning, identifying missing components of the framework and missing links between components. The framework is intended to be generic and applicable widely to coastal catchments.

## 21-13

**Diet, Health, And Cultural Links With Coral Reef Ecosystems: Dietary Change Over The Last 40 Years in A Hawaiian Community**

**Rebecca PRESCOTT*[1]**, Bruce WILCOX[2]

[1]Zoology, University of Hawaii, Honolulu, HI, [2]Tropical Medicine, Medical Microbiology, and Pharmacology, University of Hawaii, Honolulu, HI

Native Hawaiian culture has depended heavily on the ocean as a primary food source and as a cultural component for generations. However, over the past 40 years, rapid socio-ecological changes in Hawaii, including the introduction of a market economy, dramatic increases in tourism, and alterations to social structures and the environment have changed Hawaiian lifestyles to a more westernized culture. There also has been an increase in obesity, (67%), heart disease, and diabetes. In this study, researchers document dietary shifts in the predominately Hawaiian community of Waimanalo on the island of Oahu (n = 21 individuals interviewed, mean age = 67, 24% female). This pilot study found large shifts in the type of foods consumed and where the foods were collected. Pre- WWII and post WWII, marine fish made up 52.6% and 46.4% of diets respectively, and 100% of fish were caught from sea. During the current post-plantation era (starting late 1960's), ocean-caught fish has declined as a major protein source to 19.4% of diet, accompined by a dramatic increase in foods obtained from markets. In interviews, native Hawaiians identified over-fishing and depletion of ocean resources as a leading cause for shifts in diet. They also discussed restrictions to fishing gear and access to resources, as well as convienience and price of foods at markets as leading to health declines and lower fish consumption. Declines in Hawaiian marine fisheries is the perceived cause of shifts in diet within this community, and other studies have reported declines in coral reef fisheries that were commonly caught in Native Hawaiian communities. We propose that although coral reefs in the Hawaiian Islands are considered to be in fair condition, declines in coral reef ecosystem health may be related to shifts in diet among Hawaiian people and declines in human health.

## 21-14

**Impacts Of Co-Management Of Marine Protected Areas (Mpas) In The Philippines**

**Ronald MALIAO*[1,2]**, Ralph TURINGAN[1]

[1]College of Science, Department of Biological Sciences, Fish Ecophysiology Laboratory, Florida Institute of Technology, Melbourne, FL, [2]Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC) (Previous address), Iloilo, Philippines

While there is a consensus that marine protected areas (MPAs) help rebuild depleted stocks, several studies reported mixed to negative results regarding the efficacy of MPAs as a management strategy. Most MPA impact-assessment studies focused on the status of fisheries, putting the perceptions of local fishing communities on the sideline. We meta-analyzed the impacts of MPAs in the Philippines using social and biological indicators, with an aim to accumulate knowledge of the efficacy of MPAs as a management strategy. Under the social component, we used the co-management impact indicators as prescribed by the Worldwide Collaborative Research Project on Fisheries Co-management (WCRPFC). Under the biological component, we used fish trophic guilds and families as the analytical unit and compared abundance before and after MPA implementation. Our analysis revealed that under the social component, fish abundance, fisher's income, and access to resource were perceived to continually decrease, and the magnitude of decrease was correlated with the duration of MPA management. In contrast, other co-management indicators related to operational level dynamics have significantly improved, indicating that MPAs empower local fishers. The results of the biological component indicated that while total fish abundance has significantly increased, the bulk of the increase was accounted by the non-food species (Pomacentridae, omnivores) while all other groups have either decreased or remained stable relative to the baseline abundance. This result indicated that the relationship between fishing mortality reduction and fish recovery was not straightforward. We interpreted our results in the context of other correlates such as life history traits, effects of habitat alteration, trophic reorganization, genetic responses to exploitation, and Allee effect (depensation). The results of our analysis, integrating social and biological indicators, reveal an alternative view of the effectiveness of MPAs as a management strategy.

## 21-17

**Aspects Of Scaling-Up To Ecosystem Management Of Coral Reefs in The Philippines**

Patrick CHRISTIE[1], **Richard POLLNAC*[2]**

[1]School of Marine Affairs, University of Washington, Seattle, WA, [2]Marine Affairs, University of Rhode Island, Kingston, RI

The objective of the paper is to identify socioeconomic and project process variables impacting aspects of success of coral reef associated management projects in the Philippines. The paper, prepared as part of an ecosystem based management project supported in part by the National Center for Ecological Analysis and Synthesis, re-analyzes three distinct data sets from the Philippines which focus on aspects of coral reef management. The re-analyses focus specifically on variables associated with scaling up management to ecosystem relevant scales and marine protected area (MPA) networks. Size of stakeholder groups, size of management area, population size, density and homogeneity within the context of some 50 environmental, demographic, socioeconomic, cultural, project activity and project output variables are considered. Path analyses are used to test heuristic models constructed on the basis of intercorrelations between the numerous variables. The following variables are significantly correlated with measures of success such as the perception of increased fish near marine protected areas that are part of a network.

Improved coral condition (.727**)

Fishing grounds threatened by illegal commercial fishing (.372*)

Clear leader for MPA (.440**)

Population size (-.427**)

Number of elected community leaders (-.346 *)

Increased compliance (.491**)

Improved enforcement (.349*)

Strict punishment for rule infraction (.407*)

Local community enforcement group involved in MPA enforcement (-.371 *)

Increased intra-community conflict (.390*)

Increased seriousness of conflict (.406*)

n=36; $p<.05$ = *; $p<.01$=**

Multiple stepwise regression establish that the perception of unfair rule enforcement, absence of community groups, and increased tourism increase the likelihood of conflict surrounding MPA management (Adj R2=0.434, $p<0.01$, n=35). Other results will be presented.

## 21-18

**Application Of Participatory Rapid Economic Valuation To Sustainable Community Based Marine And Natural Resource Management in Fiji**

Isoa KOROVULAVULA[1], **Isoa KOROVULAVULA*[1]**

[1]Institute of Applied Sciences, The University of the South Pacific, Suva, Fiji

Economic valuation is used as the main analytical tool to compare the advantages and disadvantages of scenarios on future development. This paper presents a framework that can be applied for valuing the socioeconomic and cultural attributes of biodiversity in marine managed areas in Fiji in monetary terms. This framework has two components. First is a comprehensive and complex quantitative method of valuation. For this, environmental economics is applied, in particular the use of non-market valuation methods. This quantitative types of economic valuation often require extensive understanding of environmental impacts and high-quality data (e.g. on productivity of reef ecosystems and the import of different environmental services inputs) and at times not easy to do. The second component of this economic valuation framework is a partial quantitative economic valuation method. It is referred to as participatory rapid economic valuation (PREV). This method of eliciting economic values incorporates institutional, social, and cultural activities and equity issues at the village or community levels. It is inclusive and participatory in. nature. Hence, PREV method has the ability to provide decision-makers in developing countries like Fiji sufficient information of adequate quality to inform natural and marine resources policy choices.

## 21-19

**Towards Local Fishers Participation in Coral Reef Monitoring: A Case in Tingloy, Batangas, Philippines**

Ana Liza SUBADE[1], **Rodelio SUBADE*[2]**, Zenaida CATALAN[1]

[1]School of Environmental Science and Management, University of the Philippines Los Banos, Los Banos, Philippines, [2]Division of Social Sciences, University of the Philippines - Visayas, Miagao Iloilo, Philippines

Tingloy, composed of five islands is a popular diving site known for its rich coral reefs. However, these reefs are being threatened by man-made stresses and natural disturbances. Thus, a monitoring framework was developed through the integration of scientific and indigenous knowledge in determining and assessing the present status of coral reef environment. One of the benefits of the developed monitoring framework is the empowerment of the fishermen. Fishermen and institutions in the area in cooperation with the academe, provided the major backbone of the framework. The fishermen were interviewed, trained and participated in the whole year monitoring of the coral reef environment. The monitoring framework developed served as an overall guide for monitoring activities and the data gathered served as the baseline information of the coral reef environment in the area.

## 21-20

**"Coastal And Marine Indicators At Your Doorstep" – A Participative Environmental Outreach Program For Schools in Thailand**

**Petchrung SUKPONG*[1]**, Mark WUNSCH[2]

[1]Thailand Programme, IUCN - The World Conservation Union, Bangkok, Thailand, [2]Phuket Aquarium, Phuket Marine Biological Center, Phuket, Thailand

At the Cape Panwa peninsula on Phuket Island, Thailand, intensive resort and housing developments endanger adjacent coral reef flats that have traditionally been used as fishing grounds for octopus, crabs and fish.

This project tries to establish new ways for environmental and science education. It uses creative techniques and the production of audio-visual media in a discourse with children (age 9-12 years) and teachers to create a more intuitive and deeper understanding of local coastal environments and human impact.

To achieve this goal an alliance was formed between environmental educators, the Phuket Aquarium, the local school and a local hotel that provided seed funding as part of their corporate social responsibility (CSR) engagement.

After initial brainstorming and mind mapping the children received lively introductions to marine and coastal habitats, practiced simple investigation and monitoring techniques and produced written and illustrated field diaries. They continue monitoring their reef flat and do their own research on different aspects of marine and coastal ecology.

The children's field diaries and the teacher's feedback have been used to create a media about the marine life. These learning tools visualize the behavior of organisms, monitoring techniques as well as processes and changes in the environment.

The evaluation has shown the effectiveness and weaknesses of these tools that have lead to their refinement.

Through its sincere involvement, the school has become the initiator for an environmental awareness plan that is currently developed with participation of the whole community/with different stakeholders of the community.

Upon completion the learning toolkits will be multiplied and distributed to other schools in the wider region and translated into other languages. The approach has shown that the children have become more aware of their environment and that they are willing and capable to take leadership in environmental issues.

## 21-20

**Strenthening Civil Society To Conserve The Largest Area Of Coral Reef in The South-Eastern Caribbean (The Grenada Bank).**

**Martin BARRITEAU*[1]**, Martin BARRITEAU[1]

[1]Sustainable Grenadines Project, Union Island, Saint Vincent and The Grenadines

Strenthening civil society to conserve the largest area of coral reef in the South-Eastern Caribbean (the Grenada Bank).

The Grenadine islands lie on the Grenada Bank extending some 120 km between the main islands of Grenada and St. Vincent. The majority of the Grenada Bank is less that 50 m deep and supports the most extensive coral reefs and related habitats in the south-eastern Caribbean. The marine and coastal resources of the Grenadines are crucial for sustainable livelihoods and if not properly managed and protected, there will be a gloomy future for many Grenadines people and the marine ecosystems they rely upon.

The Sustainable Grenadines Project (SGP), supported by The Lighthouse Foundation, was developed through a participatory process (Phase 1) involving stakeholder identification and mobilisation, visioning and strategic planning. Phase 2 is a five-year, transboundary initiative based on the strategic plan that seeks to enhance the capacity of civil society to play their role in sustainable development and biodiversity conservation in the Grenadines.

The SGP core activities - planning and training workshops, attachments and exchanges, mini-projects, information dissemination and networking - aim to engage and reorient stakeholders towards sustainable use of the marine resources and the protection of the extensive coral reef-seagrass-mangrove ecosystems of the Grenadines.

The SGP has also been partnering with regional and international organisations including The Nature Conservancy to develop and implement associated projects in support of the above aim. Some of these activities are: water taxi association strengthening, coral conservation training program for schools of the Grenadines, establishment of MPAs, AGGRA and Reef Check monitoring, restoration of wetlands and lagoons, and an alternative livelihood project, on seamoss (*Gracilaria* species) farming.

## 21-21

**Community Buy in Can Make All The Difference in Protecting Valuable Urban Marine Resources: The Hanauma Bay Story**

**Shawn CARRIER*[1,2]**

[1]Sea Grant College Program, University of Hawaii, Honolulu, HI, [2]Hanauma Bay Education Program, Honolulu

The Hanauma Bay Nature Preserve is located on the south-east tip of O`ahu and resides just 10 miles away from world famous Waikiki. Hawai`i's among the most remote archipelagos on earth, and yet receives millions of visitors a year. Hawai`i's official tourism site reads "There's no place on earth like Hawai`i", approximately 20% of marine organisms are endemic to the islands. Visitors contribute greatly to the state economy however environmental impacts are left behind. Hanauma Bay, a flooded volcanic crater is home to a fringing reef, beach, and many species of marine life. Originally part of the Bernice Pauahi Bishop Estate, it was deeded as a public facility to the City and County of Honolulu and then designated as Hawaii's first marine life conservation district in 1967. Its over-popularity in the 1980s led to the establishment of a community organization concerned about the fate of this beautiful resource which helped draft and implement a management plan. An education program was started by the University of Hawai`i Sea Grant College Program at the request of the City and County of Honolulu. Over the years management tools have been refined by the City and State and the Hanauma Bay Education Program (HBEP) has matured. In 2002, a state of the art visitor center opened and a mandatory reef conservation film was introduced. HBEP's mission is to improve understanding and stewardship of coastal and marine resources, through public outreach. Hanauma Bay's recovery is a result of many organizations, a great deal of hard work by many individuals, and sound management practices, demonstrating the positive effect of public education and management. This presentation will address the rich and successful story of Hanauma Bay's development from an overused recreational area to a world-class education center and nature preserve.

## 21-22

**Local Ecological Knowledge And The Management Of Marine Protected Areas in Brazil**

Leopoldo GERHARDINGER[1], **Eduardo GODOY*[2]**

[1]ECOMAR NGO, Americana, Brazil, [2]ICMBio, Brasilia, Brazil

Site visits were done at 9 different Marine Protected Areas (MPAs) along the Brazilian coastline and semi-structured interviews were done with site managers in order to record their perception on the role of local ecological knowledge of fishermen in the management of their sites. The main types of local ecological knowledge useful for MPA management were, in broad terms, the knowledge of resource users regarding spatial distribution and seasonal variation of resources and human use of the seascape within the MPA. This can be summarised as 'where' resources and their users are located in space and time. Other types of knowledge categories were mentioned as valuable, such as knowledge on tidal cycles, species migration, sustainable resource exploitation rates, birds, navigation, wind behaviour, general and specific cycles of nature, amongst others. The utility of LEK systems for MPAs was also acknowledged on their: 1) value to define new MPA sites; 2) utility for patrolling activities (i.e. knowing where and when to focus effort) and; 3) usefulness as baseline data on less researched/assessable areas of the site. Favourable contexts for greater local ecological knowledge influence in marine protected areas management in Brazil were identified: 1) Presence of managers known to the community; 2) Dependence on individual approach adopted by a given officer; 3) MPA category; 4) Presence of a working and representative management council; 5) Identifying the issue of local ecological knowledge as a priority topic for discussion; 6) Presence of local social science research groups and; 7) LEK being readily available or systematised for use in decision making. The study shows a very large perspective for cooperation of fishermen in the management of MPAs in the country, considering the vast coastline (more than 8,000km) and the presence of hundreds of fishing communities in the Brazilian coast.

## 21-23

**Navigating The Transition To Ecosystem-Based Management Of The Great Barrier Reef, Australia**

**Per OLSSON*[1]**, Carl FOLKE[1], Terry HUGHES[2]

[1]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden, [2]Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

This article analyses social-ecological conditions that enable transitions towards ecosystem-based management, using the recent governance changes of the Great Barrier Reef Marine Park as a case study. It addresses the interplay between individual actors, organizations, and institutions at multiple levels. We highlight the crucial role of a flexible organization, the Great Barrier Reef Marine Park Authority, which initiated the transition to ecosystem-based management, and the subsequent transformation of the governance regime and provided leadership throughout the process. Strategies involved internal reorganization and management innovation, leading to an ability to coordinate the scientific community, to increase public awareness of environmental issues and problems, to involve a broader set of stakeholders, and to maneuver the political system for support at critical times. The transformation process was triggered by an emergent coral reef crisis, and it shifted the focus of governance from protection of selected individual reefs to stewardship of the larger-scale seascape incorporating 70 bioregions (including many non-reef habitats). The study emphasizes the significance of flexible governance regimes that allow for new forms of management to emerge in response to crisis. It clarifies that top-down decision making, enabling legislation or other forms of social bounds are essential, but not sufficient for shifting governance towards adaptive co-management of complex marine ecosystems.

## 21-24

**Coral Reef Resilience Decision-Making Requires An Integrated Understanding Of Coral Reef Ecosystems**

**Christopher HAWKINS*[1]**, David LOOMIS[2]

[1]Natural Resouces Conservation, University of Massachusetts Amherst, Amherst, MA, [2]Natural Resources Conservation, University of Massachusetts Amherst, Amherst, MA

A social-ecological system-based approach to coral reef management is especially important given that people's social values and activities are at the same time both the major drivers of protection to and degradation of coral reefs. Furthermore, this relationship is dynamic, in that when social values with respect to the natural environment change, as they periodically do, protection activities and negative impacts change in response. Therefore, the implications of using the reef resilience concept to

monitoring programs and management frameworks include institutionalizing holistic management thinking by recognizing the interrelationships between social, political, economic, and natural systems and broadening coral reef ecosystem monitoring parameters. This paper will outline a conceptual management model that discusses the integration of the four systems identified above, provide background about one approach to thinking complexly about coral reef management issues, and present a recent case

study of social-ecological research for the Florida Reef Resilience Program. This study, conducted between May, 2006 and July, 2007 represents a broad examination of attitudes, norms, specialization levels, attributions, and potential conflict among anglers, divers, and snorkelers throughout the Florida Keys. Data were collected in accordance with ecological zones established by the Florida Reef Resilience Program for later integration with other research efforts.

## 21-26

**Social And Ecological Assessments To Plan Improvements In Coral Reef Management Effectiveness In Las Perlas Islands, Panama**

Nohora GALVIS[1], **Nohora GALVIS*[1]**

[1]Coral reefs, Corporacion Propuesta Ambiental, Bogota, Colombia

In order to plan improvements for better coral reef management in Las Perlas Archipelago, two types of assessments of management effectiveness were applied by in situ measurements of the indicators performance and by interviewing different stakeholders to measure how they perceive the performance of the same indicators.

Measurements of perspectives from different stakeholder groups were compared about the importance they assign to key indicators of ecological, social and economic functions which were related to coral reefs ecological integrity, threatens and respective objectives of protection and sustainable use of the related benefits and services.

In Las Perlas, the overall performance was acceptable for most of the survey sites only the perspectives of tourist operators and divers show low effectiveness or acceptance to the management scheme before the new declaration of Special Management Area.

## 21-27

**The Political Aspects Of Resilience**

**Michael FABINYI*[1]**

[1]Resource Management in Asia-Pacific Program, Australian National University, Canberra, Australia

This study aims to investigate the political aspects of resilience in social-ecological systems. Based on long-term anthropological fieldwork in the Calamianes Islands, Philippines, the study focuses on the diverse and contested human interests that make up social-ecological systems. In the Calamianes, what promotes social resilience for one group of people may impact negatively for another group of people, or the ecosystem in which they live. Fishers, for example, have struggled greatly to preserve their patterns of marine resource use, and to oppose any form of regulation. In 2006, regulations to reform the live reef fish trade in the Calamianes were overturned, and the effectiveness of a series of marine protected areas (MPAs) was severely constrained by the actions of fishers in promoting their interests. These interests were based on a strong desire among fishers to maintain their livelihood and economic security, and to avoid shouldering the burdens of conservation that they believed were being unfairly placed on them. Following Armitage and Johnson (2006), this study has found that deciding "for what and for whom are we trying to promote resilience?" becomes a critical question. Answering such a question will require decisions that will favour certain elements or resource users within any social-ecological system, and disadvantage others. The study concludes therefore that such political aspects of resilience thinking require greater attention, and that governance systems that are inclusive, interactive and adaptive (Bavinck et al. 2005) are necessary, if the resilience concept is to be more widely accepted in policy and management arenas.

## 21-28

**Should We Protect The Strong Or Weak? An Analysis Of Risk And Resilience in Marine Protected Areas**

**Eddie GAME*[1]**, Hugh POSSINGHAM[1]

[1]The Ecology Centre, University of Queensland, St.Lucia, Australia

The occurrence of catastrophic disturbances such as cyclones or mass coral bleaching poses a major threat to coral reefs worldwide. Marine reserves have often been touted as way of ensuring recovery from disturbance at a faster rate than unprotected habitats; but should we protect those reefs at greatest risk of unfavourable disturbance we can not control, or instead invest our resources in consolidating the health of those reefs at least risk of such disturbance? We formally define this problem and explore the conditions under which each of these strategies is optimal. If our conservation objective is to maximize the chance at least one reef is in a healthy state then the best strategy is always to protect the reefs at lower risk of catastrophic disturbance. On the other hand, if we wish to maximise the expected number of healthy reefs in our system, then the optimal strategy is more complex; if protected reefs are likely to spend a significant amount of time in a degraded state, either through high disturbance or slow recovery rates, then it is best to protect low risk sites. Alternatively, if our reefs are generally in a healthy state due to fast recovery and low disturbance then we should, counter intuitively, protect the sites at higher risk of uncontrollable disturbance. We illustrate these strategies with an example of cyclone disturbance to coral reefs on Australia's Great Barrier Reef. The optimal conservation strategy with regard to the risk of uncontrollable disturbances can differ dramatically depending on your objective and the level of success expected within reserves. A proper treatment or risk is fundamental to all conservation actions and can indicate surprising routes to conservation success.

## 21-29

**The Implications Of Linked Social-Ecological Systems For American Samoa's Coral Reef Fisheries**

**Arielle LEVINE*[1]**, Stewart ALLEN[1]

[1]Pacific Islands Fisheries Science Center, Honolulu, HI

Even without the presence of a network of no-take marine protected areas (no-take MPAs), current levels of fishing pressure on near-shore coral reefs in American Samoa are low for small, Pacific island territories (Zeller et. al. 2006). This trend has occurred in spite of increasing population levels and improvements in fishing technology. Recent studies comparing current fish catches with archeological records illustrate that catch composition on one American Samoan island is essentially identical to pre-European contact levels (Craig et. al. 2007), indicating surprising stability over time. The reasons for relatively low fishing pressure on American Samoan reefs are complex, but relate largely to improved access to cash and a preference for store bought food, as well as the availability of cheap pelagic fish sold as by-catch or at a discount from the islands' large cannery facility. This has reduced local demand and markets for near-shore fish species; fishing today is predominantly small-scale for recreational and cultural purposes. This unusual combination of social and ecological factors in American Samoa provides a positive example of how certain social factors can result in a reduction in near-shore fishing pressure. However other socially-derived factors, including coastal development, erosion, pollution run-off, and global warming, remain highly relevant to the future and health and resiliency of American Samoa's near-shore coral reefs. These factors prove more difficult to address and require management measures beyond the establishment of no-take MPAs, looking at social and ecological issues on an extended watershed scale.

## 21-30

**Socio-economic and Ecological Monitoring of Coral Reefs at Kood Island, the Gulf of Thailand**

**Makamas SUTTHACHEEP*[1]**, Sittiporn PENGSAKUN[1], Wichin SUEBPALA[1], Dusanee CHOEITONG[1], Thamasak YEEMIN[1]

[1]Department of Biology, Faculty Of Science, Ramkhamhaeng University, Bangkok, Thailand

Fishing remains the most important economic activity associated with coral reefs and provides the main source of protein by local communities. Recently, there has been an expansion in reef based tourism in Thailand. Monitoring of coral communities in terms of ecological changes and coral reef utilization for fisheries and tourism at Kood Island and its vicinity was carried out to assess the socio-economic potential of coral reefs. There was a large area of coral reefs and pinnacles around Kood Island. Several of them have not be surveyed and scientifically reported. Approximately 30 households of Kood Island have small fishing boats. Major fishing gears were crab gill nets and traps for crabs and squids. All fishing products were sold and consumed on the island. However, there were a large number of trawling boats, pushing net boats and light fishing boats for squids from outsiders. Illegal fishing was frequently observed because of weak law enforcement in the area. Currently, tourism development is growing rapidly, especially for building large resorts. Most tourists went to diving at Mu Koh Rang, a nearby island group. Coral reefs of Kood Island largely suffered from the severe coral reef bleaching in 1998 but there was a natural recovery trend. Several coral reef areas have high potential for diving spots, such as Rad Island, Ao Toom and Hin Kong Loi Nam. The local communities has gradually realized the importance of coral reef and seagrass ecosystems for their livelihood through training courses, seminars and public awareness materials for coastal resources conservation. Integration of scientific researches and socio-economic studies is necessary for coral reef management in the Gulf of Thailand.

## 21-33

**Implications Of Coastal Development On Resilience in Linked Socio-Ecological Mexican Caribbean System**

**Jesús ARIAS-GONZÁLEZ*[1]**, Renata RIVERA[2], Yves-Marie BOZEC[1], Fabián RODRIGUEZ-ZARAGOZA[3], Castro-Pérez JOSÉ[4], Carmen VILLEGAS-SÁNCHEZ[1], Gilberto ACOSTA-GONZÁLEZ[1], Hector LARA-ARENAS[1]

[1]Recursos del Mar, Centro de Investigación y Etudios Avanzados del I.P.N., Merida, Yucatan, Mexico, [2]Departamento de Bioquímica y Biología Molecular de Plantas, Centro de Investigación Científica de Yucatán, Merida, Yucatan, Mexico, [3]Departamento de Ecología, Universidad de Guadalajara, Zapopan, Jalisco, Mexico, [4]Biología y Química, Instituto Tecnológico de Chetumal, Chetumal, Quintana Roo, Mexico

Socio-ecological systems (SES) of the Caribbean have evolved in myriad ways, but the majority have under-developed and degradation of coastal resources in common. The worldwide decrease in live coral cover and biological diversity, as well as a phase shifts in coral dominant species due to overfishing, pollution and tourism-associated coastal development, highlight the importance of understanding the source of resilience in linked SES. We have studied Mexican Caribbean reefs from a landscape perspective with three key dimensions: a) structure, i.e. fish and coral biodiversity, geomorphology, reef extension, connectivity; b) ecosystem function, i.e. fish trophic structure, trophic functioning; and c) time, i.e. temporal change of coral reef community structure and function. Our studies have been focused on two socio-ecological system scenarios (artisan fishery and tourism-coral reefs) and different conservation strategies (marine protected and unprotected areas). Until the 1970s, artisanal fisheries were the only human activities in Mexican Caribbean reefs. These included several resources, with heavy selection of conch and lobster, although scale fisheries remained relatively stable. From the 1970s on, the advent of massive tourism development has completely changed coastal resources appropriation regimes and altered ecosystem services, beginning the era of "Gringolandia, a term that reflects the circus-like spectacle of over-sized resorts" like Cancun with a chaotic tourism growth and uneven development. Changes are occurring in biodiversity, which is dependant on reefscape structure and extension, and in ecosystems function, in terms of mass balance and flux. These changes are eroding resilience. Massive tourism development in the Mexican Caribbean puts population connectivity at risk through habitat fragmentation and phase shift from coral to algae dominated ecosystems. Despite investment of millions of dollars in management, the collapse of coral reef system appears imminent. The associated social system will then need to adapt to the emerging algae-dominated ecosystem

## 21-34

**Fishing, Agriculture, Trade And Migration On Small, Overpopulated Islands in Melanesia: Moving Beyond Functionalist Analyses Of Indigenous Coral Reef Resource Use And Management**

**Simon FOALE*[1]**

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

Many studies of traditional management of coral reef fisheries by indigenous communities in Melanesia downplay or ignore the extent to which those communities have been engaged with the global economy since the early colonial era, and exaggerate the extent to which subsistence fisheries actually require management, in support of arguments about the 'adaptive' nature of traditional management institutions. Such functionalist approaches have been critiqued for many years in the anthropological literature but appear to continue to enjoy some currency in the recent efflorescence of cross-disciplinary studies that deal with 'traditional' coral reef resource use. In this paper I present a range of demographic, historical, ecological, anthropological and economic data relating to artisanal and subsistence fisheries on a number of small, over-populated (more than 100 people per square kilometer) islands in Melanesia. A key finding of the study is that on some islands, population densities well in excess of the production capacity of the local swidden agriculture system are supported primarily by cash from beche-de-mer and shark-fin fisheries, neither of which is subject to any form of community-level management. The study also shows the extent to which ties to groups on other, less densely populated islands are actively maintained through marriage, traditional trade, and feasting, and the extent to which this provides an option for emigration in the case of severe drought or cash shortage. The data underline the complexity of marine resource use and its contingency on a wide range of variables in such systems, and highlight the risks inherent in functionalist frames of analysis.

## 21-35

**Management For Resilience On The Great Barrier Reef in The Face Of Climate Change:**

**Laurence MCCOOK*[1,2]**

[1]Research & Monitoring Coordination, GBRMPA, Townsville, Australia, [2]Pew Fellow in Marine Conservation, Townsville, Australia

Globally, coral reefs are under increasing pressure from human stressors, including climate change in particular. Even under optimistic scenarios, significant climate change is now inevitable and large-scale disturbances to reefs will become more frequent and more severe, so that reef managers have a responsibility to maximise the resilience of reefs to those changes.

A number of factors have been identified as contributing to the ecological resilience of coral reefs, including:

- Reducing the extent and rate of climate change;
- Reduction in stressors, such as human derived sediments, nutrients and pollutants;
- Minimising human related disturbances;
- Intact trophic structure, especially larger herbivorous fishes;
- The biodiversity of the system;
- The connectivity and complexity of the ecosystem and the presence of refugia;
- Strong links between communities and different levels of Government, and
- Adaptive and multi-scale management.

The roles of these different factors are illustrated with examples from the management of the Great Barrier Reef. However, in isolation, most of these examples really just amount to good management: what does resilience add to good reef management?

The concept of resilience provides a valuable integrative perspective in both science and management, because:-

i. it provides a basis for recognising, and communicating to the public, that different threats are not independent, but may act synergistically, requiring integrative management; similarly, addressing combinations of threats may provide synergistic benefits;

ii. management for resilience provides the best insurance against future, unforeseen threats (or under-estimated threats);

iii. it allows the integration of ecological, social and economic issues: the "SES" or social-ecological system;

iv. it provides a basis for management which is proactive, as well as responsive to accepted threats.

## 21-36

**Towards A Greater Integration Of Social And Natural Sciences**

**Alexandra COGHLAN*[1]**

[1]Tourism Program, James Cook University, Cairns, Australia

Interdisciplinary teams are now commonplace in large natural resource management research centers. The evolution from pure biologists, to a system approach with ecologists and later the addition of social scientists and geographers reflect our understanding that no natural environment is exempt from human impacts, and that we must examine the system as a whole if we wish to protect it.

There is a recognition that, in order to successfully protect a natural resource such as coral reefs, there must be local support for the projects, and some incentive to preserve and manage the resource. As such many teams with a natural conservation goal, operate within a context of outcome and impact-driven funding. In some cases, the natural scientist who has been working near or alongside the local community for many years whilst studying the resource becomes the most obvious choice, particularly if this person has above-average social skills.

The result of this evolution from biologist/ecologist to social scientist is a new form of outcome driven social science, and a discipline aimed at achieving partnerships to protect natural resources. This paper therefore traces the diverging pathways of social and natural sciences, examining the differing research paradigms and comparing the issues of "isms" (determinism, functionalism and positivism) in the natural sciences and fluffy, fuzzy-wuzziness of the social sciences. We argue that the new social science finds itself somewhere in between.

We examine the outputs of new social scientists and argue for greater integration so that the traditional strands of social science may adopt a more outcome driven approach that allow communities to adapt to rapidly changing natural environments. Finally, we encourage more dialogue, through peer-review publications and conference presentations, between traditional social sciences and the new, emerging discipline, to add new perspectives to each and allow them to learn from each other.

## 21-37

**Exploitation And Trade Of Coral Resources in Bangladesh.**

**Mohammad Zahirul ISLAM*[1]**, Mohammad Sazedul ISLAM[2]

[1]Marine Conservation, Marinelife Alliance, comilla, Bangladesh, [2]Marine Conservation, WCRC, comilla, Bangladesh

In Bangladesh corals are being rapidly and seriously extracted and traded to major tourist town Cox's Bazar. Cox's Bazar coral market possibly the biggest open market of coral and shells in the world. One is called Jhinuk Market containing 22 shops entirely for corals and shells and Laboni beach providing more than 200 shops permanent and 150–200 mobile sellers. The approximate sales are 4-5 hundreds of thousands pcs annually including branching and tabular Acropora sp., and among massive Favites, Goniastrea, Platygyra etc. In Bangladesh the only sources of coral is St. Martin Island and southwestern marine area up to Myanmar and down farther may have connection with Margui Archipelago. But coral trade included the smuggling items from nearby Burma town, Mongdu. During the National Conservation Strategy Implementation Project/MOEF coral protection started by St. Martin Pilot Project and local volunteers of MarineLife Alliance in 2000. Currently much awareness and enforcement conducted by various GO and NGOs, instead hiding coral business ongoing at deferent spots like Cheradia, west beach, and main market. The supply from St. Martin still continuing that is traced in Cox's Bazar market. Collection and selling were done collectively by 24 personnel's at St. Martin Island, recorded during 2001-06 and out of them some were from outside and Myanmar. Several female heads were also engaged in the major smuggling. Many traders initiated the business with financial help from leading NGO, BRAC for curio business. Along with corals, more than 5 metric tons of shells also traded. Thais sp., Monodonta sp., 6000 pieces of cowries Cyprea sp., have been recorded to trade along with and unknown number of sea urchin also to make ash tray. At least total 22 species of shells majority of Gastropods are traded at Cox's Bazar curio center from St. Martin Island.

## 21-38

**Supporting Environmental Stewardship, Conservation, Livelihoods And Environmnetal Education in The Coral Archipelago Of Lakshadweep, India**

**Vineeta HOON*[1]**

[1]Centre for Action Research on Environment Science and Society, Chennai, India

The paper discusses a combination of community-based strategies being carried out in Lakshadweep Islands with micro budgets to address the issues concerned with coral reef conservation and livelihoods. The program is based on our belief that the local community will pay more attention to environmental issues if they have been involved in data gathering, analysis and establishing key learning's. They will then be able to speak with conviction and generate support for local management solutions.

Establishing a community based socioeconomic monitoring team at Agatti. Workshops for environmental wardens and local NGO's and educated youth for conducting socioeconomic assessments, reef related activity monitoring and ecosystem health monitoring. These workshops led to the formation of a local team called the ACRMN.

The coral reef awareness and education project included environmental orientation workshops for schoolteachers and children (classes 6-9) so as to bring in local environment and cultural features in their teachings. The final output was to get a children's perception of their environment and to correlate this with topics in their syllabus.

Discussions with fishers and women using the participatory appreciative enquiry approach and the Sustainable livelihoods framework to establish a livelihood strategy to increase incomes from fisheries. This led to the establishment of the Maliku Hikkimass Producers society at Minicoy.

This paper will discuss the processes adopted; key learning's from each of the projects and provides recommendations for the future.

## 21-39

**Coral Reef Conservation In A Changing Climate**

**Joshua CINNER*[1]**, Tim MCCLANAHAN[2], Joseph MAINA[2], Nick GRAHAM[3], Tim DAW[4], Selina STEAD[3], Katrina BROWN[4], Andrew WAMUKOTA[2], Mebratu ATEWEBERHAN[2], Valentijn VENUS[5], Nick POLUNIN[3]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]Wildlife Conservation Society, Mombasa, Kenya, [3]University of Newcastle, Newcastle, United Kingdom, [4]University of East Anglia, East ANglia, United Kingdom, [5]International Institute for Geo-Information Science and Earth Observation, Enschede, Netherlands

Climate change is likely to pose new challenges to the conservation of the Earth's natural resources by increasing the frequency and intensity of large-scale temperature events, which can profoundly impact sensitive ecosystems such as coral reefs. Addressing these challenges will require a response framework for pragmatic conservation actions informed by site-specific susceptibility to climate change and the capacity of societies to cope with or adapt to change. Depending on a particular location's environmental susceptibility and social adaptive capacity, appropriate conservation actions will require some combination of: (1) large-scale protection of ecosystems; (2) actively transforming and adapting social-ecological systems; (3) building the capacity of communities to cope with change; and (4) donor aid focused on de-coupling communities from dependence on natural resources. We apply our framework to five western Indian Ocean countries, where climate mediated disturbance has greatly impacted coral reefs. We integrate results from an oceanographic environmental model that uses environmental conditions during previous extreme warming events to predict the susceptibility of coral reefs to future bleaching with results from a socioeconomic survey of 29 communities that used eight quantitative indicators to provide a household-level index of social adaptive capacity. We plot communities' mean adaptive capacity against the predicted susceptibility of adjacent reefs to bleaching and examine how differing conservation actions may be appropriate across nations and sites. We find that current conservation strategies are ill-prepared for climate change. In particular, the countries with the highest susceptibility to bleaching and low adaptive capacity are those where marine conservation strategies are highly dependent on reef-related tourism, making the sustainability of this protection strategy under climate change scenarios questionable. Alternatively countries with low susceptibility to bleaching and high social adaptive capacity should be a high regional priority for reef conservation, but in practice these countries are protecting <1% of their reefs.

## 21-40

**Diving Down The Reefs? Intensive Diving Tourism Threatens The Reefs Of The Northern Red Sea**

**Harald HASLER*[1]**

[1]Department of Marine Biology, University of Vienna, Vienna, Austria

Intensive recreational SCUBA diving threatens coral reef ecosystems. The reefs at Dahab, South Sinai, Egypt, are among the world's most dived (>30 000 dives y-1). We compared frequently dived sites to sites with no or little diving. Benthic communities, hard coral cover and condition of hard corals were examined by the point intercept sampling method in the reef crest zone (3 m) and reef slope zone (12 m). Additionally, the abundance of corallivorous and herbivorous fish was estimated based on the visual census method. Sediments traps recorded the sedimentation rates caused by SCUBA divers. Zones subject to intensive SCUBA diving showed a significantly higher number of broken and damaged hard corals and significantly lower hard coral cover. Reef crest coral communities were significantly more affected than those of the reef slope: 95% of the broken colonies were branching ones. No effect of diving on the abundance of corallivorous and herbivorous fish was evident. At heavily used dive sites, diver-related sedimentation rates significantly decreased with increasing distance from the entrance, indicating poor buoyancy regulation at the initial phase of the dive. The results show a high negative impact of current SCUBA diving intensities on hard coral communities and hard coral condition. Corallivorous and herbivorous fishes are apparently not yet affected, but are endangered if hard coral cover decline continues. Reducing the number of dives per year, ecologically sustainable dive plans for individual sites, and reinforcing the environmental education of both dive guides and recreational divers are essential to conserve the ecological and the aesthetic qualities of these dive sites.

## 21-41

**Reef Conservation And Tourism Development An Open Item**

**Barbara REVELES GONZALEZ*[1]**, Arturo ROMERO PAREDES[2]

[1]SER de Quintana Roo, A.C., Chetumal, Mexico, [2]Director, Ecoturismo y Nuevas Tecnologias, Atizapan de Zaragoza, Mexico

In Mexico it´s economic incomes are based on: the sale of the petroleum, the tourism and the entrance of currencies by remittances of Mexicans that work in the United States (US).

In the case of the petroleum is an energy source that has gone exhausting and that currently is considered little viable for the future; for the case of those of remittances originating from Mexican workers in US the current tendency indicates that the next years was stabilized the entrance of currencies for this way and will tend a slope by the adoption of restrictive measures toward the entrance Mexican workers to US

In the case of the tourism is Quintana Roo the state of Mexico that more currencies enters for this activity, its cultural and natural attractions have become place the priority inside the municipal, state, and national development plans; the previous thing has had and will have a very high cost in case of modify not the current strategy of development.

In the present document the development of Quintana Roo is reviewed as focal point of the sun-and-sand-tourism of the last 20 years; taking into account the loss of ecosystems and habitats like: coral reefs, mangrove swamps, seagrass beds, among another; the overuse of the natural resources (fishing resources, vegetation) and the current tendencies of development based on the Land Use Programs the ones that have been adequate the needs of the large hotel chains and/or private economic interests.

The cost-benefits of development as until now has been conducted in relation to natural resources is too high, it is necessary to adopt long-term strategies result in the conservation of natural resources. It is the modification of environmental and development policies which will generate a sustainable future for a very long time.

Key words: coral reef, tourism, Quintana Roo

## 22-1

**Complex Ecological Effects Of Fishing Revealed Using A New Assemblage Assessment Tool That Relies On A Large Unfished Reference Area**

**Alan FRIEDLANDER*[1]**, Joshua SLADEK NOWLIS[2], Edward DEMARTINI[3], Eric BROWN[4]

[1]Biogeography Branch, NOAA, Waimanalo, HI, [2]Economics Department, Stanford University, Stanford, CA, [3]Pacific Fisheries Science Center, NOAA Fisheries, Aiea, HI, [4]Kalaupapa NHP, National Park Service, Kalaupapa, HI

Scientific management guidance is lacking for most tropical marine fisheries because of the exacting data requirements and many assumptions of conventional stock assessment models. The lack of conventional advice often leads to management paralysis even amidst strong claims about fisheries collapses based on analysis of limited or selective data. We produced unconventional preliminary assessments for 55 species within the main Hawaiian Islands (MHI) by comparing abundances there versus within the Northwestern Hawaiian Islands (NWHI) Marine National Monument—a large, virtually unfished reference area. Nearly three-quarters of the species appeared to be depleted in the MHI with abundance levels less than 25% of the NWHI. Large mobile predators were especially affected, but many other target and non-target species appeared to be in poor condition as well. When small no-fishing areas within the MHI were used as reference points, our impression of stock status would have been overly optimistic, particularly for stocks in the worst condition. By comparing size frequency distributions for certain species in the two areas, natural and fishing mortality rates were developed. Since NWHI populations experience little fishing pressure, mortality rates there represent natural mortality whereas the MHI populations experience both natural and fishing mortality. Analysis of the highly prized blue trevally (Caranx melampygus) suggested that recent fishing rates are almost double a reasonable proxy for maximum sustainable yield and that the spawning potential ratio was 11% of reproductive potential. With the help of a larger and therefore more appropriate unfished reference area, we were able to provide strong evidence of depleted fish stocks likely caused by fishing on Hawaiian shallow water reefs.

## 22-2

**Current and Future Sustainability of Island Coral Reef Fisheries**

**Katie NEWTON*[1]**

[1]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom

Overexploitation is one of the principal threats to coral reef diversity, structure, function, and resilience. Although it is generally held that coral reef fisheries are unsustainable, little is known of the overall scale of exploitation or which reefs are overfished. Here, on the basis of ecological footprints and a review of exploitation status, we report widespread unsustainability of island coral reef fisheries. Over half (55%) of the 49 island countries considered are exploiting their coral reef fisheries in an unsustainable way. We estimate that total landings of coral reef fisheries are currently 64% higher than can be sustained. Consequently, the area of coral reef appropriated by fisheries exceeds the available effective area by ~75,000 km2, or 3.7 times the area of Australia's Great Barrier Reef, and an extra 196,000 km2 of coral reef may be required by 2050 to support the anticipated growth in human populations. The large overall imbalance between current and sustainable catches implies that management methods to reduce social and economic dependence on reef fisheries are essential to prevent the collapse of coral reef ecosystems while sustaining the well-being of burgeoning coastal populations.

## 22-3

**The Need For Adaptive Management And The Challenges Of Climate Change**

**Brigid KERRIGAN*[1]**

[1]Fisheries, Queensland Department of Primary Industries & Fisheries, Brisbane, Australia

The Great Barrier Reef World Heritage Area on the east coast of Australia supports an ecologically sustainable coral and marine aquarium fin fish fishery. The collection of coral is focused in two regions adjacent to large population centres which also support significant tourism industries centred on the Great Barrier Reef. The collection of aquarium fin fish is also concentrated in areas that typically have access to required land-based infrastructure. Due to the operations of both fisheries they are highly visible and come under significant scrutiny from stakeholders. To ensure the continuation of these fisheries within a World Heriatage Area both management and industry are rethinking there approach. The added challenge is adapting management and the operation of the fisheries to the potential changes in the coral reef system that are/will occur in response to climate change. This paper outlines the adaptive co-management fisheries model being developed jointly by government and industry to deal with the uncertain challenges of climate change and oppositional public opinion of a coral fishery within the Great Barrier Reef World Heritage Area.

## 22-4

**Coupled Changes in Structure And Function in Reef Fish Assemblages: How Predators Increase Fisheries Production**

**Stuart SANDIN*[1]**

[1]Marine Biology Research Division, Scripps Institution of Oceanography, La Jolla, CA

A growing number of surveys are revealing that coral reef ecosystem structure can vary greatly, especially in response to anthropogenic stressors. Reef fish assemblages suffer a first line of impact, with large-bodied, predatory species being disproportionately removed by fishing. Despite consensus regarding such qualitative shifts in fish assemblage structure, we currently lack detailed information about ecological consequences of these shifts. From the perspective of reef fisheries, the basic question remains unanswered – how does alteration of fish assemblage structure affect productivity, i.e., production of new fish biomass per unit time. Production is the fundamental currency of fisheries management.

I have developed new analytical approaches to explore patterns of reef fish production, using both theory and statistical estimators. I will demonstrate how trophic redundancy within reef fish assemblages leads to very high energetic efficiency on reefs, and how such trophodynamics can support fish assemblages dominated by predators (e.g., inverted trophic pyramids). Systematic removal of top trophic levels (as by heavy fishing pressure) can dramatically shift biomass and production patterns of lower trophic levels, resulting in reduced productivity from the fish assemblage as a whole. Using visual count data collected across a dramatic gradient of fishing pressure, I have estimated the realized changes in fishery production (in units of instantaneous biomass production) that follow from reductions of predator biomass. Predators systematically reduce the size of prey fish relative to species-specific size maxima, resulting in a prey fish assemblage that is building more biomass through time. In the absence of predators, prey fish are more consistently near their species-specific maximum size, and thereby shunt more energy toward reproduction and respiration and less toward somatic production. Thus, the interests of conservation and fisheries management appear aligned – by maintaining (or rebuilding) predator populations, there is capacity to simultaneously maintain (or rebuild) productivity of the fishery.

## 22-5

**Fishing Pressure, Productivity, And Competition For Resources: Malthusian Overexploitaton And Efforts To Overcome It On Kenyan Coral Reefs**

Tim MCCLANAHAN[1], **Christina HICKS*[2,3]**, Emily DARLING[4]

[1]Marine Program, WCS, New York, NY, [2]Coral Reef Conservation Project, Mombasa, Kenya, [3]Marine Sciences and Technology, University of Newcastle, Newcastle, United Kingdom, [4]Simon Fraser University, Burnaby, BC, Canada

Trends in an artisanal coral reef fishery were examined using a ten year time series along a gradient of fishing intensity spanning 75 km of Kenya's most populated coastline. As predicted by Malthusian scenarios; catch per unit effort (CPUE), mean trophic level, functional diversity of fished taxa, and diversity of gear declined, while total annual catch and catch variability increased with increasing fishing pressure. The fishery was able to sustain high (~16 tons km-2 year-1) but variable yields at high fishing pressure due to the dominance of a few productive herbivorous fish in the catch. The effect of two separate management strategies to overcome this Malthusian pattern was investigated: fisheries area closure and elimination of the dominant and most "competitive" gear (pulled seine nets). We found that sites within 5 km of the enforced closure showed significantly lower total catch and catch per unit effort (CPUE), but increased yield stability and trophic level of catch than predicted by regression models normalized for fishing effort. Sites that had excluded illegal beach seine use through active gear management exhibited increased total catch and CPUE. Time for space substitutions confirmed positive correlations between time since closure and trophic level and between time since pull seine removal and CPUE. There was a strong interaction between closure and gear management, which indicates that for closures to be effective at increasing catch, there must be simultaneous efforts at gear management around the periphery of the closures. We propose that Malthusian effects are responsible for the variation in gear and catch and that active management through reduced effort and reductions in the most competitive gear have the greatest potential to increase the functional and trophic diversity and per-person productivity.

## 22-6

**Demographic Shifts in Coral Reef Fish Communities Across A Gradient Of Human Disturbance**

**Benjamin RUTTENBERG*[1,2]**, Stuart SANDIN[1], Sheila WALSH[1], Scott HAMILTON[3], Mary DONOVAN[3]

[1]Scripps Institution of Oceanography, La Jolla, CA, [2]Marine Science Institute, University of California Santa Barbara, Santa Barbara, [3]Marine Science Institute, University of California Santa Barbara, Santa Barbara, CA

Over the past few decades, direct human impacts have been increasing on coral reefs worldwide. Researchers have documented changes in individual size and community structure, and declines in the yield of reef-based fisheries resulting from these impacts. Still, there have been fewer studies of demographic shifts driven by anthropogenic effects, and nearly all of these have examined only fishery species. We examine demographic patterns from five species from a variety of trophic levels on two nearby atolls in the Line Islands, Kiritimati Island and Palmyra Atoll. These islands are similar biogeographically and oceanographically, and yet differ greatly in the level of human impacts. We present age-based demographic data, obtained using standard techniques in otolith ageing from collections of the study species from both islands. We found striking differences in demography among islands, and these patterns differed across trophic groups. On unfished Palmyra, top predators (piscivores) were larger and longer-lived than on more heavily-fished Kiritimati, though individual growth rates were comparable. In contrast, species in lower trophic groups, including mid-level predators, were smaller, experienced higher rates of mortality, and grew faster on Palmyra than on Kiritimati. Our data suggest that anthropogenic impacts lead to indirect demographic changes; on relatively impacted Kiritimati Island, the removal of piscivores leads to lower rates of predation on lower trophic groups and increased sizes and longevity, whereas on relatively pristine Palmyra, the presence of large populations of top predators results in greater predation pressure, higher rates of mortality, and faster growth for lower trophic groups. Similar data from other atolls in the Line Islands chain corroborate these findings. Improving our understanding of species specific changes that result from human disturbance can help us develop more functional approaches to managing reef fisheries.

## 22-7

**Distribution Pattern, Habitat Overlap And Trophic Interaction Of Trawl Catches Within The Ragay Gulf, Philippines Coastal Fisheries Ecosystem**

**Lualhati LACHICA-ALIÑO*[1]**, Laura DAVID[1], Matthias WOLFF[2], Porfirio ALIÑO[1], Catalina RAÑOLA[1]

[1]University of the Philippines, Marine Science Institute, Quezon City, Philippines, [2]University of Bremen, 2 Center for Tropical Marine Ecology (ZMT), Bremen, Germany

A comprehensive resource and ecological assessment was done in Ragay Gulf, Philippines. Exploratory trawl-fishing surveys characterized the distribution patterns of trawl fish catch and assessed the external factors influencing the variability of the catch within the gulf. Species composition of commercial and municipal fish catches was compared to those found within coral reef, seagrass, mangrove and soft bottom communities, to determine the degree of overlap of their associated species within the gulf's fisheries catches. Mass-balanced trophic models using species-specific ecological groups were developed to quantify the trawl fisheries' impact on the temporal biomass budget of the ecosystem. Cluster analysis based on the 38 commonly occurring and abundant species in the trawl catches revealed northern (less exposed) and southern (exposed) species clusters associated with the prevailing circulation pattern and phytoplankton density in the gulf. Further analysis of the trawl catches composition revealed two other distinct clusters indicative of the spatial distribution and intensity of the trawl fishery in the gulf. We differentiated these areas as "highly fished" and "less fished" areas. Fifty percent of the multigear fisheries catch overlapped with the four coastal habitats. Species associated with soft bottom habitats had the highest overlap with the trawl fishing areas while overlap of municipal fisheries catch was highest with species associated with coral reefs and seagrass habitats. Forty-five years historical reconstruction of the trawl fisheries using ECOSIM showed a significant decrease in the biomass of the large high value fisheries groups together with an increase of cephalopod biomass. Subsequent 10-year simulation scenarios of a trawl fishery ban revealed that important resources such as large and medium sized carnivores would not have been significantly reduced had there been a timely application of fisheries gear regulations.

## 22-8

**Impacts of Non-Professional Fisheries on Reef Fish Communities. A Case Study in New Caledonia (Western Pacific)**

**Nicolas GUILLEMOT*[1]**, Pascale CHABANET[2], Marc LEOPOLD[1], Olivier LE PAPE[3], Marion CUIF[1]

[1]Institut de Recherche pour le Développement, CRISP Program, Noumea, New Caledonia, [2]Institut de Recherche pour le Développement, Ste Clothilde, Reunion, [3]Pôle Halieutique, Agrocampus Rennes, Rennes, France

The imminent creation of a massive nickel mining complex will soon increase demographic pressure on the rural Northwest coast of New Caledonia (Western Pacific Ocean). As a consequence, fishing pressure is expected to significantly rise. Our objectives were 1) to assess to what extent six years (2002-2007) of underwater visual censuses (UVC), conducted over 60 permanent transects, reflected the fishing pressure characterised by 165 surveys of non-professional fishermen conducted in 2007 ; 2) to plan for an optimized long-term monitoring program (adequate methodologies and sampling design) to monitor the predicted fishing impact. In the study area, including three villages and five Melanesian tribes, surveys showed that non-professional fishing uptakes (~171 tons) are far more important than professional uptakes (~35 t). Non-professional fishermen target a large diversity of biotopes (barrier, intermediate and fringing reefs, mangroves, soft bottoms) and fish families. The main families targeted are Lethrinidae, Acanthuridae, Scaridae, Mugilidae, Siganidae, Serranidae, Haemulidae, Ludjanidae, Carangidae, Sparidae, Gerreidae and Kyphosidae. Furthermore, fishing practices (gear, targeted species, yearly landings) differed strongly between tribes and villages, which underlines the necessity to monitor every aspects of these non-professional activities. UVC reflected partially the effects of this complex fishery landscape. After that survey information was translated into spatially-explicit information and integrated into a GIS, UVC results compiled by biotopes and species reflected 36% of the survey information. Specifically, several key landing indicators (yield, species mid-size) were successfully related to UVC indicators (biomass, species mid-size), and both proved to be consistent for a long-term monitoring. However, UVC's sensitivity remains not completely appropriate to fully measure non-professional fishery impacts. Adequate quantification could be partially based on UVC but methods such as video observations (avoiding diver biases) could provide complementary data on targeted species. Furthermore, validation should still be based on surveys, especially targeting non-professional fishermen.

## 22-9

**Comparative Evaluation Of Reef Fish Resources Adjacent To Densely-Populated South Florida, Usa: Anthropogenic Impacts And Implications For Management**

**Todd KELLISON*[1]**, Vanessa MCDONOUGH[2], Doug HARPER[1], James TILMANT[3]

[1]Southeast Fisheries Science Center, NOAA Fisheries, Miami, FL, [2]Biscayne National Park, National Park Service, Homestead, FL, [3]Water Resources Division, National Park Service, Ft. Collins, CO

Assessing temporal and spatial trends in reef resources is important for ecosystem and fisheries management in coral reef ecosystems. Biscayne National Park (BNP), FL, USA, encompasses the northern portion of the FL Keys coral reef tract and is adjacent to a local human population of ~2.5 million (regionally ~ 6 million) in a county that has experienced considerable increases in human population (47%) and recreational fishing vessels (48%) over the past 25 years. Despite being a national park, commercial and recreational fishing is allowed in BNP. We compared the status of reef fish resources in BNP with (1) historical data and (2) data from reefs adjacent to less-populated areas along the FL Keys to assess the relative condition of reef fish resources in BNP. For the historical comparison, we repeated a study to compare current (2006-2007) reef fish community structure in BNP with that observed during 1977-1981. Reef fish communities changed considerably over time with significant declines in species richness and frequency-of-occurrence of fishery targeted and non-targeted species. For the spatial comparison, we used three data sources to compare trends in abundance and length-frequency distributions of multiple fishery-targeted species along the FL Keys. Regardless of data source, species-specific proxies for abundance and length-frequency distributions were predominantly lowest and smallest, respectively, in and around BNP. The historical trends and spatial patterns observed are consistent with those expected in heavily utilized reef systems and may continue given predicted increases in human population and fishing pressure in southern FL. Results are discussed in terms of prospects for adaptive ecosystem and fisheries management in BNP.

## 22-10

**Revealing Patterns Of Impact Of Fishing On Fish Resources From A Large Scale Regional Program**

**silvia PINCA*[1]**, ribanatake AWIRA[1], pierre BOBLIN[1], melba WHITE[2]

[1]spc, noumea, New Caledonia, [2]MIMRA, majuro, Marshall Islands

A large scale program was conducted in the Pacific region to assess the status of commercial resources and support countries in managing fisheries. Underwater visual censuses and socio-economic interviews were carried out for 5 years to collect resource status information from 17 countries. One of the main difficulties in evaluating the condition of a fishery is the lack of knowledge of the conditions that existed before fishing began. Moreover, records of changes over time are often missing, especially on a large scale. The alternative choice to understanding variation in resource availability is to compare resource status at different sites of similar environmental conditions (location, geomorphology, habitat) but under different fishing pressures. Taking into account one specific but localized historical data set along with acquired knowledge from frequent underwater observations, we decided to focus on comparing records of size and size ratio (ratio between average size and maximum size of a species) together with biomass of target commercial species to identify responses in fish populations. By analyzing groups of sites of similar geomorphogical and environmental conditions, but different levels of fishing pressure, we could find significant negative relations between in situ total commercial fish stock, carnivore mean size, specific commercial families and species size ratio and selected indicators of fishing pressure: values of extrapolated catch per village, density of fishers per area and percentage of population practicing fishing as source of income rather than simply sustenance. Such results give a noteworthy contribution to the search for indicators of fishing status which can be used when assessing fish stocks for the purpose of management.

## 22-11

**Where Have All The Big Fish Gone? Distribution Of Remaining Large Reef Fishes in The Hawaiian Archipelago**

**Benjamin RICHARDS*[1]**, Emily LUNDBLAD[1], Brian ZGLICZYNSKI[2], Marc NADON[1], Robert SCHROEDER[1], Russell BRAINARD[2]

[1]NOAA Coral Reef Ecosystems Division, Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, HI, [2]Coral Reef Ecosystems Division, NOAA National Marine Fisheries Service, Honolulu, HI

This study represents one of the first and most comprehensive efforts to investigate habitat preference of large reef fishes in the Hawaiian Archipelago. Physical characteristics of the coral reef including depth, slope, rugosity, and habitat type have been shown to play a critical role in the distribution of many reef fishes. However, research has generally focused on small spatial scales and on species living in tight association with the reef (e.g., Chaetodontidea, Pomacanthidea, Pomacentridea). While it stands to reason that similar relationships should exist, little work has focused on quantifying the effects of these habitat parameters on larger reef fishes (e.g., Carcharhinidea, Carangidea, Lutjanidea, Scaridea), many of which contribute to the highest trophic levels, are wide ranging, have extended ontogenies, and are most vulnerable to exploitation, habitat degradation and ecosystem change. This study synthesizes data collected biennially (2000-2006) along 700 surveys covering approximately 1500 hectares. Biomass and numeric density distributions of large reef fish (>50 cm TL) were analyzed with respect to depth, slope, rugosity and habitat type in a GIS framework. Bathymetric data were derived from multibeam sonar, IKONOS and LIDAR surveys. Habitat type was determined using published benthic habitat maps. Initial analyses support earlier research showing a less dense large fish population in the main Hawaiian Islands compared to the Northwestern Hawaiian Islands. Significant correlation was found between overall biomass of large reef fishes and average depth, slope, and rugosity along each transect. These results provide the scientific basis for efficient and targeted habitat-based management strategies for large reef fish, begin to define essential fish habitat for these species, and lay the foundation for similar investigations across the wider Pacific Region.

## 22-12

**Historical Photos Document Changing Reef Fish Communities**

**Loren MCCLENACHAN*[1]**

[1]Scripps Institution of Oceanography, La Jolla, CA

The importance of historical data in marine management has been demonstrated, particularly for species whose populations were reduced significantly prior to the onset of ecological data collection. Coral reef fisheries are frequently small-scale and affected by overfishing over long time periods, so that data on long-term trends are lacking. Photographs from historical archives contain information on the species composition and size structure of landings before fisheries or ecological data are available. Using photographic data from the recreational fishing industry in the Florida Keys, I quantified changes in size structure of large reef fish over the past half century (1956-2007). This extensive data set provides temporal trends in the community composition of exploited reef fish and offers baseline information on natural abundance and body size. The average size of individual trophy fish declined from 91.7 cm (SE 2.4) to 42 cm (SE 1.2) and from 19.9 kg (SE 1.5) to 3.8 kg (SE 0.3) between 1956 and 2007. The size of sharks, the largest fish targeted, dropped from 204 cm in 1956 to 87 cm in 2007. Shifts in the species and size of individuals caught demonstrate a loss of the largest predators from the reef environment. The goliath grouper (Epinephelus itajara), with an average size of 135.3 cm (SE 3.2), was the most commonly caught trophy fish in the 1950s, but was rare by 1965. The largest fish frequently caught by recreational fisheries in 2007 were snappers (Lutjanus spp. and Ocyurus chrysurus), with an average size of just 34.4 cm (SE 2.4). This remnant fishery based on increasingly small individuals underscores the depletion of reef fish communities, and the overall degradation of Florida's coral reef ecosystem. The results of this study illustrate the need to consider long term data in assessing the conservation status of exploited animals.

## 22-13

**An Appraisal of Marine Resource Use in the Far North of Madagascar: Challenges and Opportunities for Marine Conservation in Antsiranana**

**Rachel LENANE*[1]**

[1]Centre for the Environment, The University of Oxford, Epsom, United Kingdom

Design of marine conservation plans can be informed using contextual socio-economic information to develop conservation strategies that integrate sustainable livelihoods (Wilkinson *et al*., 2004; Malleret-King *et al*., 2006; Richardson *et al*., 2006).

In Northern Antsiranana, Madagascar, knowledge and beliefs were collected during interviews with 207 informants over an eight week period. Within this region marine resources represent a primary source of livelihood for the population and Protected Areas (PAs) are expanding rapidly under national legislation. By creating a narrative of local people's perceptions and use of the marine environment using qualitative methods possible conservation management strategies are identified.

In Antsiranana the marine resource trade involves numerous stakeholders operating at various spatial scales; subsistence fishermen to international holothurian exporters.

High levels of artisanal fishing provides subsistence for rural communities. Holothurian collecting is also an important activity in this region often providing households with their only source of cash income. Informants identify damaging methods of resource extraction and declining fish and holothurian populations. Knowledge of government regulations is limited and the problem is further exacerbated by low levels of formal education.

Varying types of exploitation need to be identified prior to implementing management plans as each will have specific environmental and economic impacts. Thus a stratified management plan is required to protect both livelihoods of coastal inhabitants and marine ecosystems.

Management strategies explored rely upon a combination of limits on area, time, gear and size, rather than strict PAs. It is thought that the dispersal of larval fish and holothurians, and increased pressure on surrounding marine ecosystems by displaced fishers, will have negligible effects on the benefits of PAs.

Using data from this study, in conjunction with previous ecological surveys, it might be possible to initiate an integrated, context specific approach to managing these marine ecosystems of exceptional but declining biodiversity.

## 22-14

**Observations Of Antillean Fish Trap Contents in Southwest Puerto Rico: Ways To Reduce Coral Reef Habitat Damage And Improve Catch Quality**

**Anthony MARSHAK*[1]**, Ronald HILL[2], Peter SHERIDAN[3], Richard APPELDOORN[4]

[1]Deparment of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico, [2]NOAA Fisheries, Southeast Fisheries Science Center, Galveston Laboratory, Galveston, TX, [3]NOAA Fisheries, Southeast Fisheries Science Center, Panama City Laboratory, Panama City, FL, [4]Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico

Abstract: The shelf-wide distribution of Antillean fish traps has been monitored in southwest Puerto Rico since 2002 to evaluate the benthic impacts of trap fishing within coralline habitats. Of 1438 traps documented in surface surveys to date, 161, stratified by habitat, were assessed by divers to quantify damage and record trap contents. Observed traps were predominantly arrowhead-style traps with 5-cm hexagonal vinyl-coated mesh composed either of wood or rebar frames. Most traps inspected were found within colonized hardbottom habitats dominated by soft corals at intermediate depths (12-18 m), although traps were also surveyed in high relief reef, algal flat, seagrass beds, and sediment (sand or mud) habitats. Fishes composed 78% of the total individuals caught, of which butterflyfishes, grunts, surgeonfishes, trunkfishes, and parrotfishes were most abundant. The Caribbean spiny lobster, *Panulirus argus*, was the most frequently trapped species across all habitats. Traps set in colonized hardbottom areas of moderate to high relief contained the highest numbers of observed organisms. Traps set in high relief reef habitat caught higher numbers of less valuable herbivorous fishes, with *Chaetodon capistratus* and *C. striatus* being the most numerically dominant species. Trap contents observed within less structured habitat types, such as algal flats and mud, consisted mostly of trunkfishes and grunts. Within these habitats, *P. argus* was the most frequently observed species. Due to coincident presence of spiny lobster, and a higher percentage of commercially valuable fish species, the results suggest that fishers could improve economic efficiency by fishing traps only in areas of lower structural complexity, while lessening potential for gear damage to more complex coralline habitat types.

## 22-15

**Parrotfish Densities Across A Fishing Intensity Gradient in The Caribbean**

**Denise DEBROT*[1]**, J. Howard CHOAT[2], Juan M. POSADA[3], D. Ross ROBERTSON[4]

[1]Dpto. Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela, [2]James Cook University, Townsville, Australia, [3]Dpto, Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela, [4]Smithsonian Tropical Research Institute, Panamá, Panama

Parrotfishes (Scaridae) are important components of subsistence and commercial reef fisheries throughout the Caribbean, most notably at locations were predators (e.g. groupers, snapper) have been intensively fished. Here, we compare the abundance of scarids at seven localities across a latitudinal gradient in the Caribbean (from west to east, Belize, San Blas, Curacao, Bonaire, Las Aves, Los Roques and Barbados) with differing fishing intensities for parrotfishes. At each locality we surveyed at least five sites separated by kilometers, and across different reef habitats. To estimate densities, counts were made for all species of scarids along 30 x 10 m belt transects, and along 400 x 15 m transects for the large bodied scarids. Los Roques, a National Park offshore Venezuela were fishing is restricted, supports the highest densities of the large-bodied scarids *Scarus guacamaia*, *S. coelestinus* and *S. coreuleus*. At the neighboring Las Aves, an area heavily fished for predators, but with little fishing directed to scarids, densities were also high for *S. coelestinus* and *S. coreuleus*. Bonaire, a well protected reserve, supported the highest densities of the excavating scarid *Sparisoma viride* and the large grazing scarid *Scarus vetula*. In contrast, the densities of the large bodied parrotfishes at moderate to intensively fished sites (San Blas, Belize, Barbados and Curacao) were up to 10-fold lower than at Los Roques, and were absent from all sites at Barbados. Our results suggest that parrotfish may be vulnerable to intensive fishing, and thus highlight the importance of fisheries management for the protection of reef fishes.

## 22-16

**The Effects Of Fishing And Harmful Algal Blooms On Sponge Ecology in The Florida Keys Usa**

**Donald BEHRINGER*[1]**, Mark BUTLER IV[2]

[1]Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, FL, [2]Department of Biological Sciences, Old Dominion University, Norfolk, VA

Sponges are a prominent component of coral reefs and, along with octocorals, they dominate the biota of shallow hard-bottom habitat in the Florida Keys (Florida, USA) marine ecosystem. Yet, remarkably little is known about the ecology of the large sponge species that dwell in hard-bottom or the structure, ecological function, or resilience of hard-bottom communities. Our poor understanding of these communities has been highlighted in recent years by questions about the possible impacts of ecosystem perturbations and resource exploitation on hard-bottom habitat. For example, hard-bottom communities in Florida have been subject to recurring algae blooms which can cause massive sponge die-offs; the most recent occurring in 2007. Furthermore, there are concerns about the possible ecological impacts of commercial sponge fishing on hard-bottom community structure and function. In the case of sponges, resolution of these issues has been hampered because there is no stock assessment, the most basic population dynamics for the pertinent sponge species are largely unknown, and the effect of the fishery on commercial sponges and allied species have never been studied. We conducted a series of studies to better understand: (a) the basic population dynamics of commercial sponges, (b) the impact of the sponge fishery on sponge communities, and (c) the effect of a cyanobacteria bloom in 2007 on sponge and octocorals abundance and diversity. This presentation will highlight the key findings of each of these studies, which suggest that sponge communities are robust to current rates of commercial sponge exploitation but are rapidly decimated by the cyanobacteria blooms that continue to plague Florida Bay.

## 22-17

**Managing Fishing Gear To Encourage Ecosystem-Based Management Of Coral Reefs Fisheries**

**Tim MCCLANAHAN*[1]**, Josh CINNER[2], Joseph MAINA[3], Carlos RUIZ SEBASTIAN[4], Shaun WILSON[5], Nick GRAHAM[5]

[1]Marine Programs, Wildlife Conservation Society, Mombasa, Kenya, [2]Marine Biology, James Cook University, Townsville, Australia, [3]CRCP, Mombasa, Kenya, [4]CRCP, Durban, Australia, [5]Marine Science, University of Newcastle, Newcastle, United Kingdom

We present data from two poor tropical countries, Papua New Guinea and Kenya, and show that there is a unique and consistent partitioning of the capture of species and functional groups by gear that can be used to potentially influence ecological processes and biodiversity on coral reefs that can also respond to disturbances such as coral bleaching. Hook and line capture a higher proportion of top carnivores/piscivores and target species with low susceptibility to coral bleaching. Traps and spear guns capture mostly herbivores/ominvores and target the highest proportion and number of fish species that are moderately susceptible to the impacts of coral bleaching. Nets mainly target carnivores/invertivores. The use of specific gear can be actively managed to encourage the recovery of select functional groups and adaptively managed under conditions such as high erect algae cover, sea urchin dominance, low coral cover, and coral bleaching. We present a simulation and conceptual model that examines projected effects of the gear and effort on the yields and ecological processes in the coral reef ecosystem and suggest mechanism for how this model might be practically implemented.

## 22-18

**Evaluation Of Alternative Management Strategies For The Eastern Torres Strait Reef Line Fishery**

**Ashley WILLIAMS*[1]**, Rich LITTLE[2], Gavin BEGG[3]

[1]Fishing and Fisheries Research Centre, School of Earth & Environmental Sciences, James Cook University, Townsville, Australia, [2]Marine and Atmospheric Research, CSIRO, Hobart, Australia, [3]Australian Fisheries Management Authority, Canberra, Australia

Commercial harvest of coral reef fish in the eastern Torres Strait (ETS), Australia is shared between Torres Strait Islanders and non-indigenous fishers, but to date no formal assessment of the fishery has been done, and no resource allocation or management strategies directed at the special circumstances in the Torres Strait currently exist. Here, we evaluate the strengths and weaknesses of a range of alternative management strategies related to the harvest and conservation of coral trout (*Plectropomus leopardus*), the primary target species in the ETS Reef Line Fishery (RLF). We worked with Islander and non-indigenous commercial fishers and fisheries managers to identify specific stakeholder objectives and feasible alternative management strategies to pursue them. We used a meta-population and harvest simulation model (ELFSim) to assess the combined effects of four regimes of effort control, three minimum legal size regimes and two area and two seasonal closure regimes on the status of coral trout, and compared their likelihoods of meeting conservation and fishery objectives. Results of simulations indicated that a two-month seasonal closure was a good measure for addressing conservation objectives, but tended to reduce the ability to satisfy fishery objectives. Similarly, closing areas to fishing and increasing the minimum legal size were generally good strategies for conservation objectives, but performed poorly for fishery objectives. Lowering effort was the more robust strategy for achieving both conservation and fishery objectives. This research provides a framework for the impartial evaluation of the performance of alternative management options to meet diverse and often competing objectives of stakeholders in the ETS RLF.

## 22-19

**The Status Of The Artisanal Seine Net Fishery in Rodrigues Over A 5-Year Period**

**Emily HARDMAN*[1]**, Alasdair EDWARDS[2], Jovani RAFFIN[1]

[1]Shoals Rodrigues, Rodrigues, Mauritius, [2]Division of Biology, University of Newcastle upon Tyne, Newcastle upon Tyne, United Kingdom

The seine net fishery is of great socio-economic importance to Rodrigues, with landings making a significant contribution to the total catch (42% of lagoon fish catches). Fishing activities however, appear to be impacting on fish stocks and catches have declined significantly between 1994 and 1997. An assessment of the status of the fishery commenced in 2002 and 5 years of data have now been obtained. Working in collaboration with 4 fishing teams during the seine net open season, the total length of each individual caught was determined. Over the 5-year period a total of 68,013 fish were measured. The data show that the Catch per Unit Effort and mean monthly earnings per fisher have declined significantly during this 5 year period. Although the fishery is highly multi-species with 122 species recorded, 80% of the fish landed were from 10 species, most of which are herbivores or small invertebrate feeders. The most important species during all years was the Rabbitfish, *Siganus sutor*. There has however been a change in species composition of the catch over the 5 year period with species such as *Naso unicornis* decreasing in abundance, whereas small species such as *Acanthurus triostegus* and *Gerres longirostris* increased in importance. The modal length of *S. sutor, Lethrinus nebulosus* and *Caranx melampygus* has decreased between 2002 and 2006 and over 60% of fish were caught before they reached maturity. The data indicate that the fishery has become dominated by small, herbivorous fish and that serious recruitment overfishing is occurring for some species. As a result, 4 marine reserves have now been proclaimed in Rodrigues in order to allow fish stocks to recover and to promote sustainability of fisheries in the Rodrigues lagoon.

## 22-20

**Coral Reef Fisheries For The Future? Know The Historic Baseline**

**Dirk ZELLER*[1]**, Shawn BOOTH[1], Roxanne DICKINSON[2], Lou FROTTÉ[3]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada, [2]Stanford University, Stanford, CA, [3]Insitut National Polytechnique de Toulouse, Castanet, France

Small-scale fisheries in the tropical Pacific are important culturally and for food security, yet remain extensively under-reported in national statistics which inform global data presented by the Food and Agriculture Organization of the United Nations (FAO). This contributes substantially to the undervaluation of their importance to communities, both socio-politically as well as economically. We present historic baseline catch reconstructions for the 1950-2004 period for 20 small island countries in the tropical Pacific. The reconstruction approach develops estimates of likely total catch using all available information sources, including grey literature and localised case-studies, combined with conservative assumptions, expansions and interpolations. The reconstruction suggests that unreported catches over this time period were at least equal to reported catches, but range as high as a 17-fold discrepancy. Important also is that for several countries the time series reverses from an increasing to a declining trend over time. This is likely due to localised overfishing, as well as changing consumption patterns in an era of generally high population growth rates and increasing population centralization. The discrepancy in national and hence FAO statistics is primarily driven by consistent under-representation of non-commercial (subsistence) catches in most of the island countries. While reliable yearly estimates are expensive and difficult to obtain, and are the prime reason for incomplete catch accounting by many counties, the fundamental importance of these catches to food security, especially under increasing climate change stresses cannot be underestimated. Regular, albeit non-annual, country-wide estimates of total catches should be undertaken as a priority activity by all countries, interpolated for intervening years, and included in national data reported to FAO. Due to financial and human resource limitations, such work should be facilitated or undertaken by regional agencies, e.g., the Secretariat of the Pacific Community (SPC).

## 22-21

**Applying An Optimal Resource Space Concept To Small Scale Reef Fisheries Management**

**Lydia TEH*[1]**, Louise TEH[1]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

Fishers operate according to an optimal resource space whose boundaries are defined by economic profitability, technological sophistication, and socio-cultural preferences. These 'invisible' boundaries can affect fishers' willingness to comply with, and ability to adapt to spatial restrictions. Better understanding of the factors that shape optimal resource spaces can thus lead to management decisions that are more aligned with fishers' perspectives and have a higher likelihood of being complied with and adopted. We investigate the coral reef fisheries of Pulau Banggi, Sabah, Malaysia, where a marine protected area is proposed. Our objectives are i) map fishers' optimal resource space; ii) explain ecological, socio-cultural, and economic factors that influence fishers' optimal resource space; and iii) apply optimal resource space concept to spatial management of small scale reef fisheries. We use data from fish catch logbooks to track the fishing activities of 21 fishers. We conducted semi-structured interviews with fishers to explore factors that dictate their resource use space, including market forces, fishers' motivations and perceived constraints. We find that fishers function within an optimal resource space that is delineated by socio-cultural factors such as family ties, and distance from resident village. Even though fishers are aware of locations where they perceive more fish can be caught, they rarely fish those places. While Banggi fishers face invisible boundaries that restrict them to habituated fishing grounds, outsider fishers do not face such restrictions and are not prevented from exploiting Banggi's open access fisheries. The optimal resource space concept can be applied towards analyzing user conflict, compliance, and equity issues. In the context of marine protected areas, it can help in designing spatial management strategies that are socially acceptable and ecologically sustainable to fisheries and fishing communities.

## 22-22

**Improving Management Of Coral Reef Fisheries in Data Limited Situations: Experiences From The Parfish Methodology**

**Robert WAKEFORD*[1]**, Suzannah WALMSLEY[2], Robert TRUMBLE[1], Paul MEDLEY[3]

[1]MRAG Americas, Inc., Saint Petersburg, FL, [2]MRAG Ltd., London, United Kingdom, [3]Independent Consultant, Alne, United Kingdom

Coral reef fisheries are complex systems. This is due primarily to the multi-species, multi-gear and high labour mobility that often occurs within the fisheries sector. Since many small-scale fisheries operate in remote areas and/ or in developing coastal states, the quality and quantity of data necessary to undertake basic fisheries management, including robust stock assessments, are often lacking. However, it is becoming more widely acknowledged that local stakeholder participation is an essential pre-requisite to improve overall management of the resource, but this has rarely engaged them directly within a stock assessment framework to provide information on the status of the resource. This study presents a summary and comparison of three pilot studies undertaken in Turks and Caicos, Tanzania and Puerto Rico that have been used to demonstrate a new fisheries management tool that enables stakeholders to participate directly in the stock assessment process. Through the development of a participatory fish stock assessment (ParFish) methodology, fishers are engaged at the beginning of the management process to contribute their valuable knowledge about the fishery. Using a Bayesian statistical model, information obtained from fishers help inform prior statistical distributions that are used to estimate parameters in the stock assessment model. The results have shown that this approach can be used successfully to establish preliminary estimates of stock status in data limited situations.

## 22-23

**Effectiveness Of Minimum Legal Size As A Fisheries Management Tool in A Multi-Sectoral Reef Fishery**

**Sara BUSILACCHI*[1,2]**, Gavin BEGG[3], Ashley WILLIAMS[2]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]Fishing and Fisheries Centre, School of Earth and Environmental Science, James Cook University, Townsville, Australia, [3]Australian Fisheries Management Authority, Canberra, Australia

Minimum legal size (MLS) is one of the oldest and most widely accepted management tools in fisheries and is usually based on the mean length at which 50% of a population become mature. The effectiveness of a MLS depends on a range of factors including the biology of the species, fishing behaviour, fishing gear, post-release survival, other management arrangements and compliance. In this presentation we assess the effectiveness of MLS's when applied to manage two of three sectors in a multi-sectoral fishery. The reef finfish fishery in Torres Strait, Australia, is shared among three sectors: an indigenous subsistence sector and two commercial sectors (an indigenous and a non-indigenous). In an effort to retain its cultural value, the subsistence sector is currently not regulated. However, the two commercial sectors are managed by numerous regulations including a MLS for the commercially important species. It is normal practice within indigenous communities for subsistence fishing to occur during commercial fishing trips, even though this is inconsistent with legislation. Subsistence catch taken during commercial fishing trips was monitored between May 2005 and May 2006 using an access point survey in three Torres Strait communities. We estimated that, on average, 22% of the total catch taken during commercial trips is used for subsistence. Coral trouts (*Plectropomus* spp.), carangids and snappers (*Lutjanus* spp.) were the most retained species for subsistence and were also the most commercially important. Results showed that, for some of these species, undersize fish (less than the MLS) represented 80% of the subsistence catch taken during commercial fishing trips. We conclude that the effectiveness of this management tool relies on the understanding of its rationale and its acceptance by indigenous communities.

## 22-24

**Bias Of Cpue Revealed By Considering Fisheries As Predator Prey Systems**

**Meaghan C. DARCY*[1]**, Steven JD MARTELL[2]

[1]Zoology / Fisheries Center, University of British Columbia, Vancouver, BC, Canada, [2]Fisheries Center, University of British Columbia, Vancouver, BC, Canada

The Hawaiian bottomfish fishery is a multi-species fishery, where the target species (mainly eteline snappers and one grouper species) are associated with deep reef structures and are caught using handlines. This fishery exemplifies many reef associated, multi-species fisheries, where the fishing gear simultaneously captures multiple species. Assessment of status for each species is based on effort-aggregated commercial catch statistics and single-species assessment models. Aggregation of these data assumes that the capture probabilities and targeting of each species are constant over time and those species-specific catches per unit effort (CPUE) indices are proportional to abundance. Using single-species assessment models with effort-aggregated data may be problematic because the assumption of proportionality is likely to be violated due to changes in targeting and or changes in species composition and changes in fishing technologies.

To account for species composition effects in the multi-species fisheries, we develop an effort dynamics sub-model that partitions the total effort into components of handling time and time spent searching (i.e., Holling's Disc equation). It explicitly allows for handling time influences and the differences in catchability among target and non-target species. We tested this approach using stochastic simulation-estimation experiments, where the dynamics of individual fish populations that make up a multi-species fishery and typical fisheries dependent data (i.e., species specific catch data and aggregate effort data). Simulation results demonstrate that increased handling time leads to a hyperstable index of abundance (i.e., catchability declines less rapidly than biomass) which would lead to overestimates of abundance in the classic single-species assessments. Ignoring handling time effects for fisheries such as, handline fisheries, where a large component of effort includes gear set-up and retrieval and removal of catch from the gear, results in biased abundance estimates.

## 22-25

**Estimating Harvest Pressure On Bahamian Coral Reefs Through Seafood Consumption**

**Liana TALAUE-MCMANUS*[1]**, Joy HAZELL[2]

[1]Marine Affairs and Policy, University of Miami Rosenstiel School of Marine & Atmospheric Science, Miami, FL, [2]Florida Sea Grant Lee County Extension, University of Florida, Fort Myers, FL

We designed a seafood consumption survey to compare harvest pressure estimates derived from coral reef fisheries monitoring in the Bahamas. Specifically, we estimated the fishing pressure on four major marine food resources via consumption estimates and a review of trade statistics. In addition, we disaggregated domestic consumption into urban and rural resident and tourist populations. Our sample included 221 urban respondents, 351 rural residents, and 351 tourists.

For the period of study from 2003 to 2004, we estimated annual consumption for four species: conch (Strombus gigas) consumption reached 4200 mt; grouper complex, 7910 mt; spiny lobster (Panulirus argus), 4580 mt; and snapper complex at 3200 mt. Tourists consumed 17% of conch available in the Bahamas; 14% of grouper; 12% of lobster, and only 4% of snapper. Mean weekly consumption by tourists was almost twice that of resident populations for conch and grouper, although the standard deviations were sufficiently wide to make the differences statistically insignificant. Of the four major seafood items, the spiny lobster posted the greatest trade pressure with about 69% of total catch exported to foreign markets and 31%, domestically consumed. The fisheries monitoring system in the Bahamas did not document 86% of estimated total conch catch based on consumption and trade statistics. The same holds true for 94% of grouper catch, 39% for lobster and 77% for snapper. In the absence of a proper fisheries monitoring program, a food consumption survey for residents may be implemented annually. For tourists, exit surveys can include queries on food consumption.

For species-specific seafood, consumption estimates provide a realistic complement to traditional fisheries monitoring. For multi-species seafood like groupers and snappers, a population-level monitoring using fisheries-based methods remains critical for management.

## 22-26

**Flawed Data, Reef Fisheries, And Food Security: A Close Inspection Of Marine Fisheries Catches in Mozambique, Tanzania, Fiji, And The Solomon Islands**

**Jennifer JACQUET*[1]**, Dirk ZELLER[1]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

Good management decisions often require good data. We present a simple taxonomy for fisheries catch data that can be used as a "smell-test" when considering data quality and level of reporting. When it comes to reporting, underreporting of fisheries catches is the likeliest outcome, which inevitably leads to misallocations of fisheries resources. We demonstrate underreporting of fisheries catches has occurred in four countries where local people rely heavily on coral reef fisheries for food security: Mozambique, Tanzania, Fiji, and the Solomon Islands. We present the results of catch reconstructions for these countries for the time span of FAO reporting (1950 to the present) and, in some cases, new estimates of per capita fish consumption. Reconstructed marine fisheries catches for Mozambique, for instance, are 6.2 times greater than those reported by FAO based on country reports and countrywide per capita fish consumption is estimated to be 9 kg per capita, three times what had been previously calculated based on reported data. In Tanzania, reconstructed catches now include the reef fisheries of Zanzibar and the result is that catches are 1.7 times greater than FAO reports. Finally, we discuss the policy implications of newly reconstructed reef fisheries catches, make recommendations on how to improve reporting for each country, and suggest alternatives to FAO datasets.

## 22-27

**No-Take Areas, Uncertainty And Coral Reef Fisheries Management**

**Richard APPELDOORN*[1]**, Susan SINGH-RENTON[2], Mauro GONGORA[3]

[1]Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico, [2]Caribbean Regional Fisheries Mechanism, Kingstown, Saint Vincent and The Grenadines, [3]Capture Fisheries Unit, Belize Fisheries Department, Belize City, Belize

No-take reserves are advocated as a core strategy for resource management. Within coral reef fisheries, much debate has centered on the roll of enhancing catch through individual movement from protected to unprotected areas (spillover). This debate largely ignors other critical roles reserves may play within a management context, such as maintaining spawning stock and providing control areas to assess fishing impacts. These roles directly relate to countering the degree of uncertainty traditionally characterizing data poor coral reef fisheries. This is illustrated with a recent assessment in Belize of queen conch, a commercially important gastropod inhabiting sea grass, sand and hardbottom habitats of Caribbean reef ecosystems. Visual census and landings data show the back reef conch population and fishery consist overwhelmingly of juveniles. With intense fishing having been maintained for many years, the alternative hypotheses were either that the fishery was severely recruitment overfished and near collapse, or that recruitment was sustained by an unknown spawning stock. In Belize, use of scuba for fishing is banned, effectively creating a no-take area in the deep waters in front of the Belizean barrier reef. Deep water surveys of density and size-structure found adult conch to be abundant at all stations, that these lived longer than those found in shallow areas, and that much of these conch resulted from direct settlement and not migration from shallow areas. Monitoring in small shallow reserves extending into backreef areas was sufficient to demonstrate sustained recruitment over years, much higher densities of juveniles and adults, and suggested significant spillover into fished areas. No-take areas were thus critical for maintaining the Belizean fishery in the face of intense fishing by maintaining a deep-water spawning population, and demonstrating the validity of this interpretation to management agencies.

## 22-28

**Determining The Appropriate Size Of Closed Areas For Protecting Spawning Aggregations Of Large Groupers Using Hydro-Acoustics**

**Richard S. NEMETH*[1]**, Elizabeth KADISON[1], Jeremiah BLONDEAU[1]

[1]Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Many species of tropical groupers (Serranidae) form annual spawning aggregations at predictable times and locations. This makes them extremely vulnerable to over-fishing which has lead to the extirpation of many spawning aggregations world-wide. Because a single spawning aggregation may represent the entire breeding potential of a local population, each one must be carefully protected. Seasonal or permanent fishery area closures can provide effective protection, but unfortunately the placement of closure boundaries is often disputed by fishermen because boundaries are not based on biologically relevant data. In most cases relatively little is known about the area occupied or the movement and migration patterns associated with spawning. The aim of this study was to determine the spatial and temporal pattern of movement and migration associated with spawning aggregations of Nassau (*Epinephelus striatus*) and yellowfin (*Mycteroperca venenosa*) grouper within the Grammanik Bank (GB), a small (1.5 $km^2$) seasonal closure on the southern shelf edge of the US Virgin Islands. Five male and 5 female groupers of each species were acoustically tagged and released on the aggregation site. An array of 17 acoustic receivers were placed in an overlapping curtain around the GB closure and east and west along the shelf edge, and could detect fish transmitters within a 400m radius. Both species commonly moved 1 to 3 km in a few hours and could cover 20 km in a 24 hr period. Movements of tagged groupers at the spawning site carried them across the GB closure boundaries and exposed them to fishing mortality on a daily basis. Moreover a consistently used migratory pathway was also detected between the GB and another large marine protected area (MCD) 3 km west. These results indicate that the GB boundaries should be increased to at least 10 $km^2$ and include the area between the GB and MCD.

## 22-29

**Alternance Of Opening And Closing Times To Fishing Of A No-Take Zone in Martinique (Lesser Antilles)**

**Géraldine CRIQUET*[1]**

[1]EPHE, Perpignan, France

Due to littoral ecosystems degradation and overfishing, a decrease of stocks of coastal species occurred in Martinique in the last decades. In order to block this process, several No-Take Zones (NTZs), managed by the Regional Council of Fishery, have been implemented. The particularity of these NTZs is the possibility of opening for a period goes from four to six months. The objective of the study is to assess the impact of this alternance of opening and closing periods on the reef fish community of a Caribbean cost area, Ilet à Ramier. Experimental fishing with Antillean traps were done simultaneously in the NTZ and in the adjacent non protected area (NPA) during a closing then an opening period. Total catches in the NTZ decrease of an half while those of surrounding area stay equal. But both in opening and closing period, total catches in NTZ are higher than in NPA. During the closing period, biomass of Acanthuridae, Scaridae and Lutjanidae are higher in the NTZ, biomass of Serranidae are equal both in NTZ and in NTA; and Haemulidae are more present in NTA. During the opening period, patterns are the same except for Serranidae witch biomass is higher outside the NTZ. But, while the families' biomass in the NPA stays equal we observe a decrease of Acanthuridae and overall Scaridae biomass in the NTZ. So what will be the long-term impacts of several opening periods on the reef fish community and the artisanal fishery operating on the area?

## 22-30

**Are No-Take Marine Reserves Helping To Sustain Fish Stocks? Tracking Larval Dispersal And Connectivity Of Fish Populations Within The Great Barrier Reef Marine Park.**

**David WILLIAMSON*[1,2]**, Richard EVANS[1,2], Geoff JONES[1,2], Garry RUSS[1,2], Simon THORROLD[3]

[1]School of Marine & Tropical Biology, James Cook University, Townsville, Australia, [2]Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA

No-take marine reserves have generally been established with the primary goal of protecting or restoring natural states of biodiversity and ecosystem productivity. It has been widely demonstrated that given time and adequate protection, no-take reserves can produce clear benefits for exploited species within reserve boundaries. Higher abundances of target fish species, with larger average sizes, ages and higher potential reproductive output are commonly demonstrated effects of reserve protection. In recent years there has been increasing interest in the potential contribution of no-take reserve networks to the sustainability of fisheries resources. Increased egg production per unit area of reef, means that reserves may potentially operate as sources of fish larvae. Larvae which are dispersed to surrounding open reefs may provide a recruitment subsidy to exploited fish stocks. Limited empirical data on larval dispersal distances, scales of population connectivity and export effects of no-take marine reserves remains an impediment to expansion of marine reserve networks. Furthermore, the optimal location, size and spacing of no-take reserves within networks cannot be accurately defined in the absence of such data.

Here we outline experimental trials of a new technique which utilises enriched stable isotopes to provide maternally transmitted markers from female fish to their offspring. These trials have demonstrated that the technique is effective and safe for use on large commercially important reef fishes and that treated fish present no consumption risk for humans. We also provide an overview of a research project utilising these trans-generational markers to track the dispersal of larvae of two recreationally and commercially important fish species from no-take marine reserves in the Great Barrier Reef Marine Park.

## 22-31

**Temporal Effects Of Marine Reserves On Target Fishery Species On Near-Shore Reefs Of The Great Barrier Reef, Australia**

**Richard EVANS*[1]**, David WILLIAMSON[1], Garry RUSS[1]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

The Great Barrier Reef Marine Park was established in 1975 to enable the management of the world's largest network of coral reefs. Access to the reef is limited by boat size and weather conditions. The Great Barrier Reef (GBR) is routinely referred to as one of the best managed coral reef systems. However, the GBR still faces similar issues to the rest of the world, i.e. nutrient run-off, coral bleaching, tourism, and exploitation. To manage these impacts in a large area, a multiple-use zoning plan was fully implemented in 1988. In 2004, the new Representative Areas Program was implemented to protect biodiversity, which increased the protected areas from 4.5% to 33.4% of the entire Great Barrier Reef Marine Park. Since 1998, underwater visual surveys were conducted around three near-shore continental island groups over 600km apart. These easily accessible reefs are heavily used by recreational fishers and not commercial fishers. This study demonstrates greater density and biomass in no-take marine reserves consistently over at least 5 years for two target species, *Plectropomus* spp. (coral trout) and *Lutjanus carpnotatus* (Snapper). Thus showing that recreational fisheries can impact on fish stocks as much as commercial and/or subsistence fisheries. Furthermore, with the implementation of the Representative Area Program, our research group designed a BACI sampling experiment to test the effect of the new zoning plan on the target fishery species. Recent results from this study demonstrate rapid increases in density and biomass for both species (*Plectropomus* spp. and *L. carponotatus*) by at least 50% within two years. This presentation also investigates temporal trends of the broader fish community and the benthos in relation to no-take marine reserve protection.

## 22-32

**Science to Support Coral Reef Fisheries Management: Lessons from the U.S. Coral Reef Conservation Program**

**Thomas HOURIGAN*[1]**, James BOHNSACK[2], Robert SCHROEDER[3]

[1]Office of Habitat Conservation, NOAA National Marine Fisheries Service, Silver Spring, MD, [2]Southeast Fisheries Science Center, NOAA/National Marine Fisheries Service, Miami, FL, [3]Pacific Islands Fisheries Science Center, NOAA/National Marine Fisheries Service, Honolulu, HI

The United States National Oceanic and Atmospheric Administration's Coral Reef Conservation Program supports effective management and sound science to preserve, sustain, and restore valuable coral reef ecosystems. Fisheries on U.S. reefs face many of the same challenges as those elsewhere, and addressing the adverse impacts of fishing on reef ecosystems has been a major area of focus over the program's first seven years. Integrated habitat mapping, monitoring, and targeted ecological research in both the Atlantic and Pacific are providing new insights and improved fishery management tools.

1) Habitat-stratified monitoring of reef fishes has enhanced survey precision, provided insights in how fishes use different habitats, and allowed fishery independent stock assessments of both targeted and non-targeted species.

2) New techniques allow researchers to identify nursery grounds of fish and track ontogenetic movements to the reef.

3) Broad-scale geographic surveys across gradients of fishing effort indicate that even low levels of exploitation can fundamentally alter biomass of exploited species and trophic relationships in ecosystems.

4) Hydroacoustic surveys are revealing spawning aggregation sites that can be linked with protection.

5) Monitoring of marine reserves has confirmed their efficacy in increasing the size and number of previously exploited species within reserve boundaries.

Examples of where these research results are being applied to U.S. reef fisheries management and challenges for future research will be presented.

## 22-33

**Are The Coral Reef Finfish Fisheries Of South Florida Sustainable?**

**Jerald S. AULT*[1]**, Steven G. SMITH[1], James T. TILMANT[2]

[1]Marine Biology and Fisheries, University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, Miami, FL, [2]Water Resources Division, National Park Service, Fort Collins, CO

If healthy reefs are Florida's future, exploitation of reef fish stocks must be reduced. Numerous sustainability indicators revealed that most of Florida's reef fish species are seriously overfished, assuming they are functioning as a unit stock. Annual growth in recreational fishing effort compounds this problem. We used fish population abundance and size structure data from fishery-independent (reef fish visual census) and fishery-dependent (creel surveys) monitoring programs from the Florida Keys and Biscayne National Park to estimate stock mortality rates and current reproductive potentials of the seven most commonly harvested reef fish species. We found that the majority of species in the snapper-grouper complex for which exploitation parameter estimates could be made are below the 30% Spawning Potential Ratio (SPR) federal standard for stock sustainability. Once stock exploitation status was determined, alternative fishery management actions that could possibly reduce fishing mortality and increase reproduction potential sufficiently to achieve sustainable stock conditions were evaluated. Results indicated that, when using only traditional management approaches, such as increased minimum harvest sizes or decreased bag limits, rather radical changes will be needed to achieve sustainable stock conditions for most species, and any improvements may be negated by a continued increase in fishing effort in a relatively short period of time. We conclude that non-traditional fishery management actions, such as limited entry or permanent removal of a portion of the stock from exploitation will likely be needed to achieve long-term sustainability of Florida's coral reef finfish fisheries into the future.

## 22-34

**The Relevance of Traditional Ecological Knowledge for Modern Management of Coral Reef Fisheries in the South Pacific**

**Marc LÉOPOLD*[1]**, Jean-Brice HERRENSCHMIDT[1], Randy THAMAN[2]

[1]IRD (Insitut de recherche pour le developpement), Noumea, New Caledonia, [2]USP (University of the South Pacific), Suva, Fiji

Traditional ecological knowledge (TEK) has received great attention in coral reef associated fisheries as a way to adapt modern management strategies to local environmental conditions. This specialized knowledge refers to group identity, techniques and skills which have been accumulated through generations, and improved by individual experiences. We analysed the socio-cultural role of TEK for resource management in traditional Melanesian communities in New Caledonia. A multidisciplinary survey of Ouvea customary marine tenure and fishing regulations was realized in 2006. Main chiefdoms and clans were questioned about past and present fishing activities, maritime territory rights, taboo areas and toponyms, customary authorities, socio-cultural practises and belief related to marine resources, and vernacular knowledge on marine organisms. Aerial photographs helped to collect spatial information (fishing grounds, chiefdoms boundaries…). Fishing customary rules (marine reserves, collective fishing of schooling species and access rights to well localized reef and mangrove areas) were primarily related to cultural events and social organization. Subsistence and commercial fishing co-occurs in this socio-cultural context. The relationships between TEK, population needs and uses of the environment were still tight but have changed since 1850s. Unquantifiable loss of indigenous knowledge has occurred. Nowadays, to fill the needs, modern users shunt this TEK and behave in relation to their own perceptions. Our results suggest that Ouvea customary management system is now socially rather than ecologically driven. Better consideration of socio-cultural aspects in resource conservation issues may therefore indirectly help to increase awareness on resource depletion and biodiversity loss. This emphasizes the need to enhance the socio-cultural role of TEK in South Pacific islands to achieve ecosystem sustainability.

## 22-35

**A Method For Assessing The Catch Sustainability Of Ornamental Fish Bycatch, With An Emphasis On Families Pomacanthidae And Chaetodontidae**

**Caroline FEITOSA*[1]**, Maria Elizabeth ARAÚJO[1], Beatrice FERREIRA[1]

[1]Federal University of Pernambuco, Recife, Brazil

The global effects of reef fish captured as bycatch – including ornamental species – are poorly known. Most fishes captured for the aquarium trade in Brazil belong to the Pomacanthidae and Chaetodontidae families. This study aimed to record the occurrence of bycatch ornamental fishes in trap fisheries and to assess the susceptibility and recovery of some fishes from the aquarium trade's major families. Each species was assessed according to two groups of criteria: (1) their relative vulnerability to capture by traps and (2) their population's relative recovery capacity related to sustaining mortality due to fishing. Within each group, each species was ranked (1-3) based on individual criteria representing distribution, catchability, diet, reproductive biology, removal rate for the aquarium trade, and mortality. These criteria were then weighted according to their importance and each species' mean weighted ranks for the two groups of criteria were plotted. Nineteen ornamental fish species from 14 genera and 10 families were recorded. The order of the species least likely to be sustainable was *Holacanthus tricolor*, *H. ciliaris*, *Chaetodon striatus*, and *Pomacanthus paru.* These benthic species that inhabit coral reefs are highly susceptible to capture by traps. *C. striatus* and *P. paru* were the most likely to be sustainable, although highly susceptible to capture. Although somewhat subjective, this approach is very promising for data-poor situations and may be the only one available for researchers and managers of diverse fisheries like the Brazilian trap fisheries, which occur in areas of high species richness such as coral reefs.

## 22-36

**Ornamental Fisheries As An Option To Commercial Fisheries: Would Fishermen Make The Switch?**

**Antares RAMOS-ALVAREZ*[1]**

[1]Zoology, University of Oxford, Oxford, United Kingdom

The aquarium trade in Puerto Rico is an area where many factors remain unstudied. Public policy has been implemented without taking into consideration the carrying capacity of the ecosystem or the species and with even less understanding of the users needs. Changes in fishing quotas and fishing permits were made without proper consultation or warning, making it hard for fishermen to assimilate. Past studies have found that fish are being extracted safely below the quota, when the opposite was thought. With increasing *vedas* (closed seasons) on key commercial species and SCUBA diving becoming a popular fishing method among young fishermen, ornamental fisheries might be an obvious option for these fishermen. In this study we interviewed a total of 51 fishermen, including ornamental and commercial, to further understand their needs and perceptions on fisheries, using semi-structured interviewing methods. Commercial fishermen were asked about their knowledge in the aquarium trade and they were asked if they saw it as a possible income option in the time of the *vedas.* The results present mixed views regarding the switch to ornamental fisheries (even a seasonal switch) due to the high price of the fishing permit for this type of commerce. Commercial fishermen that fish using SCUBA perceive ornamental fishing as a possible income option. This research brings light into the management of these resources as well as a possible need to change policy. Further research is suggested to look into the life histories of the key ornamental species so that more complete and specific management plans and changes in policy are made.

## 22-37

**Pacific-Wide Reduction Of Reef Fish Biomass Near Human Population Centers**

**Robert SCHROEDER*[1]**, Benjamin RICHARDS[1], Marc NADON[1], Brian ZGLICZYNSKI[2], Russell BRAINARD[2]

[1]Coral Reef Ecosystem Division, JIMAR-University of Hawaii and NOAA-Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Coral Reef Ecosystem Division, NOAA-National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, HI

Reef fishes comprise the most important renewable resource sought on Pacific coral reefs. Healthy reef fish assemblages are essential for maintaining ecosystem integrity that supports sustainable reef fisheries. Many of these resource species are particularly vulnerable to overfishing, especially targeted large/predatory species, with negative ecosystem consequences. Biennial assessments of coral reef fish assemblages were conducted around 50 U.S. Pacific Islands (from Guam to Hawaii to Samoa) from 2002 to 2007 using two complementary visual-census methods: (belt-transect [all fish] and towed-diver survey [large fish]). At the island level, regression analysis showed a strong trend of decreasing total fish biomass density with increasing human population (~proxy for fishing pressure). Highest total fish biomass density (>6.4 t/ha) was found at uninhabited Jarvis Island in the U.S. Line Islands and lowest (<0.2 t/ha) at Oahu, Hawaii (population ~900,000). The two survey methods showed generally similar trends. Apex predators were most abundant at uninhabited and/or remote islands, and lowest near human population centers. Overall, the remote, nearly pristine equatorial U.S. Line Islands (Jarvis, Kingman, Palmyra), U.S. Phoenix Islands (Howland, Baker), and Wake Atoll supported the highest fish biomass density, followed by the Northwestern Hawaiian Islands, and then by the remote northern islands of the Marianas Archipelago and atolls of American Samoa (Rose and Swains). Islands near major population centers had the lowest fish biomass density (e.g., the heavily exploited main Hawaiian Islands, the southern Mariana Islands, and the populated American Samoa Islands [Tutuila and Manua group]). This study is the first comprehensive, long-term, Pacific-wide assessment of coral reef fish assemblages using the same methodologies by the same group of researchers. Such ocean-wide comparisons of near-pristine islands to populated islands are valuable for providing the scientific basis for management options and affording managers an incentive to act.

## 22-38

**Spatio-Temporal Patterns Of Abundance, Size Frequency Distribution And Biomass Of Groupers in The Philippines**

**Samuel MAMAUAG*[1]**, Cleto NAÑOLA, JR. [2], Porfirio ALIÑO[1], Melchor DEOCADEZ[1]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]University of the Philippines-Mindanao, Davao City, Philippines

Groupers are apex predators on coral reefs that have slow growth, long life span and with low rates of natural mortality and recruitment. High exploitation levels on reefs in the Philippines may result in over-fished grouper stocks. Using fish visual census, spatio-temporal patterns of abundance, size frequency distribution and biomass of groupers were determined for six local biogeographic areas in the Philippines including sites with Marine Protected Area (MPA). Species assessed included *Plectropomus leopardus*, *Cephalopolis cynostigma*, *C. boenak*, *C. argus*, *C. urodeta*, *Epinephelus fasciatus* and *E. coioides*, among others. Composition of groupers varied among biogeographic regions with South China Sea and Sulu Sea showing greater number of species. Sulu Sea which includes Tubbataha reefs, the largest MPA in the Philippines, had the highest total biomass and also showed more larger groupers compared to others. *P. leopardus* showed the lowest abundance while *C. urodeta* and *C. argus* were the highest. These suggest that the larger *P. leopardus* have already been extirpated in many areas with some sites (e.g. Bolinao in Lingayen Gulf) having no records of size reaching sexual maturity (>30 cm TL). The level of regulation of fishing pressure suggests that *C. urodeta* and *C. argus* can attain larger sizes in the MPAs such as those in Tubbataha. Aside from fishing pressure, other patterns of distribution were confounded by the habitat preferences of the species (e.g. *C. boenak*, *E. fasciatus* and *E. coioides*) that showed some association with distinct habitat types, depth, and their biogeographic location range. These findings suggest that bigger MPAs need to be established for critical life history stages such as spawning aggregation sites since there are still records of moderate to high abundance despite the high fishing pressure.

## 22-39

**Red Hind (*epinephelus Guttatus*) Spawning Aggregations in The U.s. Virgin Islands: Movement And Migratory Patterns**

**Elizabeth KADISON*[1]**, Richard NEMETH[1], Jeremiah BLONDEAU[1]

[1]Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Spawning aggregations of commercial reef fish are extremely vulnerable to over fishing and have been decimated in tropical systems throughout the world. Seasonal and permanent fishery area closures are effective for protecting spawning aggregations however adequate size and placement of closures is dependent on accurate knowledge of the location of the aggregation site as well as movement patterns of fishes immediately before, after and during spawning. The Marine Conservation District (MCD) is a 41 km2 reserve on the Puerto Rican shelf edge that has been closed for ten years to all bottom fishing. Red hind (*Epinephelus guttatus*) spawn annually in the eastern quarter of the reserve in numbers estimated to be greater than 80,000 over a 0.35 km2 area. Tag returns of fish tagged on the spawning site indicate that red hind move west and northwest to home ranges outside of the protected area when spawning ends. The aim of this study was to determine migration routes to the aggregation site as well as movement patterns of fish while on the site between spawning events. Hydro-acoustic transmitters were inserted into red hind of both sexes caught in the aggregation area over two spawning seasons. Receivers were deployed in curtain arrays around the site and along the shelf-edge of the insular platform to detect tagged fish up to 300m away. Little significant daily movement was detected while fish were on the aggregation site over the two month spawning period indicating that the MCD was adequate in size and location to protect fish during this time. Overall spatial and temporal movement patterns were differential between sexes, however specific migratory routes were identified. These followed particular habitat types and could serve as predictors for migratory patterns of red hind in similar aggregations, influencing decisions for other marine reserve boundaries.

## 22-40

**Effects Of MPA Status On The Population Structure And Age-Based Demography Of A Heavily Exploited Reef Fish, *Lethrinus Harak***

**Brett TAYLOR*[1]**

[1]Marine Laboratory, University of Guam, Hagatna, Guam

Marine protected areas (MPAs) have been considered the most practical fishery management option for small island nations where imposing size/effort restrictions on fisherman is problematic. The success of this management option in facilitating recovery of heavily fished stocks has been well documented with numerous examples of increased abundance and biomass of target species within well protected areas. However, the success of MPA implementation in preserving exploited fish stocks for the longer-term can only be evaluated through the collection of more detailed information such as demographic parameters and accurate abundance estimates. In this study I compared total abundance, growth, age, length frequency, mortality and biomass of *Lethrinus harak* between two marine preserves and two fished sites on the pacific island territory of Guam. This fish is among the most important food fishes on Guam and is heavily exploited in both the commercial and recreational inshore fisheries. Given that landed biomass of *L.harak* has decreased significantly in the past decades despite increases in fishing intensity, I set out to test whether (1) there were significant differences in the population parameters I measured and (2) whether these results were correlated with the degree of protection from fishing. Abundance data collected by visual census, using an optimized sampling design stratified by habitat, has revealed a clear ontogenetic shift in habitat preference at all sites. Juveniles are restricted to seagrass areas while adults occupy numerous backreef habitats. For one MPA-nonMPA pair, density was greater in the fished site due to a greater abundance of juveniles, while overall biomass and spawner biomass were 4 and 142 times greater in the MPA, respectively. As habitat preferences differ among the life stages of *L.harak*, those MPAs on Guam which contain little or no juvenile habitat play a greater role in protecting older individuals with a higher reproductive potential.

## 22-41

**Using Length-Frequency Data To Identify Management Options: A Case-Study Based On Five Years Monitoring Of The Large Seine Net Fishery Of Rodrigues Island, Indian Ocean**

**Alasdair EDWARDS*[1]**, Emily HARDMAN[2], Jovani RAFFIN[2]

[1]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]Shoals Rodrigues, Pointe Monier, Mauritius

The large seine-net fishery in the 240 km² shallow lagoon of Rodrigues Island is of great socio-economic importance in terms of both protein and employment. Seine net fishing is undertaken by teams of 15 and 30 fishers, using four to eight boats. Annual landings from the fishery of 190 to 300 tonnes have been recorded since 2000. Working with local fishing cooperatives, the NGO Shoals Rodrigues has monitored the seine catch since 2002, recording the species and total length of each fish caught during 125 sampled fishing days. A total of over 68,000 fish in 110 species have been sampled with data on each individual entered on a specially designed database to facilitate analysis. The fishery is diverse and the most commonly caught species include *Siganus sutor, Valamugil seheli, Naso unicornis, Acanthurus triostegus, Lethrinus nebulosus, Mulloidichthys flavolineatus, Caranx melampygus* and *Gerres longirostris*.

Analysis of the length-frequency distributions for the primary species in the catch suggests that several of the main species caught are being severely overexploited but that others are being exploited sustainably at close to optimal levels of effort. The overexploited species tend to be those that are deeper bodied (e.g. *Siganus sutor*) and thus caught at a younger age, whereas the sustainably exploited species tend to be those that are shallow-bodied (e.g. goatfish and mullet) and thus caught much later in life.

A surplus yield model based on government fisheries statistics suggests that the fishery may be at a sustainable level overall. However, the length-frequency data shows that several species are heavily overexploited. Data on length at first capture shows that an increase in mesh size is unlikely to be practical. A network of marine reserves and an MPA are being implemented in an effort to ensure sustainability in the face of excess fishing pressure.

## 22-43

**Patterns in A Catch-And-Release Sport Fishery Targeting A Pristine Stock Of Caranx Ignobilis At Midway Atoll**

**Raymond BOLAND*[1]**, Frank PARRISH[1]

[1]NMFS/NOAA, Pacific Islands Fisheries Science Center, Honolulu, HI

From 1996 to 2001, a catch-and-release charter fishery was conducted in waters of the U.S. Fish and Wildlife Service Wildlife Refuge at Midway Atoll in the Northwestern Hawaiian Islands. In the history of the coral atoll, this was the first and only organized fishing directed at giant trevally (*Caranx ignobilis*) and it caught a total of 751 fish. Fishing logs indicated an overall trend of increased fishing effort throughout the 6-year period. Catch per unit of effort (CPUE) derived as catch per day, per trip, per boat hour, and per hook-hour declined between one-half and one-third of initial levels, then increased from 1999 to 2001. The increase of CPUE during the later part of the study corresponded to wider spatial distribution of the fishing effort throughout the atoll. In 1998 the U.S. Fish and Wildlife Service implemented a tagging study at Midway Atoll, tagging 356 *C. ignobilis* of which 24 were recaptured, 4 more than once. Time periods at liberty for the fish ranged from 0 to 389 days and movement was seen across the atoll. Recapture data for fish tagged at Midway and at neighboring atolls showed no movement of jacks between atolls. Treating the adult jacks at Midway Atoll as a closed population and assuming a constant capture probability, the number of resident jacks was estimated at 2590 (± 793 SE). The data from Midway indicates catch and release fishing has a measurable effect on the atoll's jack assemblages. It is not known whether the decline is a result of post release mortality from capture events; or the result of experienced jacks avoiding fishers.

## 22-44

**Behavioral Effects Of Fishing On Coral Reefs**

**Elizabeth MADIN*[1,2]**, Steven GAINES[3,4], Robert WARNER[1,2]

[1]Dept. of Ecology, Evolution, and Marine Biology, University of California - Santa Barbara, Santa Barbara, CA, [2]Marine Science Institute, University of California - Santa Barbara, Santa Barbara, [3]Marine Science Institute, University of California - Santa Barbara, Santa Barbara, CA, [4]Dept. of Ecology, Evolution, and Marine Biology, University of California - Santa Barbara, Santa Barbara

The community-level consequences of predator removal, and indeed the mechanisms behind them, are poorly understood in coral reef systems. However, the majority of coral reefs globally experience some degree of fishing pressure, much of which is focused on predatory fishes. To date, most research on this topic has been focused on changes in the density of prey species as the principal mechanism causing the effects of fishing to cascade through coral reef communities. However, an entirely different pathway exists by which fishing, and therefore predator removal, could fundamentally alter marine ecosystems: changes in the behavior of prey species. The Line Islands represent a gradient in human influence that ranges from nearly pristine coral reefs to ones with key upper trophic levels functionally removed. We used this system to ask whether prey fishes behave differently over a gradient of fishing intensity and thus predator biomass. We quantified behaviors of a suite of prey fishes spanning different functional groups, focusing on behaviors that are subject to a risk-reward trade-off and play a potentially important role in mediating benthic community structure. We found that these prey fishes exhibit demonstrable shifts in behavior over the gradient of predator biomass. In particular, time spent foraging versus sheltering and patterns of movement over feeding areas appear to be constrained by the level of predation risk imposed by predators. Our findings demonstrate that fishing on coral reefs may strongly affect prey species' behavior, and further suggest that these behavioral responses may have important implications for benthic community structure in ways not predicted from traditional density-mediated trophic cascade models.

## 22-45

**Reproduction, Habitat Utilization, And Movements Of Hogfish (*lachnolaimus Maximus*) in The Florida Keys: A Comparison From Fished Versus Unfished Habitats**

**Roldan MUNOZ*[1]**, Michael BURTON[1], Kenneth BRENNAN[1], R. O. PARKER, JR. [1]

[1]National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Beaufort, NC

Few studies conducted within reserves have examined the reproductive behavior of exploited reef fishes. We tested the hypothesis that reproductive output should be greater in a marine reserve (i.e., greater density and sizes of inhabitants) relative to a fished area. Our study took place in the Florida Keys National Marine Sanctuary in the Western Sambos Ecological Reserve (closed to fishing) and the Middle Sambos (fishing permitted). At these sites we gathered detailed information on microhabitat utilization of hogfish (*Lachnolaimus maximus*), their movements, encounter rates, and their reproductive behavior. Most of the data were collected with focal animal observations and the behavioral data geographically logged with a hand-held GPS. Multivariate analyses of microhabitats present on home ranges and utilized by hogfish indicate no overall differences between study sites, yet hogfish movements were greater at the fished site. Furthermore, despite a greater survey effort at the fished study site, no reproductive activity was seen there. In marked contrast, spawning was readily observed at the reserve site where 55 spawns were recorded from 6 different harems. Encounters with the potential to be inherently disruptive (i.e., male-male) tended to occur at a higher rate at the fished site. Conversely, encounters capable of stabilizing social groups (i.e., male-female) tended to occur at a higher rate in the reserve. These data suggest a breakdown of social structure at the fished site and highlight the role that marine reserves may play in the maintenance of reproductive output by site-attached fishes, particularly those with complex social and mating systems that experience intense fishing pressure; the easily-speared *L. maximus*, characterized by harem territories and female-to-male sex change, is a good example of such a species.

## 22-46

**Population Genetic Structure Of A Coral Reef Ecosystem Apex Predator, The Gray Reef Shark (Carcharhinus Amblyrhynchos)**

**Rebekah HORN*[1]**, William ROBBINS[2], Douglas MCCAULEY[3], Philip LOBEL[4], Mahmood SHIVJI[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [2]Cronulla Fisheries Research Centre, NSW Department of Primary Industries, Cronulla, Bangladesh, [3]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [4]Biology Department, Boston University, Boston, United States Minor Outlying Islands

Sharks play a major functional role as apex predators in coral reef ecosystems, raising concerns that their ongoing overexploitation will compromise the integrity and sustainability of reefs. The gray reef shark (*Carcharhinus amblyrhynchos*) is a strongly coral reef associated species whose populations are known to have declined substantially in some regions. There is no information on population structure in this species to aid in their management and conservation. We are assessing genetic structure in this species by using entire mitochondrial control region sequences and 15 nuclear microsatellite loci as markers. 93 gray reef shark samples were obtained from across the species' Indo-Pacific distribution (eastern Indian Ocean [Madagascar/Seychelles], Central Pacific [Hawaii], Southwestern Pacific (eastern Australia, Palmyra, Palau, Cocos (Keeling) Islands]). Mitochondrial (AMOVA) and microsatellite (STRUCTURE) data concordantly identify the Hawaii population as a distinct genetic group relative to other sampling locations. The microsatellite data further identify 3 distinct overall gray reef shark groups (eastern Indian Ocean, Central Pacific, and Southwestern Pacific). Our current analyses do not show any evidence of population structure among islands of the Southwestern Pacific, although this question is being further addressed with additional samples from more locations. These results show strong genetic differentiation exists in gray reef shark populations separated by expanses of open ocean, and suggest proper management of this declining species will have to occur at the very least on a regional geographic scale.

## 22-47

**Population Genetic Structure Of The Parrotfish Scarus Ghobban in The Western Indian Ocean And Its Implication For Fish Stock Management**

**Oskar HENRIKSSON*[1]**, Shakil VISRAM[2], Ruby MOOTHIEN PILLAY[3], Sadri SAID[4], Mats GRAHN[1]

[1]School of life science, Sodertorns university college, Huddinge, Sweden, [2]CORDIO East Africa, Mombasa, Kenya, [3]Mauritius Oceanography Institute, Quatre Bornes, Mauritius, [4]Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania

Much is unknown about the population structure of fish in the Western Indian Ocean (WIO). The knowledge of the genetic structure of a population is essential for the optimal designation of fish stocks this knowledge is important for sustainable management. Most fish stocks are today defined and managed by countries and not geographical regions. However, fish populations do not adhere to political boundaries, hence neither should the management of fish stocks. This study aims to investigate the genetic structure and connectivity of Scarus ghobban which is important for subsistence fishing in the WIO. Little research has so far been conducted on S. ghobban, and for this reason not much is known of its potential for migration and the genetic connectivity between different regions. The spatial genetic variation at 16 locations has been examined: 3 sites on Mauritius, 5 sites in Tanzania and 8 sites in Kenya. Levels of population differentiation were investigated using the DNA fingerprinting method Amplified Fragment Length Polymorphisms (AFLP). Results indicate the presence of several genetically differentiated subpopulations of S. ghobban, which might need to be managed separately. The implication of this data is that the current scale of management in the region is too local. Today the foremost management regime is mainly through beach management units which operate on a scale far smaller than the size of the potential fish stocks.

## 22-48

**Central Pacific Survey Reveals Lower Reef Shark Density Near Human Population Centers**

**Marc NADON*[1]**, Benjamin RICHARD[1], Brian ZGLICZYNSKI[2], Robert SCHROEDER[1], Russell BRAINARD[2]

[1]CRED, JIMAR-NOAA-PIFSC, Honolulu, HI, [2]CRED, NOAA-PIFSC, Honolulu, HI

Biennial surveys (2000-2007) of coral-reef shark populations were conducted around 50 U.S. Pacific Islands in several regions: the Hawaiian Archipelago, the Marianas Archipelago, the Line Islands, the Phoenix Islands, and the American Samoa Archipelago. Two fisheries-independent census methods were implemented by divers: stationary point counts and towed-diver surveys. Five species of sharks were recorded in sufficient frequency to allow meaningful statistical analyses: grey reef shark (*Carcharhinus amblyrhynchos*), galapagos shark (*Carcharhinus galapagensis*), whitetip reef shark (*Triaenodon obesus*), blacktip reef shark (*Carcharhinus melanopterus*), and tawny nurse shark (*Nebrius ferrugineus*). Preliminary analyses showed a highly significant negative relationship between grey reef and galapagos shark densities and proximity to human population centers (e.g., proxy for potential fishing pressure and other human impacts). Average combined numerical density for these two species near population centers was less than 1% of densities recorded at the most isolated islands (e.g., no human population, very low present or historical fishing pressure or other human activity). Even around islands with no human habitation but within reach of populated areas, gray reef and galapagos shark densities were only between 15 and 40% of the population densities around the most isolated near-pristine reefs. Trends in whitetip and blacktip reef shark numbers were similar, but less dramatic. Tawny nurse shark densities were low around most islands. This study is the first fisheries-independent large-scale survey of shark populations in the central Pacific. From our preliminary results we infer that some shark populations near human population centers are severely depleted.

## 22-49

**From Depensation To Compensation: Processes That Drive The Recovery Of A Depleted Population**

**Robert GLAZER*[1]**, Gabriel DELGADO[1], Lonny ANDERSON[2], David HAWTOF[3], Paul KUBILIS[4]

[1]Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, Marathon, FL, [2]Keys Marine Laboratory, Florida Fish and Wildlife Conservation Commission, Layton, FL, [3]Florida Fish and Wildlife Conservation Commission, Marathon, FL, [4]Program for Environmental Statistics, University of Florida, Gainseville, FL

The recovery of a depleted population depends to a great extent on the interactions between life history strategies and ecological processes. Using data from a 10-year study, we show the processes that affected how a population of queen conch (Strombus gigas) recovered in the Florida Keys archipelago. We describe the progression of the recovery from its initial stages where it was at critically low densities and was dominated by depensatory processes resulting in limited reproductive encounters. As the population density increased, the proportion of the population engaged in reproductive encounters also increased; however, the area occupied by the population remained relatively constant. In 1999, when the maximum density was achieved (approximately 1,100 conch per ha), compensatory processes predominated and the area occupied by the population expanded rapidly with a concurrent and significant shift of the population into less-favorable habitat. These processes help to explain recovery of depleted or endangered species and may provide guidance to managers on how best to design protected areas.

## 22-50

**Changes in Ecosystem Structure Induce Trade-Offs in Storage And Reproduction Across Fishes From Multiple Trophic Levels**

**Sheila WALSH*[1]**, Benjamin RUTTENBURG[1,2], Scott HAMILTON[3], Mary DONOVAN[3], Stuart SANDIN[1]

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, [2]Marine Science Institute, University of California, Santa Barbara, Santa Barbara, [3]Marine Science Institute, University of California, Santa Barbara, Santa Barbara, CA

Ecosystem structures characterized by different predation, competition, and resource regimes may select for specific energy allocation strategies at the organismal level. Shifts in energy allocation between somatic storage and reproduction may ultimately have consequences that scale back up to the ecosystem level. We tested the effect of changes in ecosystem structure on total weight, liver weight, and gonad weight for five species of fish, each representing a different trophic level. We collected fishes from a cross-island and a within-island gradient of predator biomass to control for biogeographic and regional-scale oceanographic effects. The gradients also represent gradients in resource availability. Fish weight at length decreased with increasing predator biomass for all species except the top predator. The effect was increasing with decreasing trophic level, suggesting that lower trophic level species were also affected by decreasing resource availability. Liver weight at weight of unreproductive fishes showed a similar pattern to total weight. Gonad weight at weight, however, showed differences in the direction of the effect across trophic levels. Gonad weight decreased for higher trophic level fishes but increased for lower trophic level fishes. The difference in the effect on reproductive allocations may be due to the compounded effects of increased mortality and decreased resource availability. The trend of decreasing weight at length with decreasing fishing pressure, a proxy for predator biomass, was found to be general when our data were compared to published data from other regions. Our results indicate a community-wide response in energy allocation to changes in ecosystem structure. Ecosystems dominated by predators and coral may actually increase fish community productivity by inducing shifts in energy allocation away from storage and toward reproduction. However, the net effect will depend on the relative contribution of and interactions between somatic and population growth.

## 23-1

**Conservation Of Coral Reefs By The Global Network Of Marine Protected Areas**

**Camilo MORA*[1]**

[1]Dalhousie University, Halifax, Canada

Marine Protected Areas (MPAs) are being used as a primary solution to the worldwide decline of coral reefs, but there is no global summary of their performance. In this project, I carried out a global survey to assess the regulations of MPAs and their enforcement and compliance and used existing databases to assess their levels of risk from human threats. I found that whilst 18% of the world's coral reefs are covered by MPAs, only ~2% is in areas of adequate conservation status, and less than 0.01% in areas of excellent status. Troublingly, a threefold increase in the number of existing MPAs is estimated to be necessary for the protection of ecological processes that maintain the high diversity of coral reefs. The inefficiency and insufficiency of existing MPAs in protecting coral reefs globally highlights the current vulnerability of this ecosystem and the need for an urgent reassessment of global-scale conservation strategies, if the worldwide decline of coral reefs is to be reduced.

## 23-2

**Mohéli Marine Park, Comoros – Successes And Challenges Of The Co-Management Approach**

Melissa HAUZER[1], **Chris POONIAN*[2]**, Cheikh MOUSSA IBOURA[3]

[1]C3-Comores, Iconi, Comoros, [2]Community Centred Conservation (C3), London, United Kingdom, [3]Mohéi Marine Park, Moheli, Comoros

Mohéli Marine Park (Parc Marin de Mohéli, PMM) was the first Marine Protected Area (MPA) to be established in the Comoros in 2001. Initially regarded as a model for co-management of marine resources, PMM is now operating at a vastly reduced capacity following an end to external funding sources. An assessment of current perceptions of local stakeholders of PMM was recognized as an essential first step in rebuilding its capacity and effectiveness as an MPA. This study aimed to ascertain stakeholders' current perceptions of PMM, using focus group interviews to evaluate six key parameters: (1) basic awareness, (2) value, (3) effectiveness, (4) environmental threats and solutions, (5) stakeholder roles and responsibilities and (6) future aspirations and expectations. It was apparent that most local communities were aware of the importance of PMM, but felt that it had failed to include their needs or consider their input in its management. Concern was expressed for the lack of sustainability or alternative livelihoods; inequitable distribution of benefits; exclusion of women; continuing environmental threats and a concurrent lack of enforcement of regulations. The key recommendations to arise from this work were: (1) ensure sustainability through effective financial planning and promotion of low-cost, appropriate management techniques; (2) mobilize local communities to create a truly co-managed PMM; (3) ensure tangible benefits to local communities through realistic alternative livelihood options, particularly for fishers; (4) ensure equitable sharing of benefits and awareness of PMM, (5) involve women in the management of PMM, they are the primary local educators and motivators for future generations; (6) inform law enforcement officials and members of the justice system to ensure understanding, respect and enforcement of PMM regulations.

## 23-3

**Systematic Marine Conservation Planning Towards A Representative Areas Network in Aceh, Indonesia**

**Yudi HERDIANA*[1]**, Stuart CAMPBELL[1], Andrew BAIRD[2]

[1]Wildlife Conservation Society - Indonesia Marine Program, Bogor, Indonesia, [2]Australian Research Council Centre of Excellence for Coral Reef Studies (ARCCoERS), Townsville, Australia

A turbulent history and geographic isolation have prevented systematic surveys of coral reef resources in Aceh. Following the Indian Ocean tsunami, ecological studies revealed that while most marine habitats where unaffected by the tsunami, many reefs were seriously degraded as a result of decades of destructive fishing and poor coastal development. The recovery of these degraded reefs following dramatics reductions in human activity as a result of the tsunami is remarkable. Ironically, socio-economic recovery in Aceh is re-introducing anthropogenic threats as fishing pressure and coastal development increase. Some conservation initiatives are in progress, however, these also pose a threat because they lack coordination and integration. A systematic marine conservation plan is required to allow natural recovery processes to continue and to protect marine resources from emerging threats. Here we outline an Initiative planning process following the 'Systematic conservation planning' guidelines (Margules and Pressey, 2000) in which the conservation goal was to protect at least 30% of existing coastal ecosystems. Data for the analysis included ecological (e.g. coral substrate, reef fish condition, invertebrate), socio-economic (e.g. fishing pressure) and reef resilience data collected from 64 sites within the province. Spatial information for this analysis (e.g. mangrove habitat, distance to inhabitant) was derived from satellite imagery due to an extended coast line, habitat complexity, variation in accessibility and the number of existing stakeholders throughout the region the optimal approach suggested was the establishment of many small protected areas in a network as opposed to a few large areas. Furthermore, our analysis also suggests that existing MPAs in Aceh do not achieve the target of habitat representation. This work provides a solid basis for the establishment of a network of MPAs to achieve the conservation goals for the region and protect and enhance livelihoods.

## 23-4

**Changes in The Reef Fish Biomass in Karimunjawa National Park: A Test Of The Effectiveness Of Government Gazetted Marine Parks in Indonesia**

**Rizya ARDIWIJAYA*[1]**, Andrew BAIRD[2], Tasrif KARTAWIJAYA[3], Stuart CAMPBELL[3]

[1]Marine Program Indonesia, Wildlife Conservation Society, Bogor, Indonesia, [2]ARC Centre of Excellence Studies - Coral Reef Studies, James Cook University, Townsville, Australia, [3]Wildlife Conservation Society, Bogor, Indonesia

In August 2005 following extensive community consultation, national legislation was enacted that changed the boundaries of zones that regulate fishing and other marine resource use activities in Karimunjawa Marine National Park in the Java Sea, Indonesia. The park included 5 management zones ranging from a no-take area to open access. Here, we report the results of three years of monitoring reef fish assemblages conducted to evaluate the effectiveness of the zoning regime. Fish biomass within the park has decreased by 40% since 2005. This decrease was mostly caused by a reduction in the numbers of large fish and decreases in the abundance of some of the more common family eg. Scaridae. Further analysis by trophic groups indicated that the biomass of carnivores, herbivores and planktivores had all decreased compared to 2005. Missing carnivores included large individuals from targeted families eg. Lutjanidae, Haemulidae, Serranidae and Lethrinidae whose biomass has decreased by 41 % from 2006. Scaridae fishes where the dominant herbivores and their biomass decreased by 35% from 2005. Caesionidae were the most abundant planktivore and their biomass decreased by 57% from 2006. This decrease in the biomass of Scaridae was linked to an increase in fish catch recorded within 2006. While this initial three years of monitoring is not sufficient to be confident of these trends in fish fluctuations, the decrease of several target species is a cause for concern and they should continue to be monitored. Furthermore, many of the declines were evident in all management zones, including the no-take zone, which suggests stronger enforcement and greater engagement with the fishing communities is required to prevent a continued decline in fish stocks within the park.

## 23-5

**Measuring Success in Managing Two Marine Protected Areas: Process, Indicators And Lessons in Palawan Province, Philippines**

Giselle PB SAMONTE-TAN[1], **Michael D PIDO*[2]**, Nadia P ABESAMIS[3], Ma Celeste A PONTILLAS[2], Shellane NAGUIT[3], Romeo B TRONO[3]

[1]Conservation International, Crystal Drive, VA, [2]Palawan State University, Puerto Princesa City, Philippines, [3]Conservation International-Philippines, Quezon City, Philippines

In the tropics, few efforts have been directed at evaluating the effectiveness of marine protected areas (MPAs). Concrete correlations between management actions and desired conservation outcomes are not adequately demonstrated. This paper describes the process, indicators and lessons learned in developing monitoring and evaluation (M&E) programs to assess the effectiveness of management regimes for Tubbataha Reef National Marine Park (TRNMP) and Coron Island Ancestral Domain (CIAD), both situated in Palawan Province, Philippines. The TRNMP (designated as a World Heritage Site in 1993), covers 33,200 hectares of offshore reefs of exceptionally high biodiversity. The CIAD covers 22,284 hectares of ancestral land and waters, whereby the indigenous peoples (Tagbanwa) was awarded a Certificate of Ancestral Domain Title in 1998. The process undertaken to develop the M&E programs included: stakeholder consultations and consensus on biophysical, socioeconomic and governance indicators; creation of an M&E team; data collection; information sharing; capacity building of M&E team; and institutionalization of management structure for implementation. Biophysical indicators measure how much of the marine resources, biological diversity, individual species and habitat is protected; socio-economic indicators largely measure the economic status in terms of household occupational structure; and governance indicators are mostly process indicators. The lessons learned are: active involvement of the local government units is crucial for effective MPA management; capacity building for the management staff and participating agencies is a major bridge for overcoming technical difficulties in undertaking M&E functions; developing partnerships between the local government and the local stakeholders helps in accessing relevant information; and a multi-disciplinary approach, utilizing relevant mix of indicators, provides a more complete assessment for measuring the success of MPAs. This study is an output of Conservation International-Philippines' project on "Development of Management M&E Programs for Two Protected Areas in Palawan" with funding from the United States National Fish and Wildlife Foundation.

## 23-6

**Using Ichthyoplankton Distribution in Selecting Sites For An Mpa Network in The Sulu Sea, Philippines**

Pacifico II BELDIA[1], **Wilfredo CAMPOS*[1]**, Cesar VILLANOY[2], Maritess CANTO[2], Porfirio ALINO[2]

[1]Oceanbio Laboratory - Division of Biological Sciences, University of the Philippines in the Visayas, Miag-ao, Iloilo, Philippines, [2]Marine Science Institute, University of the Philippines Diliman, Quezon City, Philippines

This investigation was conducted to provide data and information needed to establish an ecologically functional network of MPAs in the Sulu Sea Basin, by making use of data on fish larval (ontogenetic) distribution and composition, as well as dispersal modeling in identifying areas with potentially high recruitment (sink) and or areas with high potential as egg and larval sources. Highest egg and larval concentrations were observed in the immediate vicinity of the atolls and reefs along Cagayan Ridge and in embayments along the western border of Sulu Sea (east coast of Palawan) during Summer, suggesting that these areas are major sources of eggs and larvae within the Basin at this time of the year. During the transition to the NE Monsoon (October), highest egg concentrations were observed in the same areas, but larvae were most abundant along a north-south mid-basin transect from Cuyo Is. to Cagayan Ridge. Large-scale circulation patterns show that the atolls and reefs of Cagayan Ridge may be a major source of recruits to coastal habitats along the east coast of Palawan during the Summer. This link may be disrupted during the transition to the NE Monsoon as the prevailing strong northeasterly current isolates Cagayan Ridge from Western Sulu Sea. During this season, the Cuyo Group of Islands appears to be a major source of propagules to the western half of Sulu Sea, while potential exchange within atolls and reefs within Cagayan Ridge is also at its maximum. The ontogenetic distributions of several larval groups, together with dispersal modeling, are further examined to verify the above scenarios.

## 23-7

**Multiple Direct And Indirect Effects Of A Marine Reserve On Caribbean Fish And Benthic Communities**

**Alastair HARBORNE*[1]**, Peter MUMBY[1], Carrie KAPPEL[2,3], Craig DAHLGREN[4], Fiorenza MICHELI[5], Katherine HOLMES[6], James SANCHIRICO[7], Kenneth BROAD[8], Ian ELLIOTT[9], Daniel BRUMBAUGH[6]

[1]School of Biosciences, University of Exeter, Exeter, United Kingdom, [2]National Center for Ecological Analysis and Synthesis, University of California Santa Barbara, Santa Barbara, CA, [3]Hopkins Marine Station, Stanford University, Pacific Grove, [4]Perry Institute for Marine Science, Jupiter, FL, [5]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [6]Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, [7]Department of Environmental Science and Policy, University of California, Davis, Davis, CA, [8]Rosenstiel School of Marine and Atmospheric Science, Division of Marine Affairs and Policy, University of Miami, Miami, FL, [9]School of Biosciences, University of Exeter, Exeter

Data documenting many of the effects of no-take reserves are surprisingly scarce, and trophic cascades are particularly poorly understood. Here we examine both the direct and indirect effects of the Exuma Cays Land and Sea Park (The Bahamas) by sampling benthic and fish communities inside and outside the reserve, with surveys stratified by habitat ('*Montastraea* reef' and 'gorgonian plain'). To distinguish reserve effects from natural variation, we compared changes inside and outside the reserve with those seen at equivalent spatial scales in other reef systems in the Bahamian archipelago that lack reserves. Reserve-level differences in benthic or fish communities not documented in other reef systems were categorised as 'robust' effects, and were limited to *Montastraea* reefs. The reserve supported an average of ≈15% more fish species per site compared to outside the reserve. Increases in fish biomass and differences in community structure inside the reserve were limited to large-bodied groupers. This increased population of piscivorous large grouper has the potential to reduce the key process of macroalgal grazing by parrotfish prey. However, because large-bodied parrotfishes escape the risk of predation from large piscivores, the negative predation effect was overwhelmed by the positive effects of reduced fishing pressure, resulting in a net doubling of grazing. Increased grazing by parrotfishes in the reserve has lowered macroalgal cover, and caused previously undocumented changes in benthic community structure compared to sites outside the reserve. Furthermore, reduced macroalgal cover has doubled the density of coral recruits. Finally, a higher biomass of urchin predators within the park has reduced populations of the ecologically-important *Diadema antillarum* compared to outside the park. Caribbean marine reserves are a key conservation tool with a range of beneficial effects, but the trophic cascade between urchins and their predators demonstrates the complexities of restoring key processes in disturbed ecosystems.

## 23-8

**Reef Fish Spawning Aggregations Are Vulnerable: The Role Of SCRFA In Promoting Their Conservation And Management**

Patrick COLIN[1], Michael DOMEIER[2], Janet GIBSON[3], Brian LUCKHURST[4], Martin RUSSELL[5], Yvonne SADOVY[6], **Terry DONALDSON*[7]**

[1]Coral Reef Research Foundation, Koror, Palau, [2]Marine Conservation Science Institute, Falbrook, CA, [3]Wildlife Conservation Society, Belize City, Belize, [4]GCFI, Umbria, Italy, [5]Great Barrier Reef Marine Park Authority, Townsville, Australia, [6]University of Hong Kong, Hong Kong, China, People's Republic of, [7]Marine Laboratory, University of Guam, Mangilao, Guam

The Society for the Conservation of Reef Fish Aggregations (SCRFA) was formed to raise awareness of the vulnerability of reef fish spawning aggregations (FSAs) to exploitation and other negative impacts. SCRFA works towards the protection and management of FSAs while promoting a greater understanding of their form and function. SCRFA maintains a data base of known FSAs and reef fish spawning aggregation sites (FSAS); most are not managed yet, while others are afforded some form of protection from the creation and maintenance of marine protected areas, time and season closures, sales bans during spawning seasons, are reductions in effort. These management tools are usually employed singly or, to a lesser extent, in combination. SCRFA has initiated international calls for action at ITMEMS 2 and 3, at the 4th IUCN World Fisheries Congress, and elsewhere to promote conservation awareness and to stimulate the design and implementation of management efforts to achieve conservation goals. SCRFA utilizes two principal methods of surveying FSAs and FSAS towards meeting these goals. Fisher interview surveys gather local knowledge of spawning aggregation location, use, and history. Field surveys, following methods described in the SCRFA Methods Manual, are conducted to verify fisher survey data, characterize FSAS, and describe the current status of FSAs. SCRFA has conducted surveys in Fiji, Indonesia, Micronesia, Palau, Papua New Guinea, Sabah (east Malaysia), and the Solomon Islands. The outcomes of these surveys, coupled with analyses of data in the SCRFA data base, may be used to assist fisheries and conservation agencies and entities in protecting and managing FSAs and FSAS, as well as promote future research into FSA dynamics. These outcomes will be described in greater detail.

## 23-9

**Movement Patterns Of The Highfin Grouper (Epinephelus Maculatus, Serranidae) in A Fragmented Coral Reef Habitat: Implications For The Design Of Marine Reserves**

**Olivier CHATEAU*[1]**, Laurent WANTIEZ[1]

[1]LIVE, University of New Caledonia, Noumea, New Caledonia

Acoustic telemetry was used to examine the movement patterns of 7 Highfin Groupers (*Epinephelus maculatus*, Serranidae) in a fragmented habitat in New Caledonia, over a period of 375 days. The studied area included a marine reserve and two unprotected reefs separated by large areas of lagoon soft bottoms (900 m and 2000 m). The fish were detected between 7 days and 341 days. Only one fish show strong site fidelity within the hydrophone network during the study. The other fish were not detected by the same hydrophone more than 8 consecutives days. Four fish (57%) were exclusively detected on the reef where they were released. Three of them realized large within-reef movements (> 3 km) in spite of their short monitored period (up to 78 days). Three other fish (43%) were detected on a different reef than the reef where they were released. The minimum distance covered during their monitored period (9 days to 341 days) ranged from 11 km to 24 km. Three patterns of between-reef movements were identified for these fish including installation outside the reserve, multiple between-reef movements within the area, and punctual excursions outside the daily home range. The identified patterns of movements suggest the capacity for the studied fish to disperse with time. The within-reef movements confirm that partial reefs closures may not be effective to protect *E. maculatus*. The detected between-reef movements show the ability for *E. maculatus* to carry out medium-scale movements in a fragmented habitat and suggest that the studied reserve do not protect the entire population of this species.

## 23-10

**No-Take Reserves And The Benthic Assemblages Of Florida's Coral Reefs**

**Lauren T. TOTH*[1]**, Richard B. ARONSON[2], S. Robertson SMITH[3], Thaddeus J. T. MURDOCH[4], Staci A. LEWIS[5]

[1]University of South Alabama, Mobile, AL, [2]Dauphin Island Sea Lab, Dauphin Island, AL, [3]Department of Biology, Georgia State University, Atlanta, GA, [4]Bermuda Zoological Society, Flatts FL BX, Bermuda, [5]Environmental Science and Policy Department, George Mason University, Fairfax, VA

Marine protected areas have become common tools for coral reef management. Despite their widespread use, it is unclear whether the affects of protection can be translated to beneficial impacts on the benthic assemblages. The aim of this study was to characterize changes in community structure within the Florida Keys National Marine Sanctuary following the establishment of no-take reserves from 1998 to 2007. Reefs both inside and outside 3 no-take zones were surveyed using underwater video transects. A comparison between No-take and reference sites was used to determine if protection had an effect on benthic composition. A significant overall decrease in coral cover found at all sites and was consistent with trends throughout the Caribbean. The declines were in part due to the losses of the once-abundant population of *Monastrea* spp. There have been other significant changes in species dominance of scleractinian corals, and several species present at the onset of this study are no longer detectable. Despite such marked changes in benthic assemblages, there was no conclusive relationship between these shifts and levels of protection of the reefs. Although there was high cover of macroalgae during several sampling periods, substrate suitable for larval settlement accounted for 27-90% of total cover during the sampling periods. This indicates that despite the effect that no-take reserves may be having on fish populations, the causes of the continuing decline in the health of reefs in the Florida Keys operate at spatial and temporal scales beyond the scope of such protection.

## 23-11

**Scaling Up To Networks Of Marine Protected Areas in The Philippines: Biophysical, Legal, Institutional And Social Considerations**

**Alan WHITE*[1]**, Kem LOWRY[2], Patrick CHRISTIE[3]

[1]Gobal Marine Initiative, The Nature Conservancy, Honolulu, HI, [2]University of Hawaii, Honolulu, HI, [3]School of Marine Affaires, University of Washington, Seattle, WA

Marine protected areas (MPAs) are an accepted means of protecting coral reef and associated habitats and enhancing near-shore fisheries. The growing number of MPAs is stimulating the formation of planned and managed MPA networks. This study documented and learned from the development of MPA networks in the Philippines and identified critical success factors and issues. Methods were field observation by participation in MPA and fisheries management projects and a focused interview protocol that gathered opinions and observations of primary MPA network stakeholders. Findings showed that an MPA network is defined through social and ecological criteria. From a social perspective, a network is comprised of people and organizations that manage component MPAs, benefit from the network, and promote the networks' viability through shared administrative responsibility and information. To qualify ecologically, individual MPAs must interact in an ecologically meaningful manner (e.g., source or sink of larvae and propagating organisms, protection for quality habitat and threatened or endangered species, etc.) that enhance fisheries and biodiversity conservation. Thus, a MPA network is composed of individual MPAs founded on an institutional framework that supports interaction, not just a group of individual MPAs. The study found that while social and ecological criteria are shaping MPA networks through science based planning, integrated management and coordination, there exist numerous issues related to scaling up to networks from single MPAs. Issues pertain to: limiting access to resources, boundary delineation, monitoring compliance, finding common goals and identity, and conflict resolution. Success factors included common institutional processes and legal support, improved understanding of benefits from a network and improved habitat conditions and fishery yields associated with MPAs.

## 23-12

**Finding The Right Fit For Ecosystem-Based Management in The Philippines**

**Rose-Liza OSORIO*[1]**

[1]Coastal Conservation and Education Foundation, Inc., Cebu, Philippines

Spatial scales for ecological marine protected area networks do not necessarily fit into existing governance frameworks in the Philippines. The Philippines adopts a highly decentralized approach to coastal management including marine protected area (MPA) management. Each local government authority exercises management powers and responsibilities over their coastal zone which is measured from the shoreline to 15-km seaward of municipal waters. The local government initiatives have resulted to the establishment of over 300 MPAs in Central Philippines to improve marine habitats and enhance fishery resources, with only 20-30% of MPAs effectively managed with sustainable fishery benefits. With the increasing number of MPAs, the need for joint MPA management efforts in order to increase management effectiveness as well as protect areas beyond MPA boundaries has arisen. Thus, a definitive governance structure has been sought within the fisheries ecosystem scale following the ecosystem-based management approach. This paper will present the management strategies, outcomes and lessons of the Local Governance for Coastal Management Project for the Management of Coral Reefs and Fisheries in the Philippines since January 2002. The project has been working towards scaling-up the geographic scope to achieve the desired results in fisheries ecosystem management by expanding from a municipal up to a much broader collaboration at the inter-local government unit, provincial and regional scale. It focuses on activities that address the needs in institutional building and strengthening, fisheries management, habitat management, foreshore management, and coastal law enforcement.

## 23-13

**Some Hints About The Impacts Of Watershed Management On Mpas in The South Pacific Islands**

Gilbert DAVID[1], **Pascal DUMAS*[2,3]**, Marc DESPINOY[3], Morgan MANGEAS[3], Jean-Brice HERRENSCHMIDT[3]

[1]IRD, St Denis, Reunion, [2]University of New Caledonia, Noumea, New Caledonia, [3]IRD, Noumea, New Caledonia

The high islands of the Pacific are characterised by short and steeply-sloping watersheds, where erosive events can generate large sediment material run-off loads that threaten the adjacent reefs, even when these are protected by a Marine Protected Area (MPA). Because of the increasing population pressure, industry, land clearance and associated new agricultural land and other human activities are growing, thus increasing their negative impacts. To this background, the establishment of MPAs should be accompanied by an integrated management policy.

Besides, in small islands, the reef and most of the watershed are integral parts of the same village or chiefdom territory. In a region where place is the very foundation of identity, a physical bond links people to their territory, i.e. to the space that they have taken ownership of to perpetuate the social group and to satisfy their vital needs. The right spatial unit, in which any integrated watershed /coastal zone management initiative must be implemented, should be first defined.

Our global objective is to foster the emergence of an integrated cross-cutting approach based on public policy tools, monitoring methodology and local-scale stakeholder dynamics. The monitoring statement is based on a scientific foundation and indicators suited to Pacific Island settings coming from remote sensing analysis, environmental risk mapping, territoriality and socio-economic values assessment, watershed dynamics and hydrological modelling, gathered in a unique *Environmental Information System*, a Web interoperable GIS system. All the relationships between those data are then studied in order to achieve modelling and adapted integrated management policy.

## 23-14

**The Need To Use A Large-Scale Ecosystem Based Approach To Improve Future Coral Reef Management**

**Billy CAUSEY*[1]**

[1]National Marine Sanctuary Program, NOAA, Key West, FL

Scientists and managers have recognized the plummeting health of coral reefs in the Wider Caribbean for two decades. Decline in living coral cover and coral recruitment continues to occur both inside intensely managed marine parks and sanctuaries, as well as remote coral reefs. These changes are affecting the diversity and complexity of coral reef biota throughout the region. The primary cause of coral decline remains a topic of scientific debate. While traditional coral reef management practices have had some local successes, local and regional decline of corals continues. Strategies that reduce direct impacts to coral and seagrass beds, such as mooring buoys and boating restrictions, have had positive results. Marine zoning has demonstrated benefits to heavily fished species in some protected areas. Research, monitoring, and education programs have helped managers and stakeholders better understand the complexities of coral reefs and their biological and socioeconomic importance. Yet, coral reefs have continued to decline at all scales due to the impacts of climate change, land-based sources of pollution, habitat destruction and overfishing. Traditionally, coral reef managers have focused management activities within the boundaries of their specific protected areas. However, recent experience has demonstrated that managers need to be effective at broader spatial scales. The future success of coral reef management relies on the utilization of remote sensing technologies applied across broad spatial extents in an ecosystem-based approach. The global impacts of climate change on coral reefs, coupled with regional and local stressors, require managers to consider less traditional strategies to protect and conserve coral reefs. We must work cooperatively and in partnerships across both domestic and international jurisdictional boundaries, using a large-scale ecosystem-based approach to management. Such an approach must consider broad-scale watershed influences, physical and biological connectivity, reef resilience and collaborative interagency and stakeholder relationships to improve ocean governance.

## 23-15

**Defining The Biogeography Of An Endangered Reef Fish Spawning Aggregation To Inform Marine Reserve Planning And Evaluation**

**Brice SEMMENS*[1]**, Phillippe BUSH[2], Scott HEPPELL[3], Christy PATTENGILL-SEMMENS[4], Bradley JOHNSON[5], Croy MCCOY[5], Leslie WHAYLEN[6]

[1]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, [2]Cayman Islands Government, Cayman Islands Department of the Environment, Grand Cayman, Cayman Islands, [3]Oregon State University, Corvallis, OR, [4]Reef Environmental Education Foundation (REEF), Key Largo, FL, [5]Cayman Islands Department of the Environment, Grand Cayman, Cayman Islands, [6]Islamorada, Village of Isands, Islamorada, FL

Protections on spawning aggregations are critical to the long-term sustainability of many marine fishes, particularly groupers and snappers. The two biggest stumbling blocks for effective management of marine fish aggregations are: 1) limited information regarding the spatial and demographic influence of aggregation sites (i.e.- how many fish, where are they from, what is their demographic status?), and 2) limited experiences regarding socio-political methods for implementing conservation strategies. We will present results from an acoustic tagging project in the Cayman Islands explicitly designed to evaluate the recent decision to establish known Nassau grouper (Epinephelus striatus) spawning sites as marine reserves. Our study defines the biogeography of a large spawning aggregation in a group of islands separated by abyssal water, and demonstrates that aggregations can be exclusively and exhaustively representative of local (island-specific) stocks of reproductive-aged fish. Our findings will allow the Cayman Islands government to assess the current and future impacts of protections afforded local spawning aggregations.

## 23-16

**Inferring The Appropriate Spatial Scale Of Design And Management For Mpa Networks: An Interdisciplinary Case Study From The Bahamian Archipelago**

**Daniel BRUMBAUGH*[1,2]**, Kenny BROAD[3], Craig DAHLGREN[4], Alastair HARBORNE[5], Katherine HOLMES[1], Carrie KAPPEL[6], Fiorenza MICHELI[7], Jessica MINNIS[8], Peter MUMBY[5], Claire PARIS[3], James SANCHIRICO[9], Richard STOFFLE[10]

[1]Center for Biodiversity & Conservation, American Museum of Natural History, New York, NY, [2]National MPA Center, NOAA, Santa Cruz, [3]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [4]Perry Institute for Marine Science, Jupiter, FL, [5]School of Biosciences, University of Exeter, Exeter, United Kingdom, [6]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA, [7]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [8]School of Social Science, College of The Bahamas, Nassau, Bahamas, [9]Department of Environmental Science and Policy, University of California - Davis, Davis, CA, [10]Bureau of Applied Research in Anthropology, University of Arizona, Tucson, CA

Designers of MPA networks, both in theory and in practice, typically use biodiversity representation or population connectivity as criteria for the placement or spacing of individual MPAs. Rarely, however, do researchers or planners integrate inferences from both of these criteria with those derived from the study of various human dimensions. The Bahamas Biocomplexity Project (BBP), a large collaborative project, was initiated to (1) address how networks of ecologically-connected marine protected areas (MPAs) may function across realistic seascapes; and (2) respond to recent management directions in The Bahamas. Drawing on approaches from oceanography, population genetics, ecology, anthropology, and economics, the BBP is integrating theory and data in statistical and computational models about Bahamian coastal dynamics. Major areas of interest include the critical seascape dimensions for conservation planning and the crucial interactions and feedbacks among physical, biological, and social systems that can influence how MPAs and MPA networks function. Across the Bahamian archipelago, several lines of evidence, including variation in species-habitat relationships, simulations of population connectivity, population genetics, and sociopolitical considerations, suggest that primary conservation planning for coral-reef ecosystems should occur at the scale of major islands.

## 23-17

**The U.s. Coral Reef Task Force: A Model For Fostering Coral Reef Management At National To Local Scales**

**Beth DIEVENEY*[1]**, Roger GRIFFIS[2]

[1]National Ocean Service, NOAA, Silver Spring, MD, [2]National Marine Fisheries Service, NOAA, Silver Spring, MD

The purpose of this study was to assess the strengths and challenges of U.S. Coral Reef Task Force (USCRTF) efforts to mobilize U.S. coral reef conservation at local to international levels. The unique success of the USCRTF has been its ability to bring together government entities with diverse mandates to identify national goals and foster work at the local level that addresses both local and national priorities for coral reef conservation. The USCRTF includes 12 U.S. Government agencies, seven states and territories, and three Freely Associated States. This broad membership makes the USCRTF uniquely situated to promote coral reef conservation in a holistic, ecosystem-based approach. The USCRTF developed the first U.S. National Action Plan to Conserve Coral Reefs and the National Coral Reef Action Strategy which both serve to define and direct its overarching goals, objectives, and activities. These national goals were further refined into place-based Local Action Strategies (LAS) to address six priority threats: over-fishing, land-based sources of pollution, recreational overuse and misuse, lack of public awareness, climate change, and coral bleaching/disease. The LAS provide a framework for USCRTF member agencies to identify and address these threats and additional local needs, connect local priorities to national goals, coordinate Federal agency actions with local management of reef resources, and increase collaboration and resources to implement conservation actions. In addition, LAS provide a means to specifically focus on the needs of one region or jurisdiction while also providing a mechanism to apply adaptive management among and between the various regions. The USCRTF has also utilized its diverse membership to promote a broad suite of other management, research, and technical tools to more effectively and collaboratively manage coral reef ecosystems.

## 23-18

**Mesoamerican Marine Protected Area Effects on Resource User Livelihoods**

**Mark ZEGLER*[1]**

[1]Interdepartmental Graduate Program in Marine Science, University of California Santa Barbara, Santa Barbara, CA

This paper analyzes the changes in the livelihoods of local coastal resource users that occurred due to the designation of marine protected areas in Belize and Mexico within the Mesoamerican Barrier Reef Systems (MBRS). These marine protected areas are situated in coastal waters of the Bacalar Chico Marine Reserve and the Parque Nacional Arrecifes de Xcalak in Belize and Mexico respectively and were both established to promote biodiversity conservation and economic development. Fieldwork in 2004-2005 documented the changes that occurred to local livelihoods in the conservation, fishery, and tourism sectors. The modifications to coastal governance regimes changed local livelihoods in each case study area. Implementation of marine protected areas reduced fishery pressure on many commercial fish species, and increased pressure on some species targeted by tourist sport fishing boats. In both cases, some locals benefited as conservation and tourist use expanded, while others lost jobs in the fishery sector. The results of this research indicate that marine protected areas affect livelihoods and shift use from commercial fishing to conservation and tourist use of the reef. Geographic information system analyses of informant map biographies indicate that the spatial patterns of livelihood activities changed within the boundaries of each respective marine protected area. Evidence suggests protected area networks can be effective in promoting societal goals for conservation and development if geographic, institutional, and social factors are included in the design process.

## 23-19

**Coral Cover, Reef Fish Abundance And Revenues Of Gilutongan Marine Sanctuary, Central Philippines From 1998 -2007**

**Pamela Alma AMOLO*[1]**, Rizaller AMOLO[1]

[1]Coastal Conservation and Education Foundation Inc., Cebu City, Philippines

Gilutongan Marine Sanctuary (GMS) is a 15ha marine protected area (MPA) in Central, Philippines. It was established as a means to rehabilitate degraded reef and address dwindling fish catch. Its management has proven to be an effective strategy that has made it an important tourism destination and has generated economic revenues. This study examines the trends of the benthic community and reef fish population from the 10-year biophysical monitoring conducted in GMS from 1998 – 2007. It also compared the tourist arrival and revenue generated by the MPA . Benthic data showed a significant change in live hard coral cover and coral mortality index, both inside and outside the marine sanctuary, after 10 years of protection. A significant difference in fish abundance was observed inside and outside portions of the MPA. Tourist arrival and revenue rapidly increased over the first 3-years of protection and has gradually level-off in recent years. This paper also presents lesson learned in managing MPAs involving community and tourism activities. Some of which includes: management and monitoring of tourism and other potential impacts is a crucial element for MPA sustainability. Also, revenues from MPA should benefit the community primarily involved in its management.

## 23-20

**Seaweed Farming: An Alternative Livelihood, A Last Resort, Or Subsidising Overfishing Of Coral Reefs?**

**Nicholas HILL*[1,2]**, EJ MILNER-GULLAND[3], Marcus ROWCLIFFE[1], Guy COWLISHAW[1], Amado BLANCO[4], Heather KOLDEWEY[5]

[1]Institute of Zoology, Zoological Society of London, London, United Kingdom, [2]Division of Biology, Imperial College London, London, United Kingdom, [3]Division of Biology, Imperial College London, Ascot, United Kingdom, [4]Project Seahorse Foundation for Marine Conservation, Cebu City, Philippines, [5]Zoological Society of London, London, United Kingdom

A lack of options is frequently seen as the cause of overfishing and destructive fishing on coral reefs. Alternative livelihoods have therefore been embraced to address this problem. Seaweed farming is one such alternative. Some authors have recognised that seaweed farming may just become one component of a diversified livelihood in poor communities, limiting its ability to reduce fishing pressure. However, cases do exist where seaweed farming achieves this goal. But few studies have examined the conditions under which it does so, and, more importantly, the conditions under which it can result in the opposite effect. We compare the situation in island communities on Danajon Bank in the central Philippines where seaweed farming is being actively promoted and has lead to different outcomes. Using interviews and group research, we examine the conditions under which seaweed farming reduces fishing pressure at a household and community level. In one community, unique environmental conditions and community-level attributes appear to have reduced fishing pressure following the uptake of seaweed farming at both the community and household level, resulting in a perceived increase in fish abundance. Elsewhere, we find that for some households it only acts as an activity of last resort when fishing is no longer viable. Of greatest concern, seaweed farming appears to be subsidising some households' intensive fishing activity in heavily degraded areas where they are operating at a loss and would otherwise not be able to continue fishing. Understanding the conditions that lead to these different outcomes will help us to develop more effective management interventions when confronted with issues of poverty. We address the conditions that have led to these different outcomes.

## 23-21

**Fishery Management For Artisanal Reef Fisheries in Developing Countries: A Holistic Economic Approach**

**Christopher LIESE*[1]**

[1]Social Science Research Group, SE Fisheries Science Center, National Marine Fishery Service, NOAA, Miami, FL

This paper argues that traditionally exploited renewable resources in developing countries, in particular artisanal coral reef fisheries, are difficult or impossible to manage with classical fishery management tools. Further, given many special characteristics of these fisheries, even the usual policy objectives need to be questioned. By taking a closer look at the setting and the decisions that underlie the behavior of the fishing households, a different approach to management reveals itself. A set of policy options, based on a broader economic scale and new to the fisheries context, is more likely to be feasible and effective at conservation.

The explicit treatment of household-level behaviors and market settings, in addition to selected social and demographic elements, adds important dimensions to the management problem. The combination of these economic, social and demographic forces largely determines fishing pressure and hence the biological health of the resource. In turn, the status of the resource profoundly affects human well-being. A collapse will create unemployment, worsen poverty and possibly lead to large population movements. As a result, governments must find ways to conserve these resources in an effective, practical and equitable manner.

This paper tries to identify these second best solutions, i.e. feasible policies that might conserve the current health and potential of the resource in spite of it being exploited under an open access property rights regime. For instance, income diversification and alternative employment programs, usually an afterthought to conservation projects, should be reevaluated as primary tools for conservation. Further, long-term family planning policies and policies leading to poverty reduction are likely to have the greatest impact. The coral reef fishery of Minahasa, Indonesia serves as illustration throughout this paper.

The views expressed herein are my own.

## 23-22

**Coral Reef Resource Values, Trade and Sustainability**

**Benjamin STARKHOUSE*[1]**, Louise TEH[1], Lydia TEH[1], Yvonne SADOVY[2], Rashid SUMAILA[1]

[1]Fisheries Center, University of British Columbia, Vancouver, BC, Canada, [2]University of Hong Kong, Hong Kong, Hong Kong

Coral reef ecosystems are high in marine biodiversity, and are also significant socio-economically as a source of food and income in many developing countries. Trade in coral reef resources brings up biological as well as social and economic issues. The removal of target species causes disturbances to the structure of the coral reef ecosystem. Increasing demand for trade products can lead to the depletion of many fish and invertebrate stocks, resulting in economic hardship for fishers who target these species for artisanal and subsistence purposes.

First, we give an overview of our project on coral reef values, trade and sustainability. Second, we give details on the coral reef valuation component of our project. The objective being to examine the net benefit of coral reef resource export trade relative to the benefits from other uses of reef resources to the source country, here, Fiji. Although Fiji is selected for a case study, the outcomes are expected to have much broader application, especially to the island countries of the Pacific. Fiji relies on its coral reef ecosystems for food, tradable commodities and tourist dollars. Even though a substantial contributor to Fiji's economy, a comprehensive, national-level valuation of the coral reef sector is nonexistent. We will present an in depth analysis of the socio-economics of Fiji's coral reef resources. Our focus is on all reef-associated species harvested for food (finfish, invertebrates and plants), the marine aquarium industry, industrial and commercial uses of coral, reef products that are processed and/or exported, such as trochus shells, and coral reef related tourism such as diving, snorkeling and fishing. The results from this study will reveal the true direct use value of Fiji's coral reefs and can assist resource managers in developing socio-economically sustainable coral reef resource use strategies.

## 23-23

**Coral Reef Reserves In Vanuatu; Ecological Vs. Socio-Cultural Impacts**

**Christopher BARTLETT*[1]**, Charley MANUA[2]

[1]SEES, James Cook University, Townsville, Australia, [2]Nguna-Pele Marine Protected Area, Port Vila, Vanuatu

This paper examines people's perceptions of local social-ecological systems as influenced by the presence of community-based coral reef management initiatives in the Republic of Vanuatu. National and regional Melanesian characteristics, such as strong customary marine tenure and decentralized governance, are highlighted as integral to understand the existence of local marine reserves as well as to give context to historical marine resource use patterns. We assess human-nature interactions and perceptions of marine resource levels and management of all individuals from six (6) small insular communities; three (3) with strong local management regimes, three (3) without. The research employs a comparative analytic methodology based on socio-cultural and ecological participatory research. We demonstrate that communities with the most robust local management regimes and long-term coral reef reserves, have significantly different average perceptions of the SES including stronger local governance, social cohesion, management responsibility and human agency. Results indicate that small-scale marine reserves and associated activities in insular Melanesia may have influence into village social and cultural realms that transcend intended ecological benefits. It will be intimated by the authors that these social and cultural impacts may be of the most valuable benefits of marine reserves to be gained by the SES in small Melanesian communities with extremely limited sea tenure areas. This thesis is discussed in light of the temporal and spatial scales necessary for effective management of coral reef ecological systems. We conclude that some small Melanesian marine reserves, combined with the village social and cultural attributes they enhance, significantly contribute to regional management capacity, thus enriching the marine reserve 'effectiveness' debate

## 23-24

**A Business Approach To Coral Reef Management: The Main Hawaiian Islands Seascape Strategy Model**

**Melissa BOS*[1]**

[1]Conservation International, Honolulu, HI

The frontier of coral reef management involves the application of business principles and tools to conservation planning and implementation. Many current management strategies are limited by reductionism and lack of financial planning. The Main Hawaiian Islands Seascape Strategy is an example of a holistic, business-like approach to marine resource conservation. In the business analogy, a conservation planner becomes an executive of a conservation business. The business plan begins with the description of the company's product, in this case, management of ecosystem goods and services. Long-term direct and opportunity costs of management are compared with market and non-market values of ecosystem goods and services. Potential customers, revenue streams, and investment portfolios are analyzed. Commercial marketing techniques are used to target consumer behavior. Liabilities and risks of management scenarios are taken into consideration. Economic incentives and market-based approaches are included in implementation. The business approach, coupled with strategic stakeholder consultations, scientific assessments, and governance reviews, will allow management planning to progress beyond the target of sustainability to ecological, economic, social, and cultural prosperity.

## 23-25

**Economic Valuation Of The Shoreline Protection Services Provided By Coral Reefs And Mangroves – Implications For Management**

**Lauretta BURKE*[1]**, Sean PADDY[2], Charmaine O'BRIEN-DELPESH[2], Emily COOPER[1]

[1]People and Ecosystems Program, World Resources Institute, Washington, DC, [2]Institute of Marine Affairs, Carenage, Trinidad and Tobago

Coral reefs and mangroves play a critical role in protecting shorelines across the Caribbean. By reducing wave energy, coral reefs mitigate both routine erosion and damage from waves associated with small and moderate storm events. Mangroves play an increasingly important role in mitigating waves and storm surge associated with Category 3 hurricanes and larger storm events. Shoreline protection is an important and economically valuable ecosystem service. Maintaining the integrity of coral reefs and mangroves is essential to retaining their shoreline protection benefits.

Shoreline protection will become increasingly important as sea surface temperatures rise, storm intensity increases, and sea levels rise. Coastal planning to avoid development in areas that are most vulnerable to waves and storm surge, and to protect key mangrove and reef areas will become increasingly important under a changing climate.

Under a project on economic valuation of coral reefs and mangroves in the Caribbean, The World Resources Institute (WRI) and the Institute of Marine Affairs (IMA) have developed a framework for evaluating the relative vulnerability of the shoreline to waves and storm damage, and the relative share of shoreline protection contributed by these habitats. The framework integrates ten physical characteristics (including coastal elevation, slope, geomorphology, exposure, wave energy, storm regime, vegetation, and coral reef characteristics) to arrive at an index of relative stability of the shoreline. Policy makers can also use the framework to evaluate the potential economic "damages avoided" in coastal areas due to the protection provided by coral reefs and mangroves.

The methodology has been applied in Tobago, St. Lucia and Belize, and provides a valuable tool for identifying vulnerable areas and planning coastal development under changing climate, as well as valuing these shoreline protection services. The results point to the economic sense of retaining mangroves and supporting healthy coral reefs in vulnerable coastal areas.

## 23-26

**The Involvement Of The Private Sector in Marine Protected Area Planning, Management, And Conservation: Case Studies From The Indo-Pacific**

**Rick MACPHERSON*[1]**, Sherry FLUMERFELT[2], Florence DEPONDT[2]

[1]Conservation Programs, Coral Reef Alliance, San Francisco, CA, [2]Coral Reef Alliance, San Francisco, CA

Science is effective in informing the design of successful marine protected areas (MPAs), only if balanced with socioeconomic, cultural, and political realities. The importance of involving community stakeholders in MPA planning, design, and management is now widely acknowledged and accepted. One key coral reef stakeholder group that has received increasing attention in recent years are private sector marine recreation providers (MRPs)–dive, snorkel, kayak, and boating operators. MRPs in coral reef tourism destinations have a vested economic interest in supporting coral reef conservation, as their business depends upon a healthy reef. They can play a key role in successful conservation if educated, aware, and involved in the process. MRPs can also pose frustrating obstacles for marine park/resource managers if their needs are not addressed and they are not part of conservation planning. The Coral Reef Alliance (CORAL) works in the Indo-Pacific to build the support and collaboration of MRPs in marine protected areas. Through case studies we illustrate the importance and process of involving MRPs in coral reef conservation strategies. Participation of this key stakeholder group not only builds local support for conservation, but also helps fulfill critical conservation objectives such as financial support of resource management costs, assistance with biophysical monitoring of reefs, patrolling and reporting violations, educating visitors on best environmental practice, and providing local communities with non-extractive, non-destructive employment alternatives.

## 23-27

**Incorporating Traditional Management Practices Of Indigenous Peoples Of Tawi-Tawi, Philippines in Coral Reef Management**

**Filemon ROMERO*[1]**

[1]Center for Oceanographic Studies, Mindanao Sate University, Cainta, Rizal, Philippines

Tawi-Tawi province, part of the Sulu Archipelago reef complex, divides two large marine ecosystems: The Sulu Sea and the Celebes Sea. This reef complex, constituting about 25% of the total reef cover of the Philippines, performs a very critical ecological function as the spawning and nursery ground of varied marine species but also serves as corridors for migratory marine mammals, fish stocks and turtles. To address the threats to this reef complex like dynamite and cyanide fishing, the WWF Coastal Resources and Fisheries Conservation Project (CRFC) Tawi-Tawi was implemented. Management strategies that worked included laymanizing the baseline assessment results on coral reefs, reef fishes, mangroves and seagrasses as well as fisheries studies into IEC materials produced in local dialects either in broadcast or print. Engaging local government early on and providing counterparts for the initiatives developed their sense of ownership. Indigenous beliefs and traditional management systems like habitats of "revered" species, fear of retribution from the ancestors, traditional seaweed farming system, traditional "ownership" were incorporated in the management framework. The Fatwah (Islamic Guidelines) on Environmental Management were likewise developed. Coastal law enforcement remains the weakest link and needs to be improved because of some institutional and organizational problems. The declared Marine Protected Areas, all of which are coral reef ecosystems, were the spatial scale on reef conservation ranging from 84 to 3,500 hectares. The MPA Management Boards were organized and the Management Plans formulated and implemented with community participation. Now, mechanism for local environmental governance has been set up, destructive fishing practices reduced and coastal habitats protected by the communities resulting to improved fish catch and livelihood opportunities for the coastal villages. Biological indicators are used to measure coral reef management success. Likewise socio-economic indicators have also been used.

## 23-28

**An analysis of community-based marine management in Fiji Islands: Case study of Korolevu-i-wai districtt**

**Patrick FONG*[1]**, Joeli VEITAYAKI[2], Bill AALBERSBERG[3]

[1]Institute of Applied Science, The University of the South Pacific, Nasinu, Fiji, [2]School of Marine Studies, The University of the South Pacific, Suva, Fiji, [3]Institute of Applied Science, The University of the South Pacific, Suva, Fiji

The participation of local people in resource management planning, designing and implementation in Fiji has proven to contribute to the effective and sustainable management of reef systems and resources. This paper presents the results of an anlysis of a community-based management (CBM) arrangement in Korolevu-i-wai district. The result of the CBM initiative in this region has been successful with notable positive outcomes. The resource management through the CBM approach has created better overall outcomes at present (2004 onwards) than those of the former system and period. The anlysis revealed that the social cohesion amongst the community members, the perceived condition of the fishery and reef system, the condition of the terrestrial and village environment and the community's understanding of the values of the marine environment and the resources associated with it have greatly improved in the district after the initialization of the CBM project. The average CPUE and income level of fishers in the district have also increased as results of the initiative

The assesment confirmed that the key conditions for the achievement of the positive impacts of the CBM project in Korolevu-i-wai District are: political support through the recognition of the rights of the community to make development and management decisions regarding the marine environment, economic status of the community, decision making group homogeneity, people's dependence on the marine resource as a source of income, availability of alternative sources of income, active participation of the community in project implementation and coordination and support and advice from outside agencies. This analysis has established that there are vital links between the roles of the marine environment in the livelihood of the people, the impact of the people's management roles in the sustainability of the marine environment, and the social and economic elements associated with it.

## 23-29

**"To Live With The Sea"; Development Of The Velondriake Community-Managed Protected Area Network, South West Madagascar**

Alasdair HARRIS[1], **Raj ROY*[1]**

[1]Blue Ventures Conservation, London, United Kingdom

Madagascar's south-west coast supports some of the largest coral reef systems in the western Indian Ocean. These reefs are essential to the survival of the indigenous Vezo people who rely on healthy marine resources for food, transport, cultural identity and income. However coastal populations are growing rapidly and international fisheries companies have begun exploiting the region's waters through a sophisticated collection network to supply an expanding export market. In recent years local fishers have begun reporting declines in the size and number of their catches.

Following a pilot marine no take zone launched three years ago in the remote fishing village of Andavadoaka, project partners are now working with 23 neighbouring villages, and fisheries collection companies to develop a network of community-run marine and coastal protected areas that will span more than 800-square kilometres and protect coral reefs, mangroves and seagrass beds along Madagascar's south-west coast. The villages, grouped into three constituent geographic regions, have established a management committee which serves as a liaison between conservation scientists and community members, providing input and insight into all phases of conservation planning, from research activities to implementation of management plans.

Along with protecting biodiversity and livelihoods, the network aims to increase environmental awareness among communities, expand local and national capacity for biodiversity conservation and serve as a model for other community conservation and governance initiatives across Madagascar and elsewhere. Velondriake aims to benefit villages within the network by empowering members of the local communities as managers of their own natural resources, enabling communities to contribute directly to the development of sustainable resource management systems to support local culture and livelihoods. Additional benefits are being brought to partner organisations through the capacity building resulting from involvement of personnel in the project and the improved availability of data, lessons learned and best practice guidelines.

## 23-30

**Assessment Of *Trochus Niloticus* From Shallow Reef Habitats Off The Hienghène And Pweevo Communes Of New Caledonia: Government And Tribal Management.**

**Sheila MCKENNA*[1]**, Stephen LINDSAY[2], Nathalie BAILLON[3], Henri BLAFFART[4], Edmond OUILLATE[5]

[1]Independent, Tuckers Town, Bermuda, [2]Consultant, Edgehill, Australia, [3]Direction de Developpement Economique et de Development et de l'Environnement, Province Nord, Kone, New Caledonia, [4]Dayu Biik Association and Conservation International, Hieghene, New Caledonia, [5]Tribu Panie, Hienghene, New Caledonia

Kanak tribes of the Hienghène and Pweevo communes of New Caledonia collect *Trochus niloticus* by hand or by free diving for subsistence and commercial purposes. Here, government and tribal laws regulate marine resource use and an official community based management plan is in development. For each commune, data on the amount of trochus extracted are recorded by year and no data exist for the populations *in situ*. To better understand their status, an assessment of the size (basal shell diameter) and density of trochus populations on 42 shallow (depth <12m) reef habitats was conducted using a transect method on three reef types of varying distances from shore. These included near shore fringing reefs, intermediate lagoon reefs and offshore barrier reefs. Given the artisanal nature of the trochus fishery, we tested *a priori* for significant differences in size and density for the three reef types. Twenty-one tribes were also interviewed regarding their perceptions and laws on marine resources. The mean diameter of trochus was significantly smaller ($p<0.01$) on the fringing reefs compared to the lagoon and barrier reefs. Only 129 individuals were observed during the survey and tribes noted more trochus in the past. Although the study was limited spatially and temporally, the findings suggest that government laws prohibiting extraction of trochus <9 cm in diameter are being followed. Greater mean size (>11cm) and population density on the lagoon and barrier reefs implies that accessibility is a factor in addition to trochus habitat preference. Trochus extraction data by commune in the previous year with the low population densities observed suggest that this species may be over-exploited. Size restriction as a managment tool appears to be effective, however more routine and extensive assessments are needed with continued collaboration between the tribes and government to determine appropriate management measures especially for extraction quotas.

## 23-31

**A Community Based Approach To Building A Regional Coral Reef Ecosystem Monitoring Program in The Freely Associated States Of Micronesia**

Shauna SLINGSBY[1], **Sebastian MARINO*[2]**

[1]Coral Reef Conservation Program, NOAA, Silver Spring, MD, [2]Palau International Coral Reef Center, Koror, Palau

From 2005-2007, NOAA's Coral Reef Conservation Program and Palau's International Coral Reef Center collaborated with local, regional, and international organizations to build capacity in coral reef ecosystem monitoring in the Freely Associated States of Micronesia. Micronesia has some of the most diverse and resilient coral reef ecosystems in the world and is arguably one of the better investments for coral reef conservation. A community based approach was emphasized over a period of three years, focusing on building capacity of local organizations and developing relationships between regional and international organizations. Forty-three members from Micronesia's governmental regulatory agencies (Marine Resources Division and Environmental Protection Agencies), local non-governmental groups, and academic institutions were trained in coral and fish taxonomy, reef sampling methods, experimental design, statistical analyses, database management, and reporting. The states of Chuuk, Kosrae, Palau, Pohnpei, Yap and the Republic of Marshall Islands (an area covering more than 30,000 square kilometers of shallow water habitat) are now using a standardized monitoring protocol to track changes in coral reef resources. This type of monitoring program, combined with traditional management practices in Micronesia, will provide long-term ecosystem-based management in this coral reef setting.

## 23-32

**Enabling Human And Reef Systems' Adaptation To Climate Change in Belize**

**Nadia BOOD*[1]**

[1]Belize, World Wildlife Fund, Belize, Belize

The health and integrity of Belize's reef complex is under increasing threat due to adverse anthropogenic activities, which will doubtless be compounded in the face of climate change. World Wildlife Fund is working on the ground in Belize to devise adaptation strategies that foster maintenance of reef-dependent livelihoods and reef ecosystem resilience to climate change. Efforts over the past two years focused on assessing the status of reefs and identifying healthy and potentially resilient reef systems, working with partners to advocate for conservation and management of identified healthy/resilient reefs through: raising awareness of key stakeholders and the broader public on climate change issues and the need for adaptation, and working with coastal communities to identify locally based strategies to promote resilience of reefs and adaptation of the community to the impacts of climate change. A total of 140 reef sites throughout Belize were selected based on reef habitat maps and assessed in 2006, offering a representative view of the status of reefs. A number of these reefs fell within or adjacent to existing marine protected areas or areas of conservation interest. The identification of particularly healthy reefs in surprising areas has facilitated a concerted commitment by such organizations to lobby for sustainable management of those healthy/resilient reef sites of interest. Furthermore, through the public outreach and community level work, locally based adaptation strategies are being developed through a participatory effort with community members. The proactive involvement of communities serves to foster ownership of identified strategies which is hoped will facilitate their legal adoption and potential scaling-up to the national level. The main strategies being explored are ecological and social systems' vulnerability reduction, social networking, and capacity building within the process of how to build resilience in both social and ecological systems; including coastal communities, coral reefs and mangroves.

## 23-33

**Integrated Research, Development, And Education Activities Enhance The Success Of Community-Based, Marine Resource Management in The Korolevu-I-Wai District, Fiji**

**Victor BONITO*[1]**, Bill AALBERSBERG[2], Kini RAVINALOA[3]

[1]Reef Explorer Fiji, Votua village, Fiji, [2]Institute of Applied Sciences, University of the South Pacific, Suva, Fiji, [3]FLMMA Representative, Votua Village, Votua village, Fiji

Community-based management is an effective means to accomplish biodiversity conservation and replenish depleted inshore fish stocks, particularly on Pacific islands whose indigenous communities have significant control over their resources. The Fiji Locally-Managed Marine Areas (FLMMA) Network involves the participation of over 200 communities across Fiji and covers approximately 30% of near-shore areas. Active participation in and contribution to FLMMA was complimented by a village-based coral reef ecologist who undertook and assisted with the implementation of a suite of research, development, and educational activities in the Korolevu-I-Wai district. Having an ecologist based on-site and living within the community boosted local initiative and support for resource management and conservation activities, as well as facilitated and improved the implementation of management actions, development activities, and research programs. Simultaneously targeting community development priorities and economic needs along with resource management strengthened support for resource management and conservation actions. Governance issues and the growing economic needs of traditional resource owners are perhaps the greatest obstacles to community support for management actions and resource management success. Poor land-use practices and waste from land-based development remain as major threats to marine resources. With considerable threats to resources coming from people who have no legal or traditional ties to the resources nor are under the influence of local traditional governance, compliance to and enforcement of community management initiatives remains a challenge to traditional resources owners.

## 23-34

**Reef Management Using Traditional Management Practices in Vanuatu**

**Zaidy KHAN*[1,2]**, Tevi MALTALI[3,4], Sompert RENA[3,5]

[1]Communites and Coast, Foundation of the People of the South Pacific International, Suva, Fiji, [2]Locally Managed Marine Area Network, Suva, Fiji, [3]Coastal Program, Foundation of the People of the South Pacific Vanuatu, Villa, Vanuatu, [4]Village Based Resource Managed Area Network, Villa, Vanuatu, [5]Department of Fisheries, Ministry of Agriculture,Forestry and Fisheries, Villa, Vanuatu

In 2005, the Foundation of the People of the South Pacific international ( FSPI) and its network partner FSP Vanuatu (FSPV) initiated pilot projects on community based coastal resource management together with the Vanuatu Department of Fisheries (VDF), and WanSmol Bag Theatre . In 1990 the VDF started a village based trochus (Trochusniloticus) management program which included a yearly harvest plan. This concept was favorably received by many villages and later extended by implementing control on other marine resource harvest by setting traditional "tabus" or Marine Protected areas (MPAs) to manage their reef resources. The MPAs were ceremonially demarcated by village chiefs.

Although the benefits of tradition protection is recognized by the government and other stakeholders in marine resource management, in recent years this management practices has faded due to loss of traditional and cultural values and limited government resources.

With the technical assistance from VDF, FSPV has been supporting indigenous communities in assisting reef management models and tools such as MPAs through developing community coastal resource management plans and reviving tradition practices during demarcation of MPAs. So far the project have launched management plans for Paunagisu and Marou in North Efate, Aneityum Mystery island after a 3 year community process through reviving their customary ceremonies on pig killing and turtle tagging together with national governments. This tradition and ceremonial launching of community based coastal management plans with national government has drawn a high level of respect, unity and recognition for village base MPAs and has highlighted spiritual importance of respect for chiefly governance systems. The traditional management approach by communities is spreading across Vanuatu, together with words of success of restocking and spill over benefits experienced from MPAs and is becoming a model and nation wide strategies for community based coastal management.

## 23-35

**Coral Reef Management in The Pacific Islands: Governance At Risk**

**Jean-Brice HERRENSCHMIDT*[1,2]**, Sven MENU[2], Pascal HÉBERT[2], Pascal DUMAS[1,3]

[1]IRD, Noumea, New Caledonia, [2]GIE Oceanide, Noumea, New Caledonia, [3]University of New Caledonia, Noumea, New Caledonia

The Pacific Islands populations rely on their coral reefs. Some Pacific countries are therefore involved in International and Regional initiatives to protect them at a large scale with the International Community support. The authors are in charge of the implementation of community-based management plans and of scientific assessments within the framework of two major initiatives: the nomination of the coral reefs of New Caledonia on the World Heritage List and the Coral Reef Initiatives for the Pacific (CRISP) in Vanuatu, Fiji and French Polynesia.

The integrated and participative approach developed aims at avoiding some traps from the predominant ideologies led by most of Marine Protected Areas (MPAs), community-based management and sustainable development processes. Pacific cultures and customs are rich and their linkages with marine resources management are real, but the predominant methodologies either phantasm about them, either promote ideological maladjusted and simple recipes, which reveals post-colonial Governance difficulties and risks.

The Pacific societies organisations, Coral reef ecosystems and the management of archipelago countries are extremely complex. Many Pacific countries are politically unstable and their colonial heritage is diverse. The World Heritage nomination process of New Caledonia coral reefs, in a political context of decolonisation and in comparison with other Pacific countries, contributes to imagine new directions for coral reef management effectiveness. Interdisciplinary approaches and Island management from the reach down to the reef help to handle complexity. The adaptation of legal tools, Public Service capacity building and collective critical discussions about the public vs private status of the marine environment are complementary actions needed to promote modern integration of skills and competences. Responsible Coral reef and marine areas management thus play an important role in integrating Pacific cultures and modern tools, and more generally, in strengthening citizenship and state policies in order to contribute to better governance and political stability.

## 23-36

**Conserving Ecological Integrity Only If "Absolutely Necessary" – How Florida and National Park Service Policies on Marine Reserves Threaten Coral Reef Ecosystems in Biscayne National Park, Florida**

David WHITE[1], **Jack SOBEL*[2]**

[1]Southeast Regional Office, Ocean Conservancy, St Petersburg, FL, [2]Strategic Conservation, Science & Policy, Ocean Conservancy, Washington, DC

When Congress created Biscayne National Park in 1980, healthy coral reefs in the park supported robust fish and invertebrate populations. In 1983, the National Park Service (NPS) adopted a management plan establishing intent to manage recreational and commercial fishing to "sustain a composition of native marine populations similar to that which existed prior to fishing pressure." A 2001 assessment of fisheries resources and habitats in the park concluded that, following decades of significant recreational and commercial fishing pressure and related habitat impacts, the extremely poor status of reef fish resources signaled "imminent resource collapse." In 2002, NPS and the State of Florida, which share jurisdiction over fishing in the park, agreed to jointly develop a plan to manage fishing for the next 10-15 years. The state/federal agreement, codified in a Memorandum of Understanding, establishes and adopts Florida's policy that marine reserves (no-take areas) are overly restrictive and will not be implemented unless both parties agree it is "absolutely necessary." This agreement was renewed until 2012, despite a draft environmental impact statement acknowledging that marine reserves would be required to protect and conserve ecosystem biodiversity, function, and services, and to begin to restore fishery-impacted ecosystems to natural levels. A policy of only considering marine reserves within the park if all parties agree it is "absolutely necessary" sets too high a bar for ecosystem management of coral reefs in urban areas, precludes efforts to protect natural resources from impairment in national parks in the United States, and undermines a "key conservation objective" of the United States Coral Reef Task Force to protect twenty percent of Florida's coral reefs as marine reserves by 2010.

## 23-37

**Challenges Facing An Mpa Management Authority in The Context Of A Rapidly Developing Tourism Industry**

**James FOLEY*[1]**

[1]Department of Research & Development, Roatan Marine Park, Roatan, Honduras

Roatan, the largest of the Bay Islands in Honduras, is located on the Meso-American Barrier Reef. While all coral reef ecosystems in the Bay Islands are a protected area under Honduran law, no governmental management authority protects or regulates the use of this natural resource. In response to concern over reduced coral reef species abundance, the Roatan Marine Park Authority (RMPA) was created in January 2005 by the diving community. Its initial objective was to prevent illegal fishing practices along a 13.5km long stretch of the protected area, known as the Roatan Marine Park (RMP) by facilitating police patrols. While this has been partly successful, new superimposed pressures on reef resources present new challenges to the RMPA in achieving its vision of conservation-based management. The Honduran Government is encouraging large scale development of Roatan for high revenue tourism; four new cruise ship docks will bring over one million tourists per year to the island. Rapid development is racing to meet demand for luxury vacation accommodation. Despite legislation to ensure proper management for conservation and exploitation of the marine environment, poor governance, corruption and a large national debt continually impede conservation efforts. Challenges for the RMPA include addressing sediment-rich runoff from land clearing and illegal mangrove cutting to make way for development, managing poorly treated sewage discharges, and educating large numbers of short-stay tourists to minimize their impact on the marine environment. Scientific knowledge of the interrelationships between rapidly changing ecological, economic and sociological dynamics is essential to developing an effective management programme that balances conservation and economic development objectives in the RMP. The RMPA is therefore seeking to support research efforts as a means to assess methods such as activity zonation to accommodate diverse and increasing demands on ecological resources.

## 23-38

**Community Involvement in Biophysical Monitoring And Evaluation Of Marine Protected Areas in Central Philippines: Generating High Resolution Data Using Standard Methods, Utilizing Local Materials And Employing Traditional Approaches**

**Roxie DIAZ*[1]**

[1]Research/Monitoring Team, Coastal Conservation and Education Foundation, Inc., Cebu, Philippines

Since the 1970's, over 500 marine protected areas (MPAs) have been established in the Philippines with only about 10-20% being effectively managed. This study illustrates the efforts of many individuals and institutions that over the last 5 years have contributed to the creation and development of the local monitoring teams. Specifically, this study shows the materials, methods, and results of the last 3 years of data collection by the local community monitoring teams highlighting their capacity to conduct technical surveys. Using appropriate technology - customized techniques from standard monitoring methods, utilizing local materials and employing traditional approaches, 50 MPAs in central Philippines were monitored by their respective local community monitoring teams. Results from these biophysical Monitoring and Evaluation (M&E) and the performance assessments have collectively gauge the status and effective management of the MPAs providing insight on the conditions and gaps in current MPA management.

## 23-39

**Mmas: A Network Experiment in Coral Reef Adaptive Management And Conservation.**

**Les KAUFMAN*[1,2]**, Leah BUNCE[3]

[1]Biology/Marine Program, Boston University, Boston, MA, [2]Conservation International, Arlington, [3]Conservation International, Arlington, VA

The Marine Management Area Science Program (MMAS) helps coastal societies to conserve coral reef and associated environments. MMAS has five key elements: (1) a network of communities in Brazil, Belize, the TEP, and Fiji that have area management schemes, treated here as a global adaptive management experiment; (2) a monitoring system for social and natural parameters with data stream tied to decision tools and policy options; (3) data comparison across nodes to detect global signals and measure effectiveness of local action in the face of global change; (4) new diagnostic and analytical methods to increase sensitivity to both process and state changes; and (5) targeted expeditions to fill key knowledge gaps. We report early progress on monitoring and diagnostics, the spatial dynamics of coral reef health and change, on society's relationships with coral reefs, the geographical ecology and connectivity of reefs, and a doubling of known reef habitat in the south Atlantic.

## 23-40

**Socioeconomic and Governance Monitoring of Marine Management Areas: A Work in Progress**

**Giselle SAMONTE-TAN*[1]**, Adele CATZIM[2], Diane HAYLOCK[2], Isabela CURADO[3], Rodrigo MOURA[4], Patrick Sakiusa FONG[5], Juan MATE[6], Osvaldo JORDAN[7], Lucia LASSO[7], Leah BUNCE[1]

[1]Center for Applied Biodiversity Science, Conservation International, Arlington, VA, [2]Belize ISIS Enterprises, Belize City, Belize, [3]Fundacao Getulio Vargas, Sao Paulo, Brazil, [4]Conservation International - Brazil, Caravelas, Brazil, [5]University of the South Pacific, Suva, Fiji, [6]Smithsonian Tropical Research Institute, Balboa, Panama, [7]Alianza para la Conservación y el Desarrollo, Panama City, Panama

Traditionally Marine Managed Areas (MMAs) have been established to achieve biodiversity conservation goals (e.g. protect endangered species, increase fish populations); yet increasingly social, economic and cultural objectives are being incorporated into MMA planning. To better understand these human effects, a cross-site study was designed to examine the socioeconomic and governance effects of MMAs in four countries (Belize, Brazil, Fiji and Panama) as well as ecological factors influencing these outcomes. A socioeconomic and governance monitoring survey is being conducted in each of the MMA coastal communities to understand conditions prior to MMA establishment compared with current conditions. The analysis will assess the MMA socioeconomic effects, including impacts on food security and health of coastal residents, livelihoods, human threats to the marine resources, and environmental awareness and knowledge as well as assess the governance effects, including impacts on management structures and strategies, stakeholder participation and representation, property rights and access to resources, management plan compliance by resource users. In addition, enabling factors for MMA effectiveness will be determined, such as leadership and long term support of local government, participation by community and all those affected, shared benefits among participants, alternative livelihoods that are appropriate in decreasing resource use pressures within MMAs. This project is within the Conservation International Marine Management Area Science Program, is a work in progress and demonstrates the application of monitoring and research to support improved understanding and adaptive management of coral reefs and related ecosystems.

## 23-41

**Water Quality Standards For Coral Reef Protection**

**William FISHER*[1]**, Aaron HUTCHINS[2], Leska FORE[3], Wayne DAVIS[4], Charles LOBUE[5], Heidi BELL[6]

[1]Office of Research and Development, U.S. Environmental Protection Agency, Gulf Breeze, FL, [2]Department of Planning and Natural Resources, U.S. Virgin Islands, Frederiksted, United States Minor Outlying Islands, [3]Statistical Design, Seattle, WA, [4]Office of Environmental Information, U.S. Environmental Protection Agency, Ft. Meade, MD, [5]Region 2, U.S. Environmental Protection Agency, New York, NY, [6]Office of Water, Office of Science and Technology, U.S. Environmental Protection Agency, Washington, D.C., DC

Resource managers have few tools to counteract the growing impacts of human coastal and watershed activities on coral reefs. Water quality standards for coral reef protection—including biological criteria (biocriteria)—have enormous potential but are not currently used by any U.S. jurisdiction. The Environmental Protection Agency is promoting coral reef biocriteria through collaborative development of bioassessment procedures and monitoring strategies suitable for regulatory activities. A rapid bioassessment protocol (RBP) for reef-building stony corals (Scleractinia) was developed and tested as an initial step. Scleractinia were selected because much of the ecological and economic value of coral reefs is directly attributable to the physical structure of stony corals. The RBP requires only three underwater observations but provides both colony and surface area characteristics and incorporates a three-dimensional approach to document colony size (indicator of ecosystem services) and the amount of live tissue (coral capacity for growth and reproduction). Preliminary testing in the Florida Keys showed that information gained through the RBP had relevance to coral reef management and sufficient precision to distinguish spatial and temporal differences. Further validation was completed in the U.S. Virgin Islands, where corals were sampled across human disturbance gradients to determine which indicators were responsive to anthropogenic stress, a requirement for regulatory enforcement. Several RBP indicators, including taxa richness, colony size, total and live surface area were found to be positively correlated with distance from human activity. These indicators also had sufficient precision to be effective in most monitoring programs, and are now considered strong candidates for application in a regulatory context. Implementation of enforceable biocriteria will depend on the application of responsive metrics in a defensible long-term monitoring program. Once established, such a program will provide valuable, long-term records of coral condition and regulatory compliance.

## 23-42

**Spillover Of Reef Fishes From No-Take Marine Reserves: An Evaluation Using The Before-After Control-Impact (Baci) Approach**

**Ronaldo FRANCINI-FILHO*[1]**, Rodrigo MOURA[1]

[1]Marine Program, Conservation International, Caravelas, Brazil

No-take marine reserves may promote recovery of exploited populations within their boundaries and spillover of fishes to adjacent fishing grounds, thus potentially benefiting the local fisheries. Although some studies have measured spillover by examining gradients of fish abundance and body size across reserve boundaries, there are no such studies to date including information from before reserve establishment, thus seriously limiting interpretation of results. We measured reef fish spillover from a no-take marine reserve in Eastern Brazil by estimating biomass and body size across the reserve boundary before (2001) and after (2002-2005) initiation of protection. Replicate sites were sampled inside and outside the reserve, with unprotected sites included in three distance categories from the reserve boundary: 0-400, 400-800 and 800-1200 m. This latter category surpass the scales over which spillover is expected to influence patterns of fish abundance outside reserves (generally < 500 m), thus acting as a control for the reserve effect. Habitat measurements were undertaken at the same sites, from 2003 on. Biomass of the greenbeak parrotfish Scarus trispinosus, a major fishery resource and the dominant species in terms of biomass (37.4% of total biomass), was lower inside the reserve area before its establishment. During this same period, no individuals of two primary target species, the black grouper Mycteroperca bonaci and the gray parrotfish Sparisoma axillare, were recorded inside the reserve. Coral cover was consistently lower inside the reserve from 2003 on. Biomass and body size of M. bonaci, as well as biomass of the yellowtail snapper Ocyurus chrysurus, increased continuously inside the reserve after initiation of protection, with no similar increases recorded in control sites. Evidences of spillover (i.e. higher biomass inside the reserve and in unprotected sites closer to its boundary) were obtained for M. bonaci, O. chrysurus and S. trispinosus, although this pattern was only marginally significant for O. chrysurus. Despite the aforementioned positive signs, recovery and spillover of S. trispinosus were probably inhibited by increased poaching from 2003 on. Our results indicate that the no-take reserve at Itacolomis Reef was established a priori on poor quality habitats. Thus, future spatial comparisons between protected and unprotected sites would underestimate changes due to protection. These findings highlight the importance of baseline information and continued monitoring for adequately understanding the effects of no-take marine reserves.

## 23-43

**Modularizing Coral Reef Monitoring Methodologies for Better Management Effectiveness**

**Karenne TUN*[1]**, Eugene GOH[2], Loke Ming CHOU[1], Tom FOSTER[2]

[1]Biological Sciences, National University of Singapore, Singapore, Singapore, [2]DHI Water & Environment, Singapore, Singapore

To a large extent, effective management of coral reefs depends on access to relevant reef monitoring data, and their translation into useful management indices. Several globally established monitoring methodologies are currently used by coral reef monitoring practitioners (eg, AIMS LIT, Reef Check, AGGRA and Vitareef), with many modifications or enhancement to suit local situations and needs. The fact is that there is no shortage of methodologies that practitioners can employ to monitor coral reefs – yet there is little compelling evidence to demonstrate a link between monitoring and management. In many instances, monitoring results appear to be no more than a cursory tool used in management. Analysis of a variety of documents (manuscripts, technical reports, management papers, etc) that link monitoring and management show a general lack of tools that effectively translate monitoring information into useful management indices to support management decisions. Most monitoring outcomes are reported as percent benthos cover, which is not an ideal index for assessing coral reef condition, and even less ideal as a management tool for making management decisions. This paper addresses the issue of translating monitoring outcomes into relevant indices for more effective coral reef management in a highly urbanized environment with extensive anthropogenic influences. The approach focuses on identifying key management questions for the specific area being managed, which are then addressed in the form of add-on modules that are linked to existing reef monitoring methodologies,. In essence, we propose that monitoring programmes retain their existing coral reef monitoring methodologies, but tackle specific management questions by appending relevant monitoring modules to their existing protocols.

## 23-44

**Community-Based Monitoring Of Marine Ecosystem Health For St. Kitts And Nevis, Lesser Antilles: Development Of A Relational Database Based On Local And Scientific Marine Stakeholder Knowledge.**

**Raphaela STIMMELMAYR*[1]**, Mike KAPLAN[2], Jose JUGEREY[2], Nikki BANFIELD[2], Maureen SULLIVAN[3]

[1]Ross University Veterinary School, Basseterre, Saint Kitts and Nevis, [2]RUSVM, Basseterre, Saint Kitts and Nevis, [3]St.Kitts Reef Ecology Watch Group, Basseterre, Saint Kitts and Nevis

A current comprehensive assessment of coral reef health, distribution of marine species including sea turtles and coral reef fishes that occur in the waters of St. Kitts-Nevis does not exist. Tourism in the wider Caribbean is the most important economic sector, having largely replaced the formerly important agricultural economy (i.e. banana and sugar cane). Ecotourism activities such as diving and other non-consumptive resource uses such as whale and sea turtle watching are an important local tourism component. Local marine stakeholder knowledge is a largely untouched and valuable source of information relevant to Caribbean marine ecosystem health and resources. Marine data was collected from roving diver surveys (dive masters and recreational divers) and snorkel surveys using standardized fish survey sheets. Local fish names have been compiled from semi-directed interviews. Coral reef photo data (1992/93 and 2006/2007) has been digitized and a registry created. Both can be linked to survey site data. The constructed relational database allows for seamless integration with local available geographical information systems. Community based approach to marine ecological monitoring is a viable, sustainable and economical tool for the generation of scientifically valid ecological baseline data for small island developing states that otherwise lack infrastructure and resources to engage in marine research needed for development of management guidelines. Furthermore the integration of local traditional knowledge provides insight into the local shifting baseline syndrome and can generate evidence for new hypotheses.

## 23-45

**Assessing Global Coral Reef Management Using Interdisciplinary Measures Of Conservation Success.**

**Venetia HARGREAVES-ALLEN*[1]**, EJ MILNER-GULLAND[1], Jamie OLIVER[2], Trond BJORNDAL[3]

[1]Imperial College London, London, United Kingdom, [2]WorldFish Centre, Penang, Malaysia, [3]Portsmouth University, Portsmouth, United Kingdom

Donors increasingly need information to help them chose how to optimise investment for conservation and management in marine protected areas (MPAs). In this study I use a questionnaire to managers and researchers of coral reef marine protected areas to assess the factors influencing perceived conservation success. A range of indicators of conservation success have been used in the literature, including management inputs, evidence of conservation outputs and threat reduction. In my study I compare the results of using each of these measures, which encompass ecological, economic and social components of success. I place emphasis on the counterfactual through the use of geographical 'inside versus outside' measures and temporal 'before versus after' measures. I will present the results of the survey, which encompasses 80 MPAs from all over the world, from those less than 1km2 to the Great Barrier Reef Marine Park in Australia. A focus of the survey is to explore the issue of equity in terms of the distribution of management and opportunity costs and use and non-use benefits. An analysis of the financial and management strategies that are linked to more successful MPAs enables me to identify recommendations for management. Global trends in regulations, funding strategies, budgets and management actions and their impact on conservation targets will also be discussed, along with an assessment of the challenges and limitations of this research.

## 23-46

**Linking Monitoring and Management- Lessons Learned at the Sapodilla Cayes Marine Reserve, Belize**

**jocelyn FINCH*[1]**, Christina GARCIA[1], Jason GUY[2], Godwin HUMES[2]

[1]Toledo Association for Sustainable Tourism and Empowerment, Punta Gorda, Belize, [2]Belize Fisheries Department, Punta Gorda, Belize

Located at the southern terminus of the Belize Barrier Reef, the Sapodilla Cayes Marine Reserve (SCMR) was declared a marine reserve in 1996 and is a part of the Belize Barrier Reef World Heritage site. The SCMR protects important reef ecosystems, is home to essential fishing grounds, and is visited by tourists from Belize, Guatemala and Honduras. With these diverse uses and values in mind, the Fisheries Department began on-site management at the SCMR in 2001. Today the SCMR is co-managed by the Belize Fisheries Department and the Toledo Association for Sustainable Tourism and Empowerment (TASTE). In 2006 TASTE, in collaboration with the Fisheries Department, developed a basic monitoring plan for the SCMR. In 2007 the partners began implementation of this monitoring plan. The goal of the monitoring plan was to ensure consistent biological monitoring and to better link the emerging data and its analysis to management decision making. Now after a full year of monitoring with careful evaluation of the monitoring techniques and the data collected; the co-managers have gained useful insight into the strengths and weakness of this monitoring strategy. In order to guarantee that quality biological data is being applied to adaptive management a number of key gaps in monitoring and analysis must be addressed including: insufficient funding of the monitoring plan, need for trained personnel, in-depth statistical analysis training and the ability to translate scientific evidence into management action. TASTE and the Fisheries Department need to work together to develop capacity in these key areas and maintain a consistent monitoring of these important biological resources. Through continued cooperation, improved implementation of the monitoring plan and better use newly collected data, it will be easier to balance the diverse management goals of the SCMR and ensure effective adaptive management.

## 23-47

**The Science Behind Adaptive, Ecosystem Based Management in The Great Barrier Reef Marine Park**

**David WACHENFELD*[1]**

[1]Science, Technology & Information Group, Great Barrier Reef Marine Park Authority, Townsville, Australia

The Great Barrier Reef is a vast, complex mosaic of different habitats including coral reefs, sponge and soft coral gardens, algal meadows, seagrass meadows, mangrove forests, islands, pelagic and deep sea environments, which are all ecologically inter-connected. The Reef is a significant source of economic, social, cultural and spiritual values for all Australians, and is a global environmental icon. The major threats to the Great Barrier Reef are climate change, degraded water quality and fishing. These threats do not operate in isolation of one another, but rather in synergy. The Great Barrier Reef Marine Park Authority takes a holistic view, protecting the entire ecosystem, its diversity of habitats, their inter-connectivity and their associated human values from the range of threats. The Authority has specific programmes targeted at protecting biodiversity, delivering sustainable industries (particularly tourism and fishing), improving water quality and responding to climate change. With the threat from climate change rapidly increasing, there is greatly increased urgency for local management to address other threats, and focus on measures to maximise the resilience of the ecosystem. The Authority partners closely with scientists to deliver sound information to form the basis of Reef management. In particular, we have developed significant monitoring programmes for our major management initiatives, so that we can track their effectiveness and continue to adaptively manage the Marine Park into the future.

## 23-48

**Spatial Footprint And Temporal Variability Of Recreational Usage At A Remote Fringing Reef in North-Western Australia**

**Claire SMALLWOOD*[1]**, Lynnath BECKLEY[1], Sue MOORE[1]

[1]Environmental Science, Murdoch University, Perth, Australia

Worldwide, studies investigating recreational usage of coral reefs have not previously been a priority for research. However, increased visitation and documented impacts from these activities have highlighted the importance of collecting relevant usage data at a scale appropriate for management. Ningaloo Reef is a remote fringing reef which extends 300 km along the coast of north-western Australia and supports several diverse ecosystems. Although located in an isolated arid region with a permanent population of only 10 000 people, this is supplemented each year by ~ 200 000 visitors. The fringing nature of the reef, which encloses a sheltered lagoon area with an average width of 2.5 km, results in a high level of accessibility for visitors participating in marine recreational activities. Planning for the future sustainable development of the Ningaloo coast is ongoing and a project to map the spatial footprint of marine resource usage in the lagoon is underway. Part of this study included ~1 100 face-to-face questionnaire interviews with recreational participants collected throughout 2007 along the length of the reef system. Snorkelling, fishing, diving, kayaking, surfing as well as charter tours for coral viewing and manta rays were some of the popular activities recorded. As well as seasonal variation in recreational usage, demographics, visitation patterns and origin of visitors, there was also spatial variation in these patterns along the coastline. Although studies of recreational activity have been undertaken previously in the region, this is the first study that clearly displays the spatial relationship between these activities, access points and various accommodation types. The study has also allowed popular usage nodes, which could be vulnerable to impacts from recreational activities, to be identified. The fine-scale resolution and geo-referenced nature of this dataset makes it particularly pertinent to site-specific planning and management of Ningaloo Reef and the adjacent coastline.

## 23-49

**Integrating Coral Reef Data For Marine Protected Area Decision Support**

James HENDEE[1], **Frank MULLER-KARGER*[2]**, Villy KOURAFALOU[3], Lew GRAMER[4]

[1]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, [2]School for Marine Science and Technology, University of Massachusetts Dartmouth, New Bedford, MA, [3]Rosenstiel School for Marine and Atmospheric Sciences, University of Miami, Miami, FL, [4]Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL

Since 1997 NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) in Miami, Florida, has been engaged in continuing development of expert systems as a tool both for researchers and for managers of Marine Protected Areas (MPA). Recently AOML has updated this system with powerful new software called G2, which forms the heart of the new Integrated Coral Observing Network (ICON) of in situ stations and virtual monitoring sites around the world. The ICON/G2 system integrates data from in situ, satellite, radar and other measurements in near real-time, and couples that data with decision support products for over 90 coral reef locations around the world. Many ICON sites are situated within MPAs; however, the needs of MPA managers require environmental monitoring with regional as well as local coverage, thus prompting the need for extensive satellite data. Also, requirements analyses of MPA managers highlight the need for basic research to support effective decision making; one area in particular--hydrodynamic modeling, applied to forecast the delivery of nutrients and larvae to the reef--is a common need for most MPAs. This paper discusses ongoing efforts to extend our data coverage to support these promising areas of research at the most visited site in the Florida Keys National Marine Sanctuary (FKNMS), Molasses Reef. This work can serve as a model for additional sites within the FKNMS, and eventually at other MPAs in the Caribbean Sea, Pacific Ocean and Indian Ocean.

## 23-50

**Maredess: Marine Resources Decision Support System**

**Laura DAVID*[1]**, Erlinda SALAMANTE[1], Eileen PENAFLOR[1], Kathleen SILVANO[1], Kristina CORDERO[1], Marites MAGNO-CANTO[1], Irene ALABIA[1], Victor TICZON[1], Ma. Bernadette DE VENECIA[1], Roselle BORJA[1], Rommel MANEJA[1], Cesar VILLANOY[1]

[1]Marine Science Institute, Univ. of the Philippines, Quezon City, Philippines

Republic Act 8550 marked the devolution from the national to the local government of the stewardship of coastal marine resources. Although this made sense in as much as it is the local stakeholders that are in the best position to ensure sustainability of use and management, nevertheless we argue for a need for a comprehensive national strategy. This study makes use of various remotely sensed products and numerical model simulations to propose a strategy for prioritizing sites for protection. Taken into consideration are presence/absence of reefs and related habitats; entrainment/ connectivity features; variability of environmental exposure; perceived threats and vulnerability. The recommendations include prioritizing offshore reefs that are less vulnerable to thermal stress and storms; reefs that have withstood thermal fluctuations through decades; and prioritizing series of reef areas to ensure a sustainable of connectivity corridors. A map of priority sites is given for the Philippines.

## 23-51

**Software Tools For Ecosystem-Based Management Of Coral Reefs**

Sarah CARR[1], **Lindsay ELDER*[1]**, Patrick CRIST[1]

[1]EBM Tools Program, NatureServe, Arlington, VA

Ecosystem-based management (EBM) of coral reefs requires the integration of information about a vast array of environmental and human systems, including the coral reef ecosystems themselves, pollutants from land-based sources, and human uses of the ecosystems such as tourism, recreation, fishing, and shipping. A variety of software tools have been developed to help policymakers and managers collect, visualize, and analyze this information and engage stakeholders in the EBM decision making process. For example, tools can:

- predict ecosystem response to natural and anthropogenic disturbances
- help select optimal areas for conservation or restoration
- help managers and stakeholders visualize the impact of development and resource-use scenarios on ecosystems and the human communities that depend on them
- help collect local knowledge about how resources are used
- facilitate stakeholder participation in evaluating management alternatives.

Using tools can improve environmental decision making by helping resource managers incorporate science into decisions, address multiple objectives, and build consensus for management actions among stakeholders.

Navigating through the vast array of tools and determining what tools do and how they should be used can consume a great deal of a manager's time. This presentation will provide information on an array of technology tools for EBM of coral reefs and the benefits and limitations of using technology tools. We will also describe an on-line resource for comprehensive information on EBM tools (www.ebmtools.org) and provide information on relevant training opportunities.

## 23-52

**Development And Implementation Of Coral Reef Biocriteria in U.s. Jurisdictions**

**Patricia BRADLEY*[1]**, Wayne DAVIS[2], William FISHER[3], Bell HEIDI[4], Valerie CHAN[5], Buddy LOBUE[6], Wendy WILTSE[7]

[1]Office of Research and Development/NHEERL/AED, U.S. EPA, Key West, FL, [2]Office of Environmental Information, U.S. EPA, Ft. Meade, MD, [3]Office of Research and Development/NHEERL/GED, U.S. EPA, Gulf Breeze, FL, [4]Office of Water, U.S. EPA, Washington, DC, [5]Office of Research and Development/OSP, U.S. EPA, Washington, DC, [6]Region 2, U.S. EPA, New York, NY, [7]Region 9, U.S. EPA, Honolulu, HI

U.S. coral reef ecosystems are threatened by a variety of anthropogenic activities (e.g., pollution, over fishing, vessel groundings, excess nutrients, coastal development, etc.), natural stressors (e.g., tropical storms), and natural stressors that have been exacerbated by anthropogenic activities (e.g., climate change).

Biological communities are dependable indicators of the health of aquatic ecosystems because they are responsive to effects of low-level, chronic, and non-point source pollution, and to interactive stressors not captured by physical and chemical water quality standards. Under the Clean Water Act, states may adopt water quality criteria based on biological, physical, and chemical criteria. The President's Ocean Action Plan directs the U.S. Environmental Protection Agency (EPA) to develop biological assessment methods and biological criteria for evaluating the health of coral reefs and associated water quality.

Biocriteria are narrative descriptions or numeric values representing the biological condition of biological communities. Rigorous biological assessments are needed to identify metrics for a monitoring program and to set expectations for the water body. These are used to develop a scoring system to indicate the health of the water body and to develop biocriteria for each class or designated use.

EPA is fostering development of coral reef biocriteria through focused research, evaluation, and collaboration with U.S. states and territories. To date, EPA has produced and validated a Stony Coral Rapid Bioassessment Protocol for application to biocriteria and a Coral Reef Bioindicators Website (http://www.epa.gov/bioindicators/coral/coral_biocriteria.html) for dissemination of information.

EPA and the collaborating states and territories have a wide variety of ongoing activities to conduct systematic coral bioassessments, develop metrics, design monitoring programs, and work toward adoption of protective and defensible biocriteria.

## 23-53

**Developing A Model For Ecosystem Based Management in The Tropical South Pacific -Initial Results From A Case Study in Fiji**

Kathy WALLS[1], Aaron JENKINS[2], Kesaia TABUNAKAWAI[3], **Daniel EGLI*[3]**

[1]Wildlife Conservation Society - South Pacific Program, Suva, Fiji, [2]Wetlands International - Oceania, suva, Fiji, [3]Worldwide Fund for Nature - Fiji Country Program, Suva, Fiji

The Vatu-i-Ra Reefs and Great Sea Reef of Fiji are globally recognized for their outstanding biodiversity. In 2005, three NGOs collaborated to investigate ecosystem based management approaches in this area.

The scope of the project is at the seascape scale with the inclusion of the adjacent watersheds. The project focus is on two traditional fisheries management areas and their adjacent watersheds on the island of Vanua Levu. Fish caught in the management areas are important for both sustenance and income for the local communities, but some land-use practices at the sites, such as logging, widespread land clearance and sugar-cane farming, may adversely affect the marine ecosystem through sedimentation and nutrient enrichment from runoff.

Thus far, project initiatives at both sites include: establishment of marine protected areas (MPAs) through close collaboration and consultation with the local communities; active resource management committees; draft management plans and enforcement training. Marine biophysical and socio-economic surveys have provided important baseline information on the marine habitats and the local communities of the sites. A biological monitoring program has been initiated to investigate effectiveness of the MPAs. Watershed conservation has begun through development of a management plan for a forest reserve at one site, resulting in increased awareness for watershed conservation. New information on the watersheds of both sites has been obtained through development of a preliminary runoff model that demonstrates the potential impacts of sediment and nutrient runoff on the marine habitats of both sites.

The work undertaken to date has highlighted the vital roles of both local communities and science-based approaches to ecosystem assessments in managing coral reef ecosystems.

## 23-54

**Genetic structure of Heliofungia actiniformis (Scleractinia: Fungiidae) populations in the Indo-Malay Archipelago: implications for live coral trade management efforts**

**Leyla KNITTWEIS*[1]**, Wiebke KRÄMER[2], Janne TIMM[2], Marc KOCHZIUS[2]

[1]Centre for Tropical Marine Ecology, Bremen, Germany, [2]Biotechnology and Molecular Genetics, Bremen University, Bremen, Germany

The fungiid *Heliofungia actiniformis* is one of the most popular scleractinian coral species in the growing live aquarium trade, with the majority of specimens originating in Indonesia. Details on population connectivity may potentially provide important information with regards to fishery management efforts. Phylogeographic structure was examined, using ribosomal ITS1, 5.8S and partial ITS2 sequences on a small scale among populations in the Spermonde Archipelago, South Sulawesi (up to 65 km distance), and on a large scale throughout the Indo-Malay Archipelago (up to 2,900 km distance). Significant genetic structuring was found at both scales. Within the Spermonde Archipelago isolation by distance as well as local oceanographic features shaped patterns of genetic connectivity. On the large scale, the data revealed genetically distinct populations in Tomini Bay, New Guinea and the Thousand Islands near Jakarta, and a lack of genetic differentiation among populations lying close to or directly in the path of the Indonesian throughflow: from the central Visayas to the Flores Sea. Whilst the influence of both historical and present day processes on genetic structuring of *H. actiniformis* populations was revealed, large scale results further emphasised the importance of current dynamics on larval dispersal patterns in this species. Potential for larval input from surrounding populations, and the increased vulnerability of upstream as well as isolated populations should be taken into consideration when setting future harvest quotas.

## 23-55

**Conservation Of Elkhorn (Acropora Palmata) And Staghorn (A. Cervicornis) Corals Through Two Proposed Rules Under The Endangered Species Act**

**Jennifer MOORE*[1]**, Sarah HEBERLING[1]

[1]Protected Resources Division, NOAA Fisheries Service, St. Petersburg, FL

The Endangered Species Act (ESA) listing of elkhorn and staghorn corals in 2006 has necessitated the development of two rules to provide for their conservation. The NOAA Fisheries Service is responsible for the development and implementation of these rules. A proposed rule under ESA section 4(d), called a (4(d) rule, extends ESA prohibitions to the threatened corals. The 4(d) rule also provides exceptions to those prohibitions for specific activities that provide for the conservation of the species. A proposed critical habitat rule designates specific geographic areas within U.S. jurisdiction on which are found physical and biological features essential to the species' conservation and which require special management. The specifics of the two rules, their conservation goals, and effects on public will be discussed.

## 23-56

**De Facto Marine Protected Areas: Coral Reef Conservation Inside The Danger Zone**

**Charles WAHLE*[1]**, Rikki DUNSMORE[2], Lisa WOONINCK[2,3], Mimi D'IORIO[1], Lauren WENZEL[4], Claudia MAKEYEV[2]

[1]Natl. MPA Center, NOAA, Monterey, CA, [2]Natl. MPA Center, NOAA, Santa Cruz, CA, [3]Southwest Fisheries Science Center, NOAA Fisheries, Santa Cruz, [4]Natl. MPA Center, NOAA, Silver Spring, MD

Effective ocean management requires a broad understanding of spatial patterns of human use. To this end, and with support from NOAA's Coral Program, the Marine Protected Areas Center has inventoried the De Facto MPAs (DF-MPAs) in U.S. waters: areas of the ocean where access and/or use are restricted for reasons other than conservation. Many DF-MPAs are located in coral reef ecosystems, potentially providing valuable but previously undocumented conservation benefits to these often remote areas. Presently, more than 1,000 DF-MPAs occur in U.S. waters, covering 3 percent of the nation's Exclusive Economic Zone (EEZ). In the Pacific Islands, a small area (< 0.01 %) is contained in 59 DF-MPAs. A large portion (95 %) prohibit access, at least part of the time. However, for 2/3 of this area, access is restricted only temporarily, with most of this area contained within one site during intermittent target practice. In contrast, approximately 500 km2 of marine waters are off limits year round in Pacific Islands DF-MPAs, contained primarily within three sites with coral reef habitats: Barking Sands, Kaula Rock and Kahoolawe Island. Coral reef resources within these areas are afforded year-round protection from extractive activities (e.g. fishing), yielding demonstrable increases in abundance and density of commercially-important reef fishes and invertebrates. A small portion of the Caribbean waters (<0.008%) is contained in 22 DF-MPAs, distributed throughout coral reef ecosystems of Puerto Rico (14) and the U.S. Virgin Islands (8). Within the next few years, the DF-MPA area in the Caribbean region will drop by 90 percent following the decommissioning of several military installations that encompass some of the region's healthiest coral reef habitats. Although often overlooked in conservation planning, De Facto MPAs are prevalent in U.S. coral reef ecosystems and may pose real opportunities for meaningful conservation in concert with other forms of place-based management.

## 23-57

**Management And Monitoring For Coral Reef Conservation in One Of The World's Busiest Ports**

**Nigel GOH*[1]**

[1]National Parks Board, Singapore, Singapore

Between the founding of modern-day Singapore in 1819 and today, the island nation has lost an estimated 60% of its coral reef area. Most of this loss may be attributed to pressures from land-use necessitated by an increasing population and a fast-growing economy. Nevertheless, high species diversity remains on its coral reefs, with 256 species of scleractinians still extant in Singapore. This number represents more than a quarter of all hard coral species worldwide, a statistic made more noteworthy as Singapore's total land area is only 700km2. In earlier years, conservation of coral reefs was fortuitous, contrasting with a more intentional approach seen in recent years.

A major pillar of this new approach towards managing the nation's coral reef natural heritage involves the setting of strict environmental quality objectives and use of real-time feedback monitoring processes. These rigorous environmental monitoring and management plans (EMMP) allow the mitigation of impacts while allowing coastal development that is often necessary in a land-constrained situation. In Singapore, the universal problem of having many stakeholders in coastal areas is exacerbated by the intensity of use brought about by its very limited availability of land and coastal areas. Besides traditional approaches to coral reef conservation, newer approaches like active habitat enhancement measures are necessary to ensure the long-term sustainability of coral reefs in the face of these pressures.

This paper describes these measures, as well as the EMMP process in Singapore that minimizes collateral damage to coral reefs arising from coastal developments, even when these developments are in close proximity to such reefs.

## 23-58

**Science To Action For Coral Reef Conservation**

**Sebastian TROENG*[1]**, Leah BUNCE[2], Michael WELLS[3], Guilherme DUTRA[4], Lindsay GARBUTT[5], Scott HENDERSON[6], Loraini SIVO[7]

[1]Regional Marine Strategies, Conservation International, Arlington, VA, [2]Center for Applied Biodiversity Science, Conservation International, Arlington, VA, [3]Consultant, Lier, Norway, [4]Conservation International-Brazil, Salvador, Brazil, [5]Friends of Nature, Placencia, Belize, [6]Conservation International - Eastern Tropical Pacific Seascape, Puerto Ayora, Ecuador, [7]Conservation International - Fiji, Suva, Fiji

A major conservation challenge is how to best use cutting edge science results to inform effective policies and best practices for coral reef conservation. Conservation practitioners may not have access to the latest information and researchers may not always reach key decision-makers with practical and useful science-based recommendations to inform policy and best practices. Conservation International's Marine Management Area (MMA) Science Program, a four-year initiative funded by the Gordon & Betty Moore Foundation, aims to bridge this gap between science and practical conservation and to simultaneously identify the key factors responsible for influencing the success of these "Science to Action" (S2A) efforts. The program is currently supporting over 40 studies on management effectiveness, connectivity, resiliency, economic and cultural values, conservation incentives and enforcement related to MMAs. To guide the S2A efforts and to allow for posterior assessment of success, a framework has been developed that specifies the desired marine conservation outcomes (long-term goals), outputs (short-term goals), outreach and influencing activities to reach these goals, and the conditions (e.g. level of participation in research design) that may have influenced whether or not the research results contributed to achieving the conservation goals. Science to Action workshops have been held in Belize, Fiji, Brazil and Panama with the participation of the principal investigators, and with practitioners and decision-makers from each of the countries and their broader region to identify the priority activities and goals. We hypothesize that this participatory approach will ensure that science results are fed into local decision-making processes and hence increase the probability of science results informing conservation policy and practice. We anticipate that this analysis of the S2A component of the Marine Management Area Science Program will allow us to identify the key success factors for scientists and conservationists to consider when planning and implementing conservation research programs.

## 23-59

**Making Research Matter: Best Practices And Common Barriers To Applying Research Findings**

**Ruth KELTY*[1]**

[1]National Ocean Service, NOAA, Silver Spring, MD

Successful realization of coral reef ecosystem management goals depends on the ability to transition research and information out of the laboratory and into the hands of decision-makers. This talk describes best practices for increasing the impact of research investment (as identified by the U.S. Ocean Research and Resources Advisory Panel), common barriers to transition, and coral reef ecosystem cases studies in which those barriers were overcome. Collaboration between researchers and intended users of the research is essential. The most successful collaborations are launched early in the process, facilitated by a neutral third party, and engage the end users in problem formation as well as application development. Consensus documents presenting the best available science are useful in convincing users that the research/solutions are accepted. Research funding agencies can help by creating incentives for integrating application into research programs, fully funding the transition (i.e. development, validation, and training), and valuing collaboration and transition along with publication. An institutional culture that values the timely transition of relevant research will contribute to the most effective use of science in societal decision-making.

## 23-60

**Designing A Resilient Network Of Protected Areas in The Republic Of Palau, Micronesia**

**Eric VERHEIJ*[1]**, Sean AUSTIN[2]

[1]Micronesia Program, The Nature Conservancy, Koror, Palau, [2]Micronesia Program, The Nature Conservancy, Koror, Papua New Guinea

In November 2003, the Protected Areas Network (PAN) Act was passed and signed into law. The PAN Act, which has dual objectives of protecting biodiversity and natural resource management, provides a framework for Palau's national and state governments to collaborate to establish a resilient nationwide network of terrestrial and marine protected areas. As part of the design process, a number of workshops have been organized to bring together relevant government institutions, non-government organizations, community representatives, and individuals. The aim of these workshops was to ensure that decisions related to evaluating and prioritizing marine and terrestrial biodiversity are based on the most up-to-date and accurate scientific information available. In May 2006, the PAN Office, supported by the Nature Conservancy and the Palau International Coral Reef Center, sponsored a series of two workshops attended by nearly 50 participants from National and State Governments, communities and non-governmental organizations, to comprehensively review and assess the latest biodiversity and socio-economic information available for the country. Following this information/data review, maps and data layers were updated and modeled using MARXAN software to provide varying design scenarios for Palau's PAN. These scenarios will serve to enable decision makers to determine how to effectively protect and manage Palau's natural resources. At the end of the second workshop the existing 28 MPAs, of which 26 were established using the natural resource management objective, were overlaid on the map with the biodiversity priorities. The result of the overlay was an almost perfect match and therefore demonstrates that conservation of biodiversity and natural resource management can be complementary.

## 23-61

**Mitigating The Effects Of Coral Bleaching Through Improved Methods Of Marine Reserve Design**

**Ian ELLIOTT*[1]**, Helen EDWARDS[1], Peter MUMBY[1], Claire PARIS[2], William SKIRVING[3], Mark EAKIN[3]

[1]Biosciences, University of Exeter, Exeter, United Kingdom, [2]University of Miami, Miami, FL, [3]NOAA, Townsville, Australia

Conventional methods of selecting locations for marine reserves have not fully addressed the impacts of climate change and disturbance events upon coral reef ecosystems. Here we present a new approach that combines ecosystem models, climate change predictions and reserve selection tools in order to provide greater sophistication and resilience to marine reserve networks in areas prone to coral bleaching.

Reserves are chosen from potential sites in the Bahamas. The conservation value of a site is determined by its current status (dependent upon the species and habitat it contains), and by the temperature characteristics of that location. Future sea surface temperatures are projected using data from a model that incorporates IPCC climate predictions. We consider both the average summer temperature and the variability in temperature at each location and in each decade until 2100. We prioritise sites that suffer less thermal stress and are less likely to experience bleaching. Sites are further prioritised if they have strong connectivity, allowing for coral larvae recruitment from hot-variable sites with resistance to bleaching.

An optimisation algorithm returns the configurations of reserves that minimise the losses to the fishing industry whilst meeting user-defined conservation and habitat-connectivity targets. The summed irreplaceability, defined as the number of all the reserve systems to which a site belongs out of the total number of reserve systems generated, is used to identify the most frequently selected sites. Reserve system efficiency and cost are compared under different bleaching scenarios and for different biodiversity targets. Incorporating the risk of future bleaching events modifies the influence of biodiversity criteria and has a profound influence on the distribution of reserves. Our results demonstrate that an increased awareness of the impacts of disturbance events can enable more effective management of coral reef ecosystems.

## 23-62

**Management Of The Florida Keys National Marine Sanctuary As Impacts Of Climate Change Strengthen**

**Brian KELLER*[1]**

[1]NOAA/SE Region/National Marine Sanctuary Program, St. Petersburg, FL

Coral reefs within the Florida Keys National Marine Sanctuary have experienced bleaching events of increasing spatial extent and severity over the past 25 years. Live coral cover has decreased over the past decade, associated primarily with the 1997-1998 mass bleaching event and the passage of Hurricane Georges in 1998. Projections of the Intergovernmental Panel on Climate Change suggest that stressors on reef-building corals, such as ocean temperature, acidification, and tropical storm severity, will increase during the next few decades. "Adaptations" to climate change are fast gaining the attention of managers of marine protected areas. Management adaptations include four categories of actions: 1) ameliorating existing stressors in coastal waters; 2) protecting apparently resistant and potentially resilient areas; 3) developing networks of marine protected areas; and 4) integrating climate change into marine protected area planning, management, and evaluation. The National Marine Sanctuary Program has formed a Climate Change Working Group that is initiating a systematic approach to develop practical strategies for resource protection in the context of climate change. Application of these strategies in the Florida Keys National Marine Sanctuary includes: the continued use of fully protected marine reserves; continued improvements to wastewater treatment and stormwater management through the sanctuary's Water Quality Protection Program; considering further protection of apparently resistant and potentially resilient areas identified by the Florida Reef Resilience Program; planning and implementing networks of these areas; and working closely with the National Marine Sanctuary Program's Climate Change Working Group as it helps implement practical climate change strategies at each national marine sanctuary. For the Florida Keys, implementing recommendations of the Reef Manager's Guide to Coral Bleaching will be a major part of incorporating climate-change impacts into sanctuary management.

## 23-63

**Do Marine Protected Areas Mitigate Coral Cover Decline?**

**Elizabeth SELIG*[1]**, John BRUNO[2], Kenneth CASEY[3]

[1]Curriculum in Ecology, University of North Carolina, Chapel Hill, NC, [2]Department of Marine Sciences, University of North Carolina, Chapel Hill, NC, [3]National Ocean and Atmospheric Administration, Silver Spring, MD

The global decline of corals has intensified the need for management strategies that can restore coral health, particularly in the face of climate change. Marine protected areas (MPAs) have clearly been effective for fisheries management, but their effects on coral health at regional scales are not well understood. MPAs could have positive indirect effects on corals by increasing resistance through the mitigation of stressors like overfishing and nutrient run-off if there is a terrestrial component. In addition, MPAs could increase the resilience or recovery rate from disturbance events by increasing herbivore abundance through better fisheries management. Using spatial databases of MPAs and surveys from more than 3800 reefs around the world, we analyzed how MPAs and MPA duration affected the rate of change of coral cover. We found a weak positive effect of MPAs on coral cover and a positive effect of the number of years of protection on the rate of coral cover change within MPAs. We also used a 21-year satellite temperature anomaly database to specifically test whether MPAs could lessen the effects of rising temperatures and if MPAs could be better designed to maximize benefits. Although our results suggest that MPAs can increase coral resilience, the weakness of the effect underscores the need for additional and more direct conservation measures including those aimed at reducing climate change.

## 23-64

**Ecological Effects Of No-Take Marine Reserves: Tests Of Latitudinal Variation And Adult Spillover And Comparison To Partial Protection**

**Sarah LESTER*[1]**, Benjamin HALPERN[2], Kirsten GRORUD-COLVERT[3]

[1]Institute of Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, [2]National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, Santa Barbara, CA, [3]Partnership for Interdisciplinary Studies of Coastal Oceans, Oregon State University, Corvallis, OR

The study and implementation of marine reserves has increased rapidly over the past few decades, providing ample data on the biological effects of reserve protection for a wide range of geographic locations and organisms. Reserves have been shown to support more intact communities, with a greater abundance and biomass of key species compared to areas outside. Nonetheless, numerous questions remain about their potential benefits and management utility. We conducted a survey of peer-reviewed scientific literature to compile a global database of studies documenting biological effects for multiple taxa in no-take marine reserves. We show that on average reserves generate strong positive effects for the biomass, density, species richness, and size of organisms within their boundaries and we explore how these results vary across different taxa. We then address several core issues in marine reserve science. First, we compare the performance of marine reserves in tropical and temperate environments and show that reserves have parallel positive effects across latitude. Second, we present emerging evidence that spillover of adults into unprotected waters is a general and quantifiable phenomena and likely scales with reserve size. Lastly, we evaluate the relative benefit of partial protection versus full protection (no-take reserves) and show that while partial protection affords some ecological benefits over open-access, on average greater responses are likely to be found for fully protected areas. These results have important implications for future efforts to design and implement marine reserves.

## 23-65

**Development Of Resilience-Based Management Strategies For Florida's Coral Reefs**

**Chris BERGH*[1]**, Phillip KRAMER[2], William CAUSEY[3], Mark EAKIN[4], David SCORE[3], Chantal COLLIER[5], Kent EDWARDS[6], Stephanie BAILENSON[7], Peter CONE[8], Paul MARSHALL[9], Eric MIELBRECHT[10], Frank MULLER-KARGER[11], Robert VAN WOESIK[12], David VAUGHAN[13], David LOOMIS[14], Robert LEEWORTHY[4], Joanne THOMAS[2], Brian KELLER[3]

[1]Florida Keys Program, The Nature Conservancy, Sugarloaf Key, FL, [2]The Nature Conservancy, Sugarloaf Key, FL, [3]NOAA, Key West, FL, [4]NOAA, Silver Spring, MD, [5]Florida DEP, Miami, FL, [6]Florida DEP, Key West, FL, [7]Florida DEP, Tallahassee, FL, [8]Commerical Fisher, Key West, FL, [9]Great Barrier Reef Marine Park Authority, Townesville, Australia, [10]Emerald Coast Environmental Consulting, Washington, DC, [11]University of South Florida, Tampa, FL, [12]Florida Institute of Technology, Melbourne, FL, [13]Mote Marine Laboratory, Summerland Key, FL, [14]University of Massachusetts, Amherst, MA

The Florida Reef Resilience Program (FRRP) is a collaborative effort among managers, scientists, conservation organizations and reef users to develop resilience-based management strategies for coping with climate change and other stresses on Florida's coral reefs. In 2004 the 400 km long reef tract from Martin County to Dry Tortugas was classified into 59 discrete reef zones. A "Disturbance Response Monitoring (DRM)" procedure, consisting of a probabilistic sampling design and a stony coral condition monitoring protocol, was developed and applied across these zones during the annual period of peak thermal stress in 2005, 2006 and 2007. DRM results show spatial and temporal patterns in coral bleaching and colony size frequency distribution, indicating that some zones and coral species may be more resilient to stress than others. Data on water quality parameters, volunteer observations of bleaching occurrence and remotely-sensed sea-surface temperature and accumulated thermal stress were analyzed to help explain variability in stress responses. This biophysical analysis of reef resilience was paralleled by social science research focused on reef users' perceptions of reef condition, reef management strategies and the economics of reef-dependent recreational and commercial activities. Results of FRRP research and other relevant studies were communicated with stakeholders during a series of workshops designed to gather input about optimization of existing reef management and reef use strategies and to identify novel strategies. The resulting recommendations are wide ranging and include; preferred anchoring methods, voluntary avoidance of stressed reefs, timing of coastal construction activities to minimize cumulative stress on corals, changes in fishing practices and new goals for spatial coverage, distribution and type of marine protected areas in the region.

## 23-66

**Hurricane Dean impacts on Chinchorro Bank coral reefs, Mexico: Bases to implement ecosystem-based fisheries management**

**Alvaro HERNÁNDEZ*[1]**, Fabián RODRÍGUEZ-ZARAGOZA[2], Gilberto ACOSTA-GONZÁLEZ[3], Miguel RUIZ-ZARATE[4], José CASTRO-PÉREZ[5], Alicia MEDINA-HERNANDEZ[6], María GARCÍA-RIVAS[7]

[1]Mesoamerican Reef, World Wildlife Fund, Cancun, Quintana Roo, Mexico, [2]Ecology, Universidad de Guadalajara, Zapopan, Jalisco, Mexico, [3]Recursos del Mar, CINVESTAV-Merida, Mérida, Yucatan, Mexico, [4]Quimica y Biologia, Instituto Tecnologico de Chetumal, Chetumal, Quintana Roo, Mexico, [5]Quimica y Biologia, Intituto Tecnologico de Chetumal, Chetumal, Quintana Roo, Mexico, [6]Mesoamerican Reef Program, World Wildlife Fund, San José, Costa Rica, [7]Reserva de la Biosfera Banco Chinchorro, Comision Nacional de Areas Protegidas, Distrito Federal, Mexico

As part of the activities to implement the ecosystem-based fisheries management in Chinchorro Bank Biosphere Reserve (ChBBR), Mexico, an inter-institutional work team initiated a systematic monitoring to evaluate its coral reef conditions. In April 2007, the team, integrated by World Wildlife Fund, ChBBR administration, and Chetumal Technologic Institute, in collaboration with local fishermen collected data through 120 transects in five sites. This information allowed us to calculate biodiversity and ecosystem functionality. On August 2007, the eye of Hurricane Dean (category 5) hit ChBBR. In September 2007, the inter-institutional team organized a second monitoring to assess the impact of this hurricane in three sites with highest biodiversity: 1) La Caldera, 2) La Baliza and 3) Chancay.

The community parameters of fish assemblages and the conditions of habitat structure were estimated through visual census; topographic complexity ("chain" technique); Horizontal heterogeneity (video-transects); and benthic groups and type of substrate (point intercept).

The comparison of the community parameters before and after the hurricane showed a higher impact on the benthic community of La Baliza. In this site, there were significant differences in both, shallow and deep habitats due to a coverage reduction of the following groups: sand, macro-algae, and hard coral. On the other hand, in La Caldera and Chancay the impact was moderate; which registered a significant reduction of macro-algae and large reef extensions covered by mold. In the three sites, fish biodiversity and biomass was similar before and after the hurricane, but the structure of fish assemblage was significantly different. After the hurricane, key invertebrates abundance increased significantly, particularly Panulirus argus, Strombus gigas, and Diadema antillarum. These results suggest that fish resources as well as invertebrates maintained a similar biomass, although we recommend that further fisheries exploitation must be cautious to enhance natural resilience and avoid a potential collapse of the resources.

## 23-67

**Climate Change Leads: Linking Environmental Analysis To Decision Support in Florida**

Alex SCORE[1], Eric MIELBRECHT[2], Daniel WAGNER[3], Debra HARRISON[1], **Lara HANSEN*[4]**

[1]World Wildlife Fund, Marathon, FL, [2]Emerald Coast Environmental Consulting, Washington, DC, [3]Biological Sciences, Florida Institute of Technology, Melbourne, FL, [4]World Wildlife Fund, Washington, DC

Coral reefs were one of the first ecosystems where the effects of climate change were readily apparent. As a result of their high vulnerability to climate change there is a pressing need for coral reef resource managers, including those in Florida, to manage for climate change. Florida's stakeholders and decision-makers urgently need targeted research, clear communications, and accessible tools to better understand the impacts of climate change and coral bleaching so they can develop and implement successful management and mitigation initiatives. The Climate Change: Linking Environmental Analysis to Decision Support (LEADS) initiative brought together scientists, natural resource managers and decision-makers at the local, state and federal levels, with a full range of stakeholders to analyze patterns in coral resilience to climate change and transform these findings into effective management strategies. A GIS based tool was created that illustrates patterns of coral resilience within the Florida Keys National Marine Sanctuary and allows users to manipulate layers of environmental data in prescribed and unique ways. The creation of this management tool, which promotes a better understanding of local environmental parameters that are associated with assemblages of resilient coral, was based on research that synthesized existing and emerging coral bleaching and water quality data for the Florida Keys in a GIS framework and identified patterns in bleaching occurrence and recovery with respect to environmental variables. The resource management applications of this GIS-based tool will be presented along with a description of the stakeholder and decision-maker outreach process utilized in the Climate Change LEADS initiative in the Florida Keys.

## 23-68

**Large Scale Transplantation Of Corals in A Small Island State**

Stephanie DOORN-GROEN[1], **Eugene GOH*[1]**, Karenne TUN[1], Thomas FOSTER[1], Clint TIWOL[1]

[1]DHI Water & Environment (S) Pte. Ltd., Singapore, Singapore

Singapore is a small, highly urbanized and industrialized island state, with extensive marine industries fringing most of her Southwestern coast and offshore islands which are fringed by coral reefs. Land intensive port operations and petrochemical industries have played a pivotal role in the island's economic success. As these industries expand, increased demand for land has lead to land reclamation works. While some of Singapore's reef habitat has been lost as a result of this development, coral species extinctions are not evident. Moreover, although reef area has been reduced and population abundance decline is apparent, the rate of this decline also appears to have been reduced through increased management and awareness of the importance of the reef habitats.

While the transplantation of corals as a compensation measure is viewed as a poor alternative to the conservation of entire reef communities, it provides an essential management tool whenever direct impact is inevitable. In 2006, one of the largest transplantation programs ever undertaken in Asia led to the relocation of about 4,200 mature coral colonies in Southwest Singapore with diameters up to 2m. Subsequent monitoring indicated a high survival rate; 12 months after the transplantation, about 80% of the monitored corals continue to thrive in their new home. This is a positive contrast to the survival reported in previous relocation programs in Singapore during the 1990's.

This paper reports on the key elements and processes that influenced and led to the successful execution of the transplantation exercise. The paper also discusses the systematic approach undertaken as well as the selection criteria used for the receiving site, which is considered the key to the success of the transplantation works.

## 23-69

**Restore Or Not To Restore?**

**Vladimir KOSMYNIN*[1]**, Alison MOULDING[2], Richard DODGE[2], David GILLIAM[2]

[1]Bureau of Beaches and Coastal Systems, Florida Department of Environmental Protection, Tallahassee, FL, [2]National Coral Reef Institute, NOVA Southeastern University, Dania, FL

Most coral reef scientists and managers would agree that coral reefs are degrading at ever increasing rates from a multitude of natural and anthropogenic stressors occurring at global, regional, and local scales. However, there is less agreement on the circumstances that warrant restoration and if costs outweigh benefits. In many cases observed recovery rates are slow, and new communities often have compositions differing from the original. Requirements for restoration of human-induced local damages often differ widely among countries. Efforts may involve reattachment of corals or their propagation (enhancement of recruitment) using various methodologies. The success of such local restoration is variable and depends on many natural and human induced factors. Nevertheless, published data and experimental results of projects in Southeast Florida demonstrate a high probability of success. Some would argue that restoration is insufficient to address large-scale degradation issues and, consequently, that limited funds should instead be directed at reducing impacts. While it is true that regional damages resulting from hurricanes, tsunamis, disease outbreaks, and bleaching events may involve areas too large for full-scale restoration, smaller scale restoration is an important management tool that could potentially benefit local and regional coral populations and speed recovery. Locally restored areas may serve as sources of coral propagation and stepping stones in connectivity between reefs. Restoration projects are also important in generating public awareness and support of conservation efforts. Additional research efforts directed at finding and testing new coral reef restoration methodologies should be continued. Unaided recovery of injured coral reefs now represents a much less likely scenario given the considerable local, regional, and global stressors.

## 23-70

**The Management Of Coral Reefs – Where We've Gone Wrong; How We Can Fix It**

**Peter F SALE*[1]**

[1]International Network on Water, Environment and Health, United Nations University, Hamilton, ON, Canada

Ecologists studying coral reefs long ago shifted from an assumption that these were ecosystems essentially untouched by humans, to a recognition that human impacts have become pervasive and severe, but they have meanwhile been party to a disastrous separation of science from management – a separation that keeps their growing understanding from being integrated into management action. Managers, when they have moved beyond the wishful thinking of paper parks and public awareness campaigns, have put undue faith in the effectiveness of Marine Protected Areas while ignoring both the lack of scientific underpinning of many management practices and the elephant which is rampant and growing over-exploitation of reef resources. The result is a sad history of progressive decline. Reefs suffer a diversity of often synergistic stresses. There is a way forward if we first decide that we really want to have sustainable coral reef systems in our future. This path requires that we firmly embrace the precautionary principle, that we recognize and reduce over-exploitation, and that we vigorously apply the science we have in hand to improve management now. Along the way we need to develop new science to provide a basis for more sophisticated management than is now possible. There is hope for a future for coral reefs, but only if scientists and managers act now to reduce controllable stresses, freeing these ecosystems to better cope with less manageable pressures of climate change. Achieving this future will require far more effective demonstration than yet achieved of the value of coral reefs to coastal populations.

## 23-71

**Are There "Ten Commandments"for Coral Reef Management?**

**Barbara BEST*[1]**

[1]Office of Natural Resources Management, U.S. Agency for International Development, Washington, DC

In an effort to capture the essential management actions required for Ecosystem-Based Fisheries Management, several fisheries scientist have proposed 10 guiding principles or "commandments". Could coral reef management benefit from a similar effort to capture critical management guidelines? To initiative a discussion within the coral reef community, an initial draft set of guidelines are presented. These commandments are based largely upon experience in less-consuming countries with weak governance and institutions but are widely applicable.

The first cluster of guidelines involves spatial attributes: 1. look upstream – take a watershed approach. 2. look down -- establish depth refugia. 3. look near then far -- include associated habitats then other functionally-connected reefs.

The second cluster focuses on the management process: 4. Understand the cultural, social, economic and governance context and work accordingly. 5. Focus on the consultative process early -- the science process should not outpace the stakeholder process. 6. Build management resilience – provide redundancy in leadership and capacity, strengthen management entities and organizations, and ensure revenue streams. 7. Address sea tenure and access rights – create incentives for environmental stewardship through clearly defined access and use privileges. 8. Focus on the decision-making process so that sound information and science is incorporated into decisions. 9. Create local economic incentives for conserving biodiversity and ecosystem services. 10. Address the drivers of international trade that threaten reefs, from fishing to tourism to other extractive industries.

## 23-72

**Ecological Criteria For Prioritizing Wider Caribbean Reefs in Need Of Protection**

**Judith LANG*[1,2]**, Robert GINSBURG[3,4], Kenneth MARKS[4,5]

[1]Independent, Ophelia, VA, [2]Marine Geology & Geophysics, RSMAS, University of Miami, Miami, [3]Marine Geology & Geophysics, RSMAS, University of Miami, Miami, FL, [4]Ocean Research and Education Foundation, Coral Gables, [5]Independent, Boca Raton, FL

Reefs with an abundance of healthy corals (including some that are large), ample crustose coralline algae and little macroalgae, are obvious candidates for protection and conservation. (Large corals provide habitat space for other organisms as well as larvae for future generations of framework builders or possible remediation efforts; abundant crustose corallines and sparse macroalgae signify the probable availability of larval recruitment sites.) To determine whether or not reefs with these characteristics are actually being protected, an easily calculated benthic condition index (BCI) based on the AGRRA project's coral and algal indicators has been developed. BCI values have been calculated for the over 700 surveys conducted between 1998 and 2004 on reefs in the wider Caribbean that had been stratified by zone (as bank, crest, fore, patch). This information will be posted online at www.agrra.org to help guide difficult decisions regarding where to focus local protection and management efforts. For example, sites rated overall as "well above average" (WAB) occurred in 15 of the 22 nations or territories and on 29 of the 50 insular or continental shelf units that were surveyed. Nearly half of these WAB sites are presently located in a marine protected area (MPA) of some designation. High priority should be given to protecting the remaining WAB sites, particularly those in areas with few or no established MPAs. Sites with high values for the macroalgal indicator signify overfishing of herbivorous fishes or nutrification, and could be further examined for potential causes and remediation strategies, the efficacy of which could be assessed during future surveys. In the absence of recent hurricanes or other mechanical damage, a paucity of large corals indicates poor environments for net reef growth, although other reasons may exist for their conservation.

## 23-73

**Caribbean Coral Reefs: Reversing The Slippery Slope To Slime**

**John OGDEN*[1]**

[1]Florida Institute of Oceanography, University of South Florida, St. Petersburg, FL

Coral reef monitoring and research programs, such as the Caribbean Coastal Marine Productivity (CARICOMP) network of marine laboratories and many others, have provided rich documentation of the continuing decline of Caribbean coral reefs and linked coastal ecosystems of the past 50 years. While science and management have achieved some local successes, particularly at the political level, in implementation of management plans largely based on small marine protected areas, there is little evidence that this effort has increased reef resistance and resilience to human disturbances. In spite of considerable depth of scientific understanding that the Caribbean Sea functions as a large marine ecosystem with coherent, region-wide ecological responses, there has been only one attempt to implement a regional management, scientific and governance scheme across a large coral reef region. Drawing on this experience, I suggest that a familiar land-use planning approach be implemented in a demonstration project within the contiguous Exclusive Economic Zones of several island countries. Within this large coral reef ecoregion, existing environmental and scientific information as well as traditional knowledge and human use patterns will be organized in a geographic information system format. This will allow stakeholders to apply management tools, particularly zoning, to separate conflicting human activities and plan for protection of critical conservation areas. Unlike land-use planning, ocean-use planning can be implemented on a trial basis with the plan adjusted over time with new knowledge. It will also provide new scientific information at more appropriate, large geographic scales on the resilience of coral reefs. It is past time to act. Coral reefs require comprehensive planning within ocean ecoregions if they are to sustain future human use and the beauty, wonder and lifting of the spirit that they so uniquely provide.

## 23-74

**Shifting Baselines, Local Impacts, And Global Change On Coral Reefs**

**Jeremy JACKSON*[1,2]**, Nancy KNOWLTON[3]

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, [2]Smithsonian Tropical Research Institute, Balboa, Panama, [3]Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, DC

The lush coral reefs of the remote, uninhabited and protected atolls of the Central Pacific raise basic questions about the importance of local impacts versus global change for the health of coral reef communities worldwide. Despite increased warming and high numbers of degree heating weeks that cause coral bleaching, these reefs still support extraordinarily abundant fish populations dominated by apex predators and living coral ranging from 44 to 56% live coral cover. This is as true of atolls in areas of intense upwelling and high productivity like Jarvis, Howland, and Baker, where nutrient concentrations greatly exceed those supposed to cause coral disease and mortality, as for atolls like Kingman and Palmyra in areas of much lower productivity. Detailed, long-term studies are lacking to determine whether these reefs somehow resisted bleaching or, as we believe more likely, have recovered from bleaching due to high recruitment and rapid growth of corals coupled with lower levels of macroalgal overgrowth, coral disease, and outbreaks of coral predators. Regardless, the simple persistence and obvious resilience of these reefs contradicts the widespread belief that the effects of global change are so overwhelming that local human impacts such as fishing and pollution can be safely ignored. More importantly, the quasi-pristine reefs of the Central Pacific are invaluable as monitoring stations for consequences of global change under ecologically optimal conditions of minimum local human impact, and as sites for observations of ecological processes and experiments on reefs that have not experienced the extreme degradation typical of other reefs worldwide. Experimental confirmation that local protection increases coral resilience to global change would provide the concrete evidence necessary to promote costly changes in management to more stringently regulate exploitation and pollution of reef ecosystems elsewhere.

## 23-75

**Plan B For The Anthropocene**

**Roger BRADBURY*[1]**, Robert SEYMOUR[2,3]

[1]Resource Management in Asia-Pacific Program, Australian National University, Canberra, Australia, [2]Department of Mathematics, University College London, London, United Kingdom, [3]CoMPLEX, University College London, London, United Kingdom

The Earth system is in transit from its current state, the Holocene, to a new one, the Anthropocene. The transition is being forced by the relentless process now called globalisation – really just the most recent half-century of the last few millennia of the transformation of the planet by human beings. The change is now locked in and is irreversible. Global warming is not the cause, but merely one of the more obvious symptoms of an inexorable process.

We don't know the details of the Anthropocene but we can now see its shape emerging clearly. The land, where people live, is becoming a new single, tightly interconnected, and greatly simplified agro-ecosystem whose contradictions – in terms of energy and mass fluxes and balances – will be resolved in the sea, where people don't live. The sea, already a single system, will host a vastly simplified ecosystem whose closest historical analogue will be the pre-Cambrian seas dominated by life forms such as jelly animals and algae.

Both the land and the sea will be inherently unstable and so need to be tightly managed. The management implications are profound. We may need to manage coral reef ecosystems through the transition into a reduced future shape, preserving what we can of their ecosystem function, perhaps at the expense of their current biodiversity and structure. Because most policy settings and management strategies are focussed on preserving reefs in something like their present Holocene state, they are, to that extent, unrealistic and unworkable. We will sketch the elements of an alternative policy and management framework – a Plan B – for the reefs of the Anthropocene.

## 24-1

**Fates Of Restored Acropora Palmata Fragments At The M/v Fortuna Reefer Grounding Site, Mona Island Puerto Rico: Lessons Learned Over 10 Years**

Andrew BRUCKNER[1], Ron HILL[2], **Robin BRUCKNER*[3]**

[1]NOAA Coral Reef Conservation Program, NOAA, Silver Spring, MD, [2]Southeast Fishery Science Center, NOAA Fisheries, Galveston, TX, [3]Office of Habitat Conservation, NOAA Restoration Center, Silver Spring, MD

Restoration of detached Acropora palmata fragments generated by the M/V Fortuna Reefer grounding off Mona Island (18°02'N; 67°51'W) was completed on October 14, 1997, three months after the grounding. Fragments (n= 1857) were secured to either reef substrates or dead standing A. palmata skeletons using stainless steel wire. Fragments experienced high rates of early mortality (57% surviving after 2 years) primarily attributed to wire breakage and removal during winter storms, overgrowth by bioeroding (clionid) sponges, disease, and predation by Coralliophila abbreviata (gastropods). Fewer than 10% (n=166) of the fragments were alive after 10 years. Most survivors resembled adult colonies with tissue covering their upper skeletal surfaces, extensive branching (mean= 5 branches, 89 cm in length), and a substantial increase in height (mean = 39 cm tall). Survivors included representatives of all size classes originally attached (15-340 cm), although the mean length of survivors (78 cm) was significantly larger than dead fragments (62 cm). Most surviving fragments were secured to the reef (70%) and oriented upright (>80%). These were 13% larger (mean=79 cm original length; current length= 120 cm) and had grown upward 14% more than fragments attached to skeletons. The most significant ongoing sources of mortality include snail predation (8%), overgrowth by sponges (6%), and disease (6%). While some fragment mortality can be directly attributed to the restoration approaches used at this site, most losses were due to disease and corallivory, two pervasive problems affecting acroporids throughout the region. Since 2001, we have documented an increase in corallivore abundance and a severe outbreak of disease; these primarily affected unrestored colonies, and have caused the loss of >95% of the colonies in surrounding areas. To improve our ability to recover and rebuild degraded acroporid populations, restoration approaches need to be combined with measures to mitigate disease and corallivory.

## 24-2

**Gardening Coral Reefs – New Insights For Coral Reef Restoration By Using Branching Corals As Ecosystem Engineering Species**

**Yael HOROSZOWSKI*[1,2]**, Jean-Claude BRETHES[3], Baruch RINKEVICH[1]

[1]National Institute of Oceanography, Israel Oceanographic & Limnological Research, Haifa, Israel, [2]ISMER, Universite du Quebec a Rimouski, Rimouski (Quebec), Canada, [3]ISMER, Universite du Quebec a Rimouski, Rimouski (Quebec), QC, Canada

Many of the world's coral reefs are experiencing a severe degradation due to anthropogenic activities that have significantly weakened the reefs' ability to cope with disturbances. Due to the ineffectiveness of traditional measures, active restoration has now become the premiere method of rehabilitation. In past efforts, coral colonies were taken from healthy localities and transplanted into denuded areas. This, however, resulted in low survival rates and inflicted stress on donor colonies. With the aim of overcoming these pitfalls, we tested the application of the "gardening coral reefs concept," a method inspired from forest restoration guidelines. This method involves generating and farming large stocks of new coral colonies in an *in situ*, floating nursery prior to their transplantation into degraded reefs.

The experiment targeted a degraded zone of Eilat's Reef, Israel. Two transplantation events were carried out: In November 2005, 550 nursery-grown colonies of two branching scleractinians (*Stylophora pistillata*, *Pocillopora damicornis*) were transplanted on five denuded knolls. In May 2007, 330 nursery-grown colonies of three branching species (*S. pistillata*, *P. damicornis*, *Acropora sp.*), one massive species (*Favia favus*) and one hydrozoan (*Millepora dichotoma*) were added.

The first two years of monitoring revealed low mortality rates of the new transplants. The new ecological and spatial niches resulting from the autogenic engineering characteristics of the transplants were immediately colonized by coral-obligatory invertebrates. When following influences on local fish community we witnessed an increase in the habitat's carrying capacity, reflected by higher fish abundance with no modification of the species composition. *S. pistillata* colonies from both transplantations released planula larvae. Thus, the nursery-grown transplants are not only reinforcing the local coral community but are also contributing to larval pool by participating in the local coral reproduction.

## 24-3

**Coral Transplantation in a Degraded Lagoon Environment: Differential Results of Three Species**

**Edgardo GOMEZ*[1]**, Patrick CABAITAN[1], Helen YAP[1]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines

A major challenge to restoration ecologists concerning reef corals is the determination of the appropriate species to use, and how to deploy them in the field to ensure good survival and growth. We transplanted three coral species which represent different life history strategies, viz., *Montipora digitata, Porites cylindrica, and Pavona danai.* Our study aims to establish viable coral populations within a range of conditions in a degraded lagoon environment (Bolinao, northwestern Philippines). The basic assumption is that prevailing environmental factors are still favorable for scleractinian survival, growth and reproduction, but that limitations probably exist in terms of potential recruitment, substrate suitability, and competition with other, established, benthic species. Degraded bommies along a gradient from sheltered to exposed conditions were used as platforms for the transplantation of branch fragments of the three species mentioned above. There was variable success ranging from high mortality for a usually fragmenting species, *M. digitata*, to virtually no mortality for *P. cylindrica*, with *P. danai* towards the more positive end. Growth of the transplants appeared to be better in environments that resembled more closely those of their naturally established (source) populations. The experimental treatments included variations in density and orientation of the transplants (attachment to horizontal and vertical surfaces), for which there appear to be no statistically significant differences in terms of growth and survival.

## 24-4

**Coral Transplants As Rubble Stabilizers: A Technique To Restore And Mitigate Damaged Reefs**

**Pablo ROJAS*[1]**, Laurie RAYMUNDO[1], Roxanna MYERS[1]

[1]Marine Laboratory, University of Guam, Mangilao, Guam

Developing workable stabilizing techniques to mitigate the effects of coastal construction, ships groundings and destructive fishing have been challenging well-informed decision makers for the past 30 years. Coral communities reduced into rubble are less likely to provide potential substrate for recruits due to instability and have slim chances to recover. We tested the efficacy of using two species of corals with contrasting morphologies as rubble consolidators. Three experimental plots were established in a 14 m2rubble field at 15 m depth in Sumay Mound, Apra Harbor, Guam. Eighteen fragments each of *Porites rus*, a submassive species that forms basal plates and *Porites cylindrica*, an upright branching species were transplanted to each plot in June 2006. We cemented each fragment to pieces of rubble to provide minimum stability and monitored for consolidating ability, measured in survival and basal growth and branching. We hypothesized that *P. rus*, which is hardy and forms extensive basal plates like forming plate would be superior as a consolidator to *P. cylindrica*. After 13 months, growth and overall survival varied significantly between species. Survival of *P. rus* was 99% and 80% for *P. cylindrica*. Monthly mean basal growth was 0.76 mm for *P. rus* and 0.16 mm for *P. cylindrica*. *Porites rus* proved superior as a stabilizer due to its plate-like forming base that enhanced fragment stability. *P. cylindrica* failed to attach to substrate and its mortality was higher. Transplants required occasional recementing in the early stages and cleaning of seasonally abundant macroalgae. Our study demonstrated that a morphologically complex, hardy, plate-forming coral species can be used to stabilize coral rubble. With minimum maintenance at post-transplantation, *Porites rus* established themselves within one year and showed positive growth, high survival and attachment to the substrate.

## 24-5

**How Quickly Do Coral-Fragments Of Different Species 'self-Attach' After Transplantation?**

**James GUEST*[1]**, Rommi DIZON[2], Chiara FRANCO[3], Alasdair EDWARDS[1], Edgardo GOMEZ[2]

[1]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]Marine Science Institute, University of the Philippines, Diliman, Philippines, [3]Department of Marine Science and Technology, Newcastle University, Newcastle upon Tyne, United Kingdom

Although corals regularly undergo colony fragmentation, mortality of unattached coral fragments can be high. Consequently the speed at which fragments 'self-attach' to substrata is likely to be critical to survival. During reef restoration interventions, coral transplants are often attached using epoxy or other adhesives, however self-attachment by growth of coral tissue onto the substrate is likely to provide a more secure and lasting bond. While it is known that coral fragments can generate new tissue to bond to the substratum within a few weeks of transplantation, surprisingly little is known about the speed of self-attachment. In this study, self-attachment times as well as growth rates and survival of transplanted fragments from thirteen coral species on replicated calcium carbonate substrata were examined experimentally in north-western Philippines. Two independent experiments were carried out. The first examined self-attachment, growth rates and survival in eleven species from different families representing a range of morphologies over approximately two years, whereas the second examined self-attachment times of three fast-attaching *Acropora* species in detail over one month. In the first experiment, *Acropora muricata* was significantly faster to self-attach (median time 39 days) compared to all other species, while *Echinopora lamellosa* was slowest to self-attach (median time 167 days) and was significantly slower than all other species except *Porites lutea* and *Pavona frondifera*. In the second experiment, *A. muricata* (branching) was significantly slower (median time 24 days) than *A. hyacinthus* (tabular) and *A. digitifera* (digitate)(median time 16 days). Results reveal that *Acropora* species have significantly faster attachment times than the other coral taxa studied. However branching *Acropora* species - which tend to fragment more frequently - do not necessarily have faster self-attachment times than other morphologies.

## 24-6

**Restoration Of Threatened Acropora Cervicornis Corals: Clone As A Factor in Mortality, Growth, Branching, And Self-Attachment**

**Austin BOWDEN-KERBY*[1]**

[1]Counterpart International, Suva, Fiji

The potential of farming *Acropora cervicornis* corals to restore this threatened species to Caribbean reefs was investigated, with particular emphasis on genetic factors relating to the relative success of culture methods. Clones from both high and low energy areas were sampled, to determine the relative importance of intraspecific variability and source environment on experimental outcomes. Corals were sampled from eight isolated *Acropora cervicornis* populations; thirty 10cm coral fragments obtained from each. Half of the samples were obtained from reef front coral thickets, and half were obtained from back reef areas. Fragments were attached to wire frames using colored ties to distinguish between clones, six branches per clone per frame. Sites were located in shallow back reef areas <2m deep, on five different reefs in the La Parquera reef system, Puerto Rico, with each frame placed on sand. Measurements were taken at one year for mortality, growth, branching density, and self attachment. Analysis was done separately for clones obtained from back reef and reef front areas. Results indicate that clone is a highly significant factor for all of the variables studied: mortality, growth, branch density, and attachment. There was up to a six-fold difference in relative growth based on clone alone. Back reef and reef front clones of *A. cervicornis* differed significantly in branch diameter, relative growth, and attachment ability after growing together for one year, suggesting a genetic basis to morphology and adaptation to specific environments. Frame culture was effective as a culture method, with mean growth rates ranging from 7-fold to 21-fold during the year. The application of this information to *A. cervicornis* restoration work ongoing in the Dominican republic and Honduras is also presented.

## 24-7

**Survival, Growth, And Fecundity Of Acropora Muricata And Hydnophora Rigida After Fragmentation And Transplantation**

**Kareen VICENTUAN*[1]**, James GUEST[2], Porfirio ALIÑO[1], Andrew HEYWARD[3]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [3]Australian Institute of Marine Science, University of Western Australia, Crawley, Philippines

Coral transplantation is seen as one way of rapidly restoring coral cover and structural complexity to degraded reefs. However little is known about the potential negative affects on the health of the donor colonies due to removal of fragments. In this study, we examined the effects of fragmentation and transplantation on the survival, growth and reproductive effort of donor colonies and transplants of *Acropora muricata* and *Hydnophora rigida* using 2 fragment sizes (ca. 5 and 10 cm long). Fragments were removed from replicate donor colonies and attached to replicated calcium carbonate substrata (dead giant clam shells) at an *in situ* nursery in a protected lagoon site in north-western Philipines. A second set of control colonies were tagged but left untouched. A replicate set of control fragments was also collected and transplanted beside the donor colonies. The annual pattern of reproduction of natural colonies was also examined over a period of 1 year. Survival, growth and reproductive output of half of the donor colonies and transplants were examined 4 months after fragmentation and transplantation (in March 2007, prior to the predicted spawning dates) The remaining replicates were to be examined after 17 months, however most of the remaining colonies and transplants died due to a coral bleaching event and an outbreak of *Acanthaster planci* at the study sites. Thus, only results of the four months post-manipulation will be presented here. Preliminary results indicate that their reproductive effort is significantly higher in donor colonies compared to transplanted fragments and that large fragments have higher (albeit not significant) reproductive effort than small transplants. Reproductive output of the donor colonies was not significantly different from control colonies suggesting fragment removal did not negatively affect the health of the donor colonies.

## 24-8

**Use Of A Mechanical Removal Device To Control Alien Algal Blooms On A Coral Reef in Kane'ohe Bay, Hawai'i**

**Eric CONKLIN*[1,2]**, D. Eric CO[1], Brian HAUK[2,3], Cynthia HUNTER[4], Anthony MONTGOMERY[3], Brian PARSCAL[5], Celia SMITH[5]

[1]The Nature Conservancy of Hawai'i, Honolulu, HI, [2]Hawai'i Institute of Marine Biology, University of Hawai'i, Kaneohe, [3]Department of Land and Natural Resources, State of Hawai'i, Honolulu, HI, [4]Biology Program, University of Hawai'i, Honolulu, HI, [5]Botany Department, University of Hawai'i, Honolulu, HI

Coral reefs around the world are increasingly undergoing shifts from coral to algal domination in response to anthropogenic stressors. These "phase shifts" are most often attributed to increased nutrient inputs and/or decreased grazer abundance. On many reefs in Hawai'i, they are at least partially the result of a third contributing factor, the introduction of alien macroalgae. On reefs in Kāne'ohe Bay, O'ahu, these alien algae are rapidly spreading, overgrowing and killing reef building corals and associated benthic species. The objective of this study was to determine if the use of an underwater vacuum cleaner ("Super Sucker") to remove accumulations of algal biomass is an effective management tool to reverse the trend towards algal domination of reefs. The Super Sucker removed 8298kg of the alien alga *Gracilaria salicornia* from two sites on a fringing reef over several months, reducing algal cover from ca. 65% to ca. 15% and increasing rugosity and the availability of coral settlement substrata. Expectations were that alien algal biomass would slowly increase following removal due to intrinsic growth of remnant algae and the importation of algae from adjacent reef flat habitats, necessitating continued removal efforts. However, alien algae continued to decrease several months after removal until they were effectively absent from the removal sites. The Super Sucker appears to have reduced algal abundance below a tipping point at which the existing herbivore populations can control algal abundance. These encouraging results suggest that, at least under some circumstances, mechanical removal of alien algae from overgrown reefs may be a viable remediation technique that has the ability to produce long-lasting changes to benthic communities.

## 24-9

**Sponge-Mediated Coral Reef Restoration: Efficiency, Sustainability And Relative Performance**

**Brendan BIGGS*[1]**

[1]Biological Sciences, Florida State University, Tallahassee, FL

Physical disturbances damage coral reef three-dimensional structure, leaving behind unstable debris. Reef recovery is dependent, in large part, on coral reestablishment, and substratum stability is critical to the success and survival of live fragments and coral recruits. Coral reef sponges, whose attachment can anchor live coral and stabilize loose carbonate, help mediate the process of reef rejuvenation by providing time for the consolidation of coral skeletons by crustose coralline algae. Restoration efforts currently employ epoxy and cement to secure rubble and upended colonies, but these agents are unnatural, possibly less attractive, and potentially unfavorable to coral larvae. Utilizing organisms that naturally bind and stabilize rubble to help restore reefs has largely been overlooked. On shallow, fringing reefs in Curacao, four treatments varying substratum and binding agent -- coral rubble alone, coral rubble seeded with sponge fragments, coral rubble bound by cement, and cement rubble bound by cement -- were used to assess the performance of sponges relative to cement as a binding agent and to investigate preference of coral larvae for natural vs. artificial substrata. Regrowth of branch tips removed from sponges (*Niphates erecta*, *Aplysina cauliformis*, and *Aplysina* sp) for seeding coral rubble was also measured to evaluate the sustainability of sponge use. Sponge fragments attached to rubble readily, stabilizing and anchoring piles rapidly. Rubble piles with sponges had significantly more coral recruits, and were taller and tighter in shape, than coral rubble alone. Recruitment was heaviest to coral rubble bound by cement, but did not differ significantly for natural vs. artificial substrata. Regrowth was slowest for *N. erecta*, while both *Aplysina* species replaced tissue rapidly. Results indicate that using sponges to boost reef recovery is both feasible and sustainable and would be an effective natural addition to current restoration techniques.

## 24-10

**Species Specific Sensitivities Of Transplanted Coral Fragments From Eleven Species To Predation And Bleaching**

**Romeo DIZON*[1]**, James GUEST[2], Edgardo GOMEZ[1], Alasdair EDWARDS[2]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom

The selection of appropriate coral species is critical to the success of restoration interventions involving coral transplantation. Knowledge about the tolerance of species to various stressors, e.g. predation, disease and bleaching, is essential in deciding which are most suitable for transplantation. In this study, the performance among species and between two fragment sizes (3 to 5cm and 5 to 11cm) was compared for 11 coral species (*Acropora muricata*, *Echinopora lamellosa*, *Hydnophora rigida*, *Heliopora coerulea*, *Montipora digitata*, *Pocillopora damicornis*, *Pavona frondifera*, *Porites cylindrica*, *P. lutea*, *P. nigrescens* and *P. rus*). A total of 100 fragments of each species were attached to a standard calcium carbonate substrate (dead *Tridacna* shells) at five sites in a shallow lagoon (3-4 m depth) near Bolinao, north-western Philippines during December 2005 and February 2006. The survival and status of the 1100 transplants were monitored fortnightly for the first 6 months and semi-annually subsequently. On each occasion, mortality, partial mortality, predation and bleaching were noted for each transplant. Early mortalities were due to the predation of the muricid gastropod, *Drupella* sp., on *A. muricata* and the nudibranch, *Phestilla* sp., on the *Porites* transplants. Elevated water temperatures during June and July 2007 caused total or partial bleaching in 62% of the living transplants. Subsequently, survivorship of the transplants dramatically decreased. Periodic monitoring from July to November 2007 revealed inter-specific differences in their relative resistance to, and recovery from bleaching. *P. frondifera* was the most resistant species while *H. coerulea*, *P. lutea* and *M. digitata* were the fastest to recover. Although some species were generally susceptible to bleaching, some genotypes within a species showed remarkable recovery after bleaching.

## 24-11

**Assessment Of Gorgonian Transplantation Techniques Offshore Southeast Florida, Usa**

**Vanessa BRINKHUIS*[1]**, Alison MOULDING[1], Vladimir KOSMYNIN[2], David GILLIAM[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]Florida Department of Environmental Protection, Tallahassee, FL

Due to continuing anthropogenic degradation of coral reefs worldwide, there is need for effective and experimentally tested reef restoration protocols. Much effort has been spent on scleractinian coral transplantation. However, less attention has been directed towards effective techniques for the transplantation of gorgonians (Coelenterata: Octocorallia). This study used clippings from healthy adult *Pseudopterogorgia acerosa* and *Plexaura flexuosa* gorgonian colonies to test the effectiveness of several gorgonian attachment techniques. In April 2007, 40 donor colonies of each species were tagged. A total of 80 clippings (25cm) were collected from each species (2-3 clippings from each donor colony). A ship grounding site offshore Broward County, Florida was chosen as the transplantation site. Forty clippings from each species were attached with cement, and 40 were attached with epoxy (attachment material treatments). In addition, 40 clippings from each species had 10 cm of their base tissue removed from around their proteinaceous axis, and 40 clippings did not undergo base stripping (base treatment). Donors and clippings were monitored 1, 2, 3, and 6 months post-transplantation. Within the first month all clip wounds on the donor colonies were completely healed. By 6 months species specific differences in success were evident. The highest percent attachment and survival was 100% for both *P. flexuosa* base treatments attached with epoxy, and the least successful treatment, with the highest percent missing and lowest survival at 60%, was the *P. acerosa* non-base-stripped treatment attached with cement. It appears that for *P. acerosa,* tissue that had not been stripped became necrotic and sloughed off, resulting in a loose attachment which prevented the clippings from growing over the attachment material. This project provides resource mangers with quantitative evidence that gorgonian transplantation can be an effective part of reef restoration activities.

## 24-12

**Staghorn Corals Transplantation, a Method to Increase Axial Polyps (AP) Quantities of Transplants Using Cicatrisation Tissues High AP Generation Potential. Applications on Acropora microphtalma, Acropora muricata and Acropora pulchra**

**Cedric GUIGNARD*[1]**, Thomas LE BERRE[1]

[1]Seamarc Pvt Ltd, Male', Maldives

High growth rates and availability of broken fragments have made staghorns the most commonly transplanted hard coral species. During the first 3 months after transplantation, Axial Polyps Generation (APG) is an important factor to consider for the future transplant's shape and productivity. Then avoiding any damage of Initial Axial Polyps (IAP) seems logical to preserve the "branching" fragments potential. However, recent observations made in the Maldives indicate that cicatrisation tissues covering broken sections, here named "Cuts", had a higher APG potential than IAP themselves. To verify this hypothesis, an initial experiment using 80 fragments of *Acropora muricata,* has been set up to compare APG of the fragments with at least one IAP to those without. After 3 months the results showed a significant difference. Transplants with IAP presented an average of 3,0 AP (+/- 0,5 at 95% CI) while transplants without IAP presented an average of 5,9 AP (+/- 0,6 at 95% CI). To investigate a practical application of this result, several experiments including also *Acropora pulchra* and *Acropora microphtalma* species have been launched following different protocols where fragments where especially damaged to increase the quantity of cicatrisation tissue areas. These damages are named "Extra Cuts" and aims at producing Extra Axial Polyps (EAP), this to valorise fragments Radial Polyps (RP) areas which have been proved to have a low APG potential in the first experiment. This permitted to develop a method able to produce EAP and then to increase transplants AP quantities without causing any significant mortality. This method was found easy and productive to valorise a fragment stock.

## 24-13

**Using Reef Resilience Principles To Improve Staghorn Coral (Acropora Cervicornis) Restoration in The Florida Keys**

**Meaghan JOHNSON*[1]**, Phil KRAMER[1], Ken NEDIMYER[2]

[1]The Nature Conservancy, Summerland Key, FL, [2]Healthy Reefs Inc., Tavernier Key, FL

Significant declines in living coral coverage within the Florida Keys National Marine Sanctuary (and worldwide) have occurred in recent decades due to local, regional, and global threats. In particular, populations of the important reef building branching staghorn coral, *Acropora cervicornis*, have declined 80-90% throughout the Caribbean and western Atlantic since the late 1980's, and has recently been listed as threatened under the Endangered Species Act in May 2006. This project aims to restore degraded reefs in the Upper Keys by transplanting fragments of naturally occurring, and wild staghorn coral. Approximately 25 staghorn coral colonies naturally settled onto a privately owned live rock farm within Sanctuary waters in the Upper Keys. In addition to these 25 parent colonies, 22 wild colonies were collected, fragmented, and brought back to the live rock farm (coral nursery). All of these colonies were fragmented, and cemented to small cement casts, that remain on platforms within the coral nursery. The genotypic identity of these corals was also determined within the first six months. This genetic marker will serve as a tool that allows for long term tracking of recruitment and proliferation. In November 2006, these fragments were outplanted to four different restorations sites, located within different reefs zones determined by the Florida Reef Resilience Program. These restoration sites will be monitored for coral growth rates, mortality, and the recolonization of reef-dwelling organisms. We expect to create a series of localized staghorn thickets following the rapid growth and expansion of the transplanted fragments. This project has now been expanded to three more sub-regions( Lower Keys, Miami transition, Broward), with future plans to expand to the Caribbean region.

## 24-14

**Coral Recovery And Rehabilitation From Blast Fishing in Indonesian Rubble Fields**

**Helen FOX*[1]**, Roy CALDWELL[2], Sangeeta MANGUBHAI[3]

[1]Conservation Science, World Wildlife Fund-US, Washington, DC, [2]University of California, Berkeley, Berkeley, CA, [3]P.T. Putri Naga Komodo, Labuan Bajo, Indonesia

Although fishing with explosives (dynamite or homemade bombs) continues to impact reefs throughout Indonesia and beyond, there are success stories where blasting has been halted and the surviving reefs protected, such as in Komodo National Park. Here, we report results of long-term research (10 y) examining natural recovery from blast fishing and the efficacy of rock piles as a low-tech, locally-available reef rehabilitation method. Comparative studies in North Sulawesi of acute single blasts of known age showed that this rubble slowly stabilized, and craters filled in with surrounding coral and new colonies. After five years, coral cover within craters no longer differed significantly from control plots. In contrast, the large rubble fields created by chronic blasting in Komodo remain devoid of corals despite adequate supply of coral larvae, with no appreciable natural recovery over 10 years, hence the need for rehabilitation research. After pilot studies of different methodologies (1998-2002), locally quarried rocks were chosen to scale up. In 2002, four different configurations of rock piles were installed at four sites, covering ~6000$m^2$total. Rock piles stabilize the rubble, attenuate water currents, re-create the three-dimensional structure of an intact reef, and provide surfaces for coral recruitment and refuges for other invertebrates and fish. Coral recruitment was considerable and coral colonies grew at the rate of 15-20 cm/year at some sites, but rubble encroachment remains a problem at the highest current sites. Thus, this rehabilitation method is feasible at these scales at lower cost than most, although this work highlights the need for comparative studies. Furthermore, it would likely be cheaper and more efficient to prevent the damage in the first place.

## 24-15

**Lessons for Minimizing Impacts to Coral Reef and Other Ecosystems from the 2004 Tsunami**

**Dwayne MEADOWS*[1]**

[1]Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD

The 2004 Indian Ocean tsunami left a vast amount of destruction in its wake on land and in the sea. About 60% of coral reefs in affected areas of Thailand were damaged. Many damaged reef areas in Thailand and Sri Lanka were high value tourist attractions or provided other important ecosystem goods and services. We were part of a fortuitous partnership of people with experience in reef restoration, coral reef science, marine debris removal, construction, professional SCUBA diving, business, marketing, and environmental NGOs. We helped organize and funded multiple restoration and cleanup projects that restored damaged and detached sea fans in Similan Islands Marine National Park, restored hard corals, removed over 400 tons of marine debris, and provided sustainable management advice to local stakeholders and decision-makers. We later became involved in advising emergency management agencies on tsunami preparedness and response. We report on lessons learned for re-attachment of large sea fans, triaging and organizing large-scale volunteer marine debris recovery and coral ecosystem restoration efforts, and mitigating and planning for future natural disaster impacts on fishery ecosystems. We argue that "natural" disasters can cause significant damage to reefs, and much damage results from human sources that are not "natural" and can be mitigated or prevented (such as siting and land use decisions that lead to debris affecting reefs). Thus we disagree with those who say natural events like hurricanes or tsunamis "are not appropriate for reef restoration". Further, governments need to recognize the economic and inherent values of ecosystem goods and services in natural disaster response legislation and policies (e.g., The Stafford Act in the U.S.) to improve outcomes. We also argue that ecosystem advocates need to adopt the language of emergency management and become more involved in emergency management disaster planning.

## 24-16

**Sea Fan Recovery after the Tsunami 2004 at Mu Ko Similan National Park, Andaman Sea, Thailand**

**Sakanan PLATHONG*[1]**, Charles BENZIES[1], Fumihito IWASE[2]

[1]Coral Reef and Benthos Research Unit, Department of Biology, Prince of Songkla University, Hat Yai, Songkla, Thailand, [2]Kuroshio Biological Research Foundation, Tokyo, Japan

At the Similan Islands, Thailand, one of the biggest impacts from the tsunami was on the gorgonian sea fan where approximately 250 individual colonies were found to have fallen from their substrate. As part of the reef recovery efforts following the tsunami, a project aimed at sea fan reattachment was launched in January 2005 and continued through the year. Many fallen sea fan colonies were lying on the sea floor for 2 weeks - 4 months, where they suffered tissue damage. Initially the sea fans were temporarily supported in the flowing current to enable feeding while methods of permanent reattachment were investigated. Fallen sea fans were reattached using a variety of methods. One hundred sixty four colonies were cemented to a rock substrate aboard a boat and then replaced by divers back in the floor. Wooden wedges were used to hold 54 sea fans into cracks in the rock substrate. Iron rods hammered into the sand, rocks placed at the base of the sea fan and cable ties were also used to support sea fans temporarily. Many large sea fans had to be cut into segments to make them more manageable. In total, about 450 whole sea fans or colony fragments have been recovered and reattached. Recovered sea fans showed a high occurrence of infected tissue due to an unknown microbial infection, often resulting in severe or total tissue loss and death of the colony. The infection, characterised by white matter spreading rapidly over the axial skeleton, was shown to be Aspergillosis. As of February 2006, about 80% of recovered sea fans found and about 50% of the total number of colonies recovered has survived.

## 24-17

**Coral Community Restorations Following Vessel Groundings in Broward County, Florida: A Review Of Efforts And Future Needs**

Bruce GRAHAM[1], **Erin HODEL*[1]**, Anne MCCARTHY[1]

[1]CSA International, Inc., Stuart, FL

Frequent vessel groundings have impacted coral communities offshore Broward County, Florida, causing structural and biological impacts of variable severity and areal extent. To accelerate natural recovery processes of damaged habitat, CSA International, Inc. (CSA) has conducted restoration following six of these groundings. Restoration included reattachment of displaced and fractured biota, re-establishment of structural complexity, rubble stabilization, and removal of material that may impede natural recovery. In total, over 2,000 scleractinian corals, gorgonians, and sponges were reattached, and approximately 147 tons of rubble were stabilized to restore the three-dimensionality of the habitat. Post-restoration monitoring has only been conducted at several restoration sites. CSA conducted monitoring of re-attached coral colonies, coral recruitment, and other epibenthos at multiple-year intervals after restoration of the *M/V Firat* grounding. Monitoring of epibenthos and ichthyofauna was performed 6 months after restoration of the *M/V Eastwind* grounding. Together, these data indicate high survivorship of reattached biota (≥90%), successful recruitment of corals and other epibenthos to restored substrates, and re-established abundances of reef fishes. Furthermore, CSA has tagged and mapped over 1,000 biotal specimens and conducted baseline biological surveys from the six restoration sites to facilitate potential monitoring. Future monitoring of biotal reattachment success and health, coral recruitment and survivorship, succession of epibenthos, and reef-fish assemblages at these restoration sites would greatly benefit evaluation of their long-term success. These restorations offer a unique opportunity to examine biotal succession and recovery times of coral communities following vessel groundings in southeast Florida. CSA is currently seeking means to continue monitoring these restoration sites to evaluate their long-term success and gather data to support future decision-making about restoration actions and inputs into Habitat Equivalency Analyses, an important tool in determining lost ecological services.

## 24-18

**Large Coral Transplantation in Bal Haf (Yemen): An Opportunity To Save Corals During The Construction Of A Liquiefied Natural Gas Plant Using Innovative Techniques**

**Olivier LE BRUN*[1]**, Eric DUTRIEUX[2], Fannie SEGUIN[3], Robert HIRST[4], Ibrahim AL-THARY[4,5]

[1]CREOCEAN, LA SEYNE SUR MER, France, [2]CREOCEAN, Montpellier, France, [3]CREOCEAN, St Pierre d'Oléron, France, [4]Yemen Lng Company, Sana'a, Yemen, [5]Yemen Lng Company, St Pierre d'Oléron, Yemen

As part of a mitigation measure associated with the construction of a Liquiefied Natural Gas (LNG) plant, four large coral transplantation missions were carried out in Bal Haf (South of Yemen), About 1,500 selected coral colonies were removed from four areas to be damaged with a surface area of 900, 2,700 and 3,500 m2.respectively. The coral colonies were transported and cemented in five new sites of 300 to more than 500 m2 surface area. They belong to more than 40 species and 23 genera, with a dominance of massive forms such as *Platygyra daedalea*, *Porites lobata-lutea*, *Favites sp* and *Echinopora lamellosa.*

These transplantations included moving 130 large *Porites lutea-lobata* weighing from 200 kg up to 4 tonnes, using new transplantation techniques.

Growth, *in situ* mortality and health condition of the transplants were monitored over nine months on a quarterly basis and will be followed for another 2 years at least. Photo quadrats, close up pictures of single remarkable colonies and growth measurements for *Acropora* species and a selection of large *Porites* were carried out during each of the three operations.

Overall survival of corals nine months after transplantation was an encouraging 95%. Most losses of transplants were due to sedimentation of fine particles in the transplanted areas, fish predation, fishermen activity and hydrodynamic effects. Evidence of new growth was observed, especially on *Acropora* species, *Porites lobata-lutea* and, to a lesser extent, on some faviids.

These transplantations carried out on a large scale clearly demonstrate the capacity of corals to adapt to a new environment, in favourable conditions. They prove that carefully designed coral reef rehabilitation strategies can be part of industrial development processes, whenever necessary.

## 24-19

**Coral Relocation For Impact Mitigation in Northern Qatar**

**Deborah KILBANE*[1]**, Bruce GRAHAM[1], Robert MULCAHY[1], Dr. Ali ONDER[2], Mark PRATT[2]

[1]CSA International, Inc., Stuart, FL, [2]Safety, Health, Environmental, & Risk Management, Qatar Liquefied Gas Company Ltd., Doha, Qatar

A large-scale, long-distance coral relocation project was conducted as mitigation for potential impacts to hard coral habitat associated with marine construction activities offshore Ras Laffan Industrial City, Qatar. Working under the guidance of the Supreme Council for the Environment and Natural Reserves, Qatargas Operating Company Limited and its Expansion Projects engaged in a project to transplant over 4,500 corals from proposed pipeline corridors. Corals were transported 46 km from the north coast of Qatar to a fasht coral habitat along the east coast. This project represents an option for off-site mitigation and is an excellent example of proactive environmental regulation, corporate responsibility, and advanced field technology applied in concert to reduce impacts to a viable hard coral habitat.

Hard coral relocation, which salvages and utilizes hard corals to accelerate natural coral habitat recovery in other areas, was implemented to reduce impacts associated with pipeline construction activities. Proven techniques for coral reattachment and newly developed methods designed to enhance coral survival were used for the efficient mass recovery, transport, and deployment of the corals. The relocation site was selected from 7 candidate sites based on local stakeholder consultation, the presence of an existing coral population, relative similarity of physical characteristics to the impacted area, and availability of suitable substrate for coral reattachment. Hard corals were transported in a specially designed, flow-through seawater holding pool during the single day transit to the relocation site and reattached using concrete. Within the reattachment site, temperature data loggers were deployed and approximately 5% of the reattached corals and control corals were selected and uniquely tagged for subsequent monitoring. Initial monitoring indicated high survival rates and habitat enhancement based on assessment of coral, epibiota, fish, and urchin populations. Future long-term monitoring will provide information on coral community dynamics in the Arabian Gulf.

## 24-20

**Lessons Learnt From Applied Restoration Projects**

**Sandrine JOB*[1]**

[1]Reef Restoration, CRISP, Noumea, New Caledonia

The talk aims at presenting some lessons learnt from 4 restoration projects that have been conducted in the Indo-Pacific (Mayotte, New Caledonia, Fiji and Tuvalu; the 2 last projects being conducted under the CRISP Program).

A brief overview of these projects, their objectives, methods used and general results will be given. An analysis of what went right or wrong will lead to possible recommendations on how the projects could be redesigned to enhance their results.

Based on this specific work, a best practices guideline for conducting applied restoration projects will be discussed and general key instructions to follow while designing a restoration project will be proposed. This work is currently being performed for the writing of a Manual on Reef Restoration, a joint venture between CRTR and CRISP.

## 24-21

**Mass Culture Of Reef Building Corals in Open Water At Akajima Marine Science Laboratory**

**Makoto OMORI*[1]**, Kenji IWAO[1], Hiroki TANIGUCHI[1], Minoru TAMURA[1]

[1]Akajima Marine Science Laboratory, Okinawa, Japan

Since establishment in 1988, Akajima Marine Science Laboratory made effort to study reproduction and evolution of corals at Akajima Island, Okinawa. Based on the knowledge acquired in the process, the scientists are now developing techniques to culture *Acropora* corals from eggs using sexual reproduction. They have overcome a number of hurdles, including 1. prediction of spawning date and time, 2. collection of larvae from the sea or fertilization of gametes in the laboratory, 3. mass culture of planula larvae, 4. introduction of the larvae to substrate, and 5. cultivation of juvenile corals in cages in open water. The juvenile corals were cultured together with juvenile top shells, *Trochus niloticus*, which were used to control macroalgal growth. In June 2005, *Acropora tenuis* was cultured from eggs and by December 2006 the juvenile corals had grown to an average diameter of 5.8 cm in cages suspended 2 m above the seafloor in open water. About 2,000 colonies were then transplanted onto nearby degraded bommies and fixed in place using pegs and underwater glue. Six months later, in June 2007, 89% of the colonies were alive, firmly attached to the substrate, and had increased in size to an average diameter of 9.1 cm. After further development, this technique promises to be an economical and effective way to culture corals for restoration of damaged reefs.

## 24-22

**Mass Culturing Of Corals Using Sexual Reproduction Technique In Thailand**

**Suchana CHAVANICH*[1]**, Voranop VIYAKARN[1], Chalothon RAKSASAB[1], Pataporn KUANUI[1], Kenji IWAO[2], Makoto OMORI[2]

[1]Marine Science, Chulalongkorn University, Bangkok, Thailand, [2]Akajima Marine Science Laboratory, Okinawa, Japan

Recently in Thailand, mass culturing of spawning corals using sexual reproduction technique was developed. Gametes of 4 coral species (*Acropora millepora*, *Acropora hyacinthus*, *Acropora humilis*, and *Platygyra daedalea*) were collected from natural habitats and fertilized on a land-based rearing system. Then, planula larvae were induced to settle on substrates, and were reared in this system for 2 weeks to 6 months before transferred to floating cages in the sea. In the rearing system, the rates of fertilization of each species ranged between 92.1 – 97.0%. Meanwhile, the self fertilization rates of the same colony in each coral species ranged between 1.9 – 3.3%. After the fertilization, the survival rates of larvae were between 83.4 – 94.2%, and the settlement rate of planula larvae were 49.5 – 75.2%. In all species, the embryo developed into a planula stage within couple days, and settled on the substrates within 4 – 5 days after the gametes were released from the parental colonies. The results from the experiments showed that high numbers of larvae settled on the bottom of the settlement plates compared to the top or sides of the plates. In addition, planula larvae of *Pocillopora damicornis* were collected and reared in the rearing system. The settlement rates of *P. damicornis* larvae were 62.8%, and the survival rate of juvenile corals after the settlement was 71.9%. The growth rates of five species ranged between 1.5 – 3.7 mm per month. This is the first time that Thailand has success in the mass coral culturing using gametes. At present, juvenile corals were about 6 months old and the maximum size was about 1 cm in height.

## 24-23

**Implementing *acropora Spp.* larval Settlement Techniques And A Coral Hatchery System To Gain Insights Into The Survivorship Of Juvenile Acropora Spp. Polyps**

**Charles BOCH*[1]**, Aileen MORSE[2]

[1]Interdepartmental Graduate Program in Marine Science, University of California Santa Barbara, Santa Barbara, CA, [2]Marine Biotechnology Center, University of California Santa Barbara, Santa Barbara, CA

A pilot study was conducted (2006) at the Palau International Coral Reef Center (PICRC) to compare the efficacy of several types of "larval flypaper" for settlement of some common regional *Acropora spp.* larvae in a controlled laboratory setting and to determine and compare the survivorship of newly settled *Acropora spp.* polyps in a coral hatchery. For the first experiment, we used coralline algae (*Hydrolithon sp.*) derived "larval flypaper" in 6-well culture plates to settle *A. digitifera* larvae. For the second experiment, we used small (~1-2 mm) coralline algal chips in 6-well culture plates to settle *A. tenuis* and *A. digitifera* larvae—however, species were not distinguishable after settlement. Newly settled polyps in the culture well plates were placed facing up or down in the hatchery. A subset of each experiment was transplanted to Ioul Luke's Reef to compare the over-all survivorship. At 44 days from the initial start of the experiments, total survivorship in the coral hatchery ranged from 57 – 87%. After 70 days, total survivorship dropped to 30 – 31% before dropping to a final survivorship of 0% at the end of the 126-day experiment. For the reef experiment, after 126 days, total survivorship ranged from 8 to 9%. A rise in phosphate level, a steep temperature drop and significant algal fouling in the hatchery system were recorded about two months into the experiment. The decline in survivorship with this increase in algal fouling led us to conclude that, at this location, it would be advisable to hold newly settled polyps in the hatchery for a period of approximately two months before polyps become negatively impacted by algal fouling. We conclude "larval flypapers" are an efficient method to settle some *Acropora spp.* larvae and coral hatcheries provide valuable insights into the factors that may determine juvenile polyp survivorship.

## 24-24

**Assessing The Efficacy Of *in Situ* Coral Larval Seeding Under High Rates Of Early Post-Settlement Mortality**

**Wade COOPER*[1]**, Diego LIRMAN[1], Megan PORTER[1], James HERLAN[1], John PARKINSON[1]

[1]Division of Marine Biology and Fisheries, RSMAS, University of Miami, Miami, FL

For degraded reef systems with low natural recruitment, active restoration techniques to seed larvae directly onto the reef may provide the impetus to replenish adult stocks. However, *in situ* seeding techniques have only been attempted in a handful of known studies, and the success has been limited in most cases. The goals of this study were to assess the efficacy of seeding larvae directly onto denuded reef substrate and explore techniques to improve the success of this active seeding strategy. In addition, this study compared the success of this direct *in situ* seeding approach to an *ex situ* approach where larvae were settled onto small substrate chips, reared in the laboratory for different periods of time (1 week and four months), and then transplanted onto the reef. Overall, survivorship from *in situ* seeded larvae of the brooder *Porites astreoides* followed an exponential decline with typically less than 10% surviving after two weeks, and in one case survivorship of a cohort was less than 1% after 17 days. In some trials, survivorship was dependent on the general substrate type on which they settled, and survivorship improved when potential predators were excluded by cages. However, the magnitude of these effects was minimal when compared to the improved survivorship of those larvae settled and reared in the lab and then transplanted to the reef at a later age. Given these high rates of early post-settlement mortality within the first few days and weeks, *ex situ* settlement with later transplantation to the reef may be a more efficient use of resources for seeding efforts.

## 24-25

**Development Of A Coral Nursery Program For The Threatened Coral Acropora Cervicornis in Florida**

**James HERLAN*[1]**, Diego LIRMAN[1]

[1]Marine Biology and Fisheries, University of Miami, Miami, FL

Acroporid corals were among the most abundant reef-building corals on Caribbean reefs until a drastic decline resulted in losses of up to 95 % at many locations. This regional decline prompted the listing of *Acropora* as 'threatened' under the U.S. Endangered Species Act in 2006. In response to the need for localized efforts to protect and recover surviving populations of staghorn coral, *Acropora cervicornis*, an underwater nursery was established in Biscayne National Park, Florida. The goals of this nursery, one of four such nurseries established in Florida, are to develop effective fragmentation and propagation methodologies and to evaluate the role of genetics on coral resilience.

In June 2007, branch clippings (10 cm) were collected from *A. cervicornis* colonies and fragmented into 3-7 cm sections that were glued onto cement bases in vertical and horizontal orientation. The bases were glued onto cinder blocks and placed in the nursery established at 6 m of depth. The fragmentation and transplantation methods used were very efficient and resulted in limited fragment mortality;14 % of fragments died within the first month, but subsequent mortality has been minimal.

The growth of fragments was influenced by time after transplantation, size, and orientation. The growth rate of fragments was 0.6 cm/month during the first 6 weeks after transplantation and increased to 0.9 cm/month in the subsequent 6 weeks. Growth was positively related to initial fragment size, and fragments in horizontal position grew significantly faster (0.9 cm/month) than fragments in vertical position (0.6 cm/month) due to the ability of these fragments to grow from both ends. The fast growth of this species makes it an ideal candidate for restoration programs and it is expected that the staghorn fragments kept in Florida nurseries will provide an expanding coral stock to be used in future reef restoration and scientific experiments.

## 24-26

**Comparisons between Directly Transplanted and Nursery-reared Coral Fragments in Bolinao, Northwestern Philippines**

**Dexter DELA CRUZ*[1]**, Baruch RINKEVICH[2], Edgardo GOMEZ[3], Helen YAP[1]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa, Israel, [3]The Marine Science Institute, University of the Philippines, Quezon CIty, Philippines

Direct transplantation is the current method of choice in reef restoration efforts worldwide, though with varying degrees of success, probably due to the stress imposed on the fragments or whole colonies used. The alternative method of rearing fragments in coral nurseries located at sheltered reef zones is now used as an intermediate step with the goal of producing robust transplants that will survive better than directly transplanted fragments. These two methods are compared in field experiments in Bolinao, northwestern Philippines using 2 common species, *Echinopora lamellosa* and *Merulina scabricula*. The first experiment compares the survival of wild nubbins (~3-4 cm) that are maintained in a field nursery versus similar fragments that are transplanted directly to dead coral bommies. The second experiment compares the performance of nursery-reared coral nubbins with that of similar-sized fragments (~5 cm) collected from the wild by attaching both types of transplants to natural substrates. Survival was monitored monthly. Three end points were selected, namely, 7 months after transplantation (normal conditions), a month after the June 2007 bleaching event (elevated water temperature) and 3 months after bleaching (post-bleaching recovery phase). Kaplan-Meier survival analyses (employing Gehan's-Wilcoxon pairwise test) showed that the three end points yielded consistent results. There were significant differences between the two methods for *E. lamellosa* in the first experiment, while there were no significant differences between wild and nursery-grown corals for both species in the second experiment. These results indicate that some species fare better when maintained in nurseries; however, this advantage is not necessarily carried over after they are transplanted to natural substrates.

## 24-27

**Use Of Aquacultured Coral Fragments For Restoration Activities in The Florida Keys: Culture Techniques And Health Certification**

**Ilze BERZINS*[1]**, Craig WATSON[2], Roy YANONG[2], Kathy KILGORE[2], Casey COY[1], Ryan CZAJA[1], Lauri MACLAUGHLIN[3], Billy CAUSEY[3]

[1]The Florida Aquarium, Tampa, FL, [2]Tropical Aquaculture Laboratory, University of Florida, Ruskin, FL, [3]Florida Keys National Marine Sanctuary, Key West, FL

Many species of Atlantic Scleractinia can be fragmented and grown successfully in aquaculture systems, but can they be reintroduced to the wild? This study addressed two primary questions concerning the use of aquacultured fragments for restoration: 1) whether culture techniques affect survival and growth of reintroduced fragments, and 2) could these fragments be a vector for disease when returned to a restoration site?

Addressing the first question, 210 fragments were cut from 7 species (30 per species) of coral collected from the Truman Annex site in Key West Harbor. The fragments (*Siderastrea radians*, *Solenastrea bournoni*, *Montastrea annularis*, *Montastrea cavernosa*, *Diploria clivosa, Dichocoenia stokesii*, and *Stephanocoenia michellini*) were distributed to two culture locations and one open reef site. The land-based fragments were grown in culture for 7 months prior to transplantation in the field. Transplantation of corals to Miss Beholden grounding site, Western Sambo Reef, occurred in December, 2006. Monitoring of the site will follow 3 month intervals for 2 more years.

To answer the second question, a standard best management practice was developed to ensure that corals intended for reintroduction are healthy prior to restoration. These procedures and other diagnostic methods were used to develop criteria for issuance of a federal health certification before reintroduction of corals to restoration sites.

## 24-28

**Genet Considerations in Acropora Cervicornis Propagation in Restoration**

**Andrew ROSS*[1]**

[1]Life Sciences, University of the West Indies, Montego Bay, Jamaica

Coral restoration, propagation and gardening are concepts gaining interest and impetus in research and backing in conservation, aesthetics and politics as the plight of corals gains popular visibility, particularly in the specter of global climate change. In investigating propagation it is important to understand the how choice of parent material influences final outcomes. Significant differences in growth rate, branching morphology and resistance to bleaching were recorded between genets of Acropora cervicornis propagated in buoyant-line nurseries in Montego Bay, Jamaica in 2005 through 2007. In 2005 differences between genets were noted in growth rate, branch number and overall branched growth rates. In 2006 final length differences were noted between genets at all depths without differences within genets between depths. Branch number and overall branching length were different between depths however, with higher overall branching length and branch number at shallower depths. Strong genet differences were also seen in susceptibility to bleaching at all depths. These patterns continued through the 2007/8 experiments using ramets produced in the 2006 growth trials, though bleaching was driven largely by re-fragmentation and nursery fouling organism contact and stinging stresses. Although some level of adaptation or hardening to stress-related bleaching was observed, genets with faster growth and branching were always relatively more resistant to bleaching and associated death indicating generally stronger or weaker genets. It is apparent that choice in genet for propagation must be carefully considered in any restoration programme, particularly considering the monetary costs involved and the potential rarity of the species concerned. Similarly, the long-term goals of any propagation programme must be considered such as breadth of genetic differentiation for effective sexual reproduction or long-term success through associated human gardening or other water quality and ecosystem management programmes when choosing the genets invested in.

## 24-29

**A Land-Based Resource For Ecologically-Important Western Atlantic Corals**

**Thomas CAPO*[1]**, Phillip GILLETTE[1], Daniel DIRESTA[2], Richard CURRY[3], Chris LANGDON[1], Andrew BAKER[1], Diego LIRMAN[1], Iliana BAUMS[4]

[1]MBF, University of Miami RSMAS, Miami, FL, [2]Department of Biology, University of Miami, Coral Gables, FL, [3]Biscayne National Park, Homestead, FL, [4]Department of Biology, Pennsylvania State University, University Park, PA

Coral reefs in the continental US show their greatest development along the SE coast of the state of Florida. The northern portion of the reef tract is found within Biscayne National Park, where it is of high intrinsic value for both scientific and recreational reasons. The state of the reef has declined over recent years due to both natural and anthropogenic stressors. Given these threats, the loss of corals within the park due to accidental boat groundings represents a significant impact on an already dwindling resource. In 2000, we initiated a collaborative research program to evaluate rehabilitation of damaged areas based upon coral fragments recovered from these areas. Orphaned fragments were collected from grounding sites and relocated to a field-nursery in BNP as well as the University of Miami's land-based Coral Resource Facility. Research over the past four years has focused on the initiation of clonal lines to produce uniform ramets for manipulative experiments and on factors controlling *ex situ* growth rate. Continuing trials are targeting four key parameters of coral growth and survival: fragment size, supplemental feeding, water movement, and light. The UM Coral Resource Facility now houses over two dozen coral species, of which five have been targeted for intensive culture and mass growout: *Acropora cervicornis, A. palmata, Montastraea faveolata, Oculina* sp.*,* and *Porites furcata*. To ensure genetic diversity, five independent clonal lines of each species are in the isolation process. Presently we are providing microcolonies, nubbins, and macrocolonies with a known environmental history and documented genetic profile to investigators for studies in coral physiology, epidemiology, ecotoxicology and restoration research. Incorporating advances in coral propagation and building on our successful growout, we are expanding the present UM facility to hold more than 10,000 coral fragments of the 5 target species in support of coral research.

## 24-30

**Spatial and Temporal Patterns In The Recruitment And Settlement Behaviour Of Scleractinian Coral Larvae On Artificial Substrata: Applicability And Implications For Coral Reef Restoration**

**Cristiana DAMIANO*[1,2]**, Peter HARRISON[1]

[1]School of Environmental Science and Management, Southern Cross University, Lismore, Australia, [2]National Marine Science Centre, Coffs Harbour, Australia

The discipline of coral reef restoration through larvae reseeding remains in its formative stage. While preliminary studies have indicated the viability of inducing laboratory-cultured coral larvae to settle on reefs, almost no work has been done to determine their subsequent growth and survival, or the extent to which such 'reseeding' facilitates the rapid and efficient recovery of coral communities. This latter information is a prerequisite for reseeding techniques as a mechanism for promoting the restoration of corals. Equally importantly, identifying the key factors influencing the fate of coral recruits is an essential component of coral reef ecology that will ultimately assist management agencies to define clearer protocols for their future conservation throughout the world. Here we present results of research done from 2003/06 to assess the applicability, benefits and disadvantages of scleractinian coral larvae rearing and reseeding techniques on artificial substrata under laboratory conditions at Heron Island Research Station, Australia. Gravid colonies of *Acropora millepora* and *Platygyra daedalea* were collected and the predictable annual mass spawning provided access to large quantities of larvae, which were reared in aquarium facilities for six days and transferred to 70-l plastic tanks, containing three replicates of two preconditioned ceramic tile orientations (horizontal and 45°). After seven days, settled spats were taken back to the reef and monitored for growth and survival via a repeated-measure sampling technique. High rates of settlement and recruitment were observed for *A. millepora* planulae, supporting the viability of using laboratory-reared larvae for coral reef rehabilitation and restoration programs. However, longer-term survival rates were low, particularly after a widespread bleaching event that affected Heron Island's reefs during summer 2006/07. Although these results are preliminary, they nevertheless support the need for ongoing research to more fully describe the ecological processes contributing towards planulae recruitment and survival as a prerequisite for restoration programs.

## 24-31

**Reef Restoration—The Good And The Bad**

**Jere LIPPS*[1]**

[1]Integrative Biology & Museum of Paleontology, University of California--Berkeley, Berkeley, CA

Little good and a lot of bad come from reef restoration. Reefs damaged by humans and nature are "restored" using unnatural materials as substrata quickly occupied by corals and fish. This is commonly considered good, for seemingly the reef has been returned to a "healthy" state; fish can be caught again and tourists return for the "beautiful reefs". Restoration, the act of restoring to a former state, has never been accomplished on a reef; rather reefs have been manipulated to conform to particular human values without regard for the entire reef--its ecology, trophodynamics, hydrodyamics, physical or chemical characteristics of pseudo-substrata, geochemistry, nutrient supply, and even reef aesthetics among a multitude of others. People seemingly cannot leave well enough alone when it comes to reefs that have been noticeably damaged. Yet, that is exactly what reefs need—time without interference. Emotional reactions without careful analysis of the total consequences of various methods are ill-advised. Reefs evolved over millions of years in one of the harshest environments on earth—the air-water interface. They are well adapted to recover from physical damage of almost any sort. Reefs are not fragile. Thoughtful assistance would help, using materials occurring naturally within reef systems, by involving regional stakeholders in natural processes of restoration, and by stringent protection regulations and agreements. Opportunistic "restoration" by well-meaning, misguided or avaricious people without careful consideration of what really constitutes a reef is a major mistake that will eventually need restoration itself. Do we need more junk on our reefs?

## 24-32

**Reef Rehabilitation At Maiton Island: The Prototype Of Rehabilitation By Using Artificial Substrate in Thailand**

**Hansa CHANSANG*[1]**, Nalinee THONGTHAM[1], Ukkrit SATAPOOMIN[1], Niphon PHONGSUWAN[1], Pitul PANCHAIYAPHUM[2], Vipoosit MANTACHITRA[3]

[1]-, Phuket Marine Biological Center, Phuket, Thailand, [2]-, Phuket Marine and Coastal Resources Conservation Center, Phuket, Thailand, [3]Burapha University, Faculty of Aquatic science, Chonburi, Thailand

A pilot project on rehabilitation was carried out at reef of Maiton Island using triangular concrete modules as artificial substrate for coral settlement. The reef was physically damaged by storm and no noticeable recovery was observed after 8 years. Two hundred and twenty-five modules of 50x50x50 cm were placed covering area of 225 $m^2$. The structural design for the modules was based on the objective of study complexity of module structures to reef fish colonization and coral settlement. Monitoring on development of colonization of sessile organisms especially coral and fish population have been carried out periodically.

The modules had successfully increased coral recruitment. Complexity of substrate surface increased chances of coral recruitment. After 7 years, there were 16 genera of coral settled on the surfaces. The total coral cover was about 53-60% of module surface. For fish recruitment, early colonization of fishes in term of number of species and individuals were rapid with in the first 4 months. Fish assemblages did not differ among different complex modules. The fish assemblages stabilized after 7 years and 88 species of 23 genera were sighted. The development of fish assemblages correlate with increasing coral coverage on module surfaces.

At present, there are 1280 modules in the reef covering the minimum area of 1280 $m^2$. This artificial reef will continue to evolve and increase in community complexity. It is evaluated as a successful project considering the outcome and cost effective including labor input.

## 24-33

**Transplantation of *Porites lutea* to Rehabilitate Degraded Coral Reef at Maiton Island, Phuket, Thailand**

**Nalinee THONGTHAM*[1]**

[1]Phuket Marine Biological Center, Phuket, Thailand

*Porites lutea* is among the most common coral species found in Thai waters. Its solid, hard structure enables it to withstand storms and strong waves. It is also tolerant to heavy sedimentation, thus it is appropriate to be used as the main structure in rehabilitation of degraded coral reefs. However, as its growth rate is slower than branching corals, it is not often used for transplantation. The objective of this study, which began in December 2004, is to determine the survival and growth of different sizes of transplanted *P. lutea* at Maiton Island off Phuket, Thailand. Fragments in three different sizes, 4.5x4.5 cm, 3x3 cm and 2x2 cm, were detached from coral colonies and each size was replicated 45 times. Coral colonies of about the same size as the fragments were also collected for comparison. The fragments and coral colonies were cemented on concrete blocks and placed at the same depth as the reef where the corals were taken. Percentage of survival and detachment, as well as diameter and height of those corals were monitored every 3-4 months for 2 years. Survival of bigger fragments and colonies was higher than the small ones, which had more tendency (76%) to be detached from the substrate after ninth months. Mortality of all sizes was between 2 and 17%. Self-attachment of both fragments and colonies was apparent just after one month, but growth in height was slow. A study conducted over 10 years in an adjacent area found that it takes at least seven years for the concrete block to be fully covered and the coral blend with the natural environment. The study found that *P. lutea* could be used as the main structure in rehabilitating coral reefs.

## 24-34

**The Population Of Hard Coral Colonies Growing On Ecoreefs® Artificial Modules On Manado Tua Island, Bunaken National Park, North Sulawesi, Indonesia**

**Tries RAZAK*[1]**

[1]Research Consultant, EcoReefs Project at Bunaken National Park, Bandung, Indonesia

Bunaken National Park in North Sulawesi was established as a marine national park in October 1991 and is one of Indonesia's most well-known marine ecotourism and diving destinations. Unfortunately, many reef areas within the park have been decimated into fields of coral rubble from dynamite fishing that peaked around 30 to 40 years ago. A rehabilitation program was then implemented in December 2003 where 620 EcoReefs® modules were installed on a blast-damaged sloping reef area. In the present study, "returned" populations of hard corals were examined within two-and-half (June 2006) and three years (December 2006) after the installation. On the first trip, 138 modules were examined and a total of 5626 colonies belonging to 31 genera in 15 families were found. The second research trip was performed six months after the first one (December 2006) where 112 modules were studied; the same 112 modules studied on the first trip. Hard coral population on EcoReefs® modules was dominated by family Pocilloporidae, Acroporidae, Milleporidae and Poritidae; that altogether covered 91.4% (June 2006) and 85.4% (December 2006) of the total population. The number of corals per module ranging between seven to 122 colonies; and there was an increase in the average abundance with 45 colonies/module in December 2006 compare to 12 colonies/module (July 2004) and 41 colonies/module (June 2006). In regards to colonies' physical condition, up to 62.1% (December 2006) of the total population were alive and healthy; this number was higher in June 2006 with 77.6%. The remaining of the population (37.9% and 22.4% respectively) were dead colonies covered with algae/crustose coralline algae/sponge, bleached or infected by diseases. These findings showed that artificial reefs can be used as a catalyst in resurrecting marine life, still conserving the live reef ecosystems are easier and cheaper.

## 24-35

**Eco-Block As A Coral-Friendly Contrivance in Port Construction**

**Hidekazu YAMAMOTO*[1]**, Norikazu MAEKOUCHI[2], Takashi ANO[2], Megumi OOGI[2], Syuichi TSUDA[2], Kazuo KURITA[3]

[1]Coastal Environment Department, ECOH Corporation, Taito-ku, Japan, [2]Okinawa General Bureau, Cabinet office, Naha City, Japan, [3]Okinawa General Bureau, Cabinet office, Miyako City, Japan

We confirmed the natural attachment of coral colonies on breakwaters in Naha Port, Okinawa Prefecture in 1989. Having fixed 30 quadrates to the breakwaters, we have been monitoring the growth of corals every year since 1990. The results complied until 2003 were reported by Ooka et al. (2006).

Focusing on this phenomenon as a clue to afford a coral-friendly approach in port construction, we began the development of technology to enhance coral recruitment and growth on concrete armor blocks. The development concept centered on creating roughness on conventionally smooth block surfaces, thus imitating natural substrates as near as possible. The primary experiment began in Naha Port in 1990, followed by the second one in 1991. The findings from these experiments were then applied in the project of the Eco-block in 1999, a wave-dissipating block with abrasive protrusions on its surface. Since the installation of Eco-blocks in 1999, the growth and recruitment of corals on them have been monitored yearly in 36 fixed quadrates. With information obtained here, a similar attempt is underway in Hirara Port in Miyako Island. The surfaces of armor blocks were unevenly processed before their deployment to breakwaters, and their effectiveness has been continually monitored.

Eco-blocks with abrasions at depths of about 5mm and 10mm showed a greater effectiveness in coral settlement. The initial coral recruitment was found to be higher at depths of C.D.L. 5m and shallower. The same results were obtained from the experiment in Hirara Port.

Ooka, S. et al. (2006) Growth of coral assemblages on artificial structures and surrounding natural substrates. Proc. 10th Int. Coral Reef Symposium, Naha., p.91-98.

## 24-36

**Benthic And Fish Community Succession After The 2005 Red Tide Disturbance in The Eastern Gulf Of Mexico: Are Artificial Reefs Effective Mitigation Tools?**

**Jennifer DUPONT*[1]**, Pamela HALLOCK[1], Walter JAAP[2]

[1]College of Marine Science, University of South Florida, Saint Petersburg, FL, [2]Lithophyte Research, Saint Petersburg, FL

A harmful algal bloom (red tide) and associated anoxic/hypoxic event in 2005 resulted in massive fish kills and the collapse of epibenthic communities in depths less than 25 meters along the central west Florida shelf. An ongoing monitoring study provided a focused time series (2005 to 2007) of community successional stages at two natural hardbottom ledge sites and six artificial reef sites, situated in comparable depths (~20 meters), allowing us to assess the potential use of artificial reefs as benthic invertebrate and fish recruitment/recovery tools during future disturbances. Radical changes in community structure were observed at both the artificial and natural habitats after the red tide. Epibenthic invertebrate and fish diversities and abundances were significantly lower (t-tests: $p<0.03$) immediately after the peak of the red tide event (August through November 2005) compared to pre-red tide data. Coral community diversities at natural ledges were higher than artificial reef diversities during all samplings. Species including *Oculina diffusa, Solenastrea hyades, Stephanocoenia intersepta* and *Siderastrea radians,* appear to have bleached during the red tide disturbance, but recovered soon thereafter as large (>10 cm) colonies were recorded. Juvenile recruits were abundant on exposed substrate during post-disturbance samplings. Artificial reefs had much lower benthic diversities and were dominated by smaller *Cladocora arbuscula* and *Phyllangia americana* corals. Fish community diversities and abundances were higher at the artificial reef habitats. Successional stages tended to follow a predictable progression and revert to a pre-red tide state, corroborating previous predictions that the fluctuating nature of the shallow eastern Gulf of Mexico may limit the effective species pool of colonists. Artificial reefs appear to be significantly more effective in recruiting diverse and abundant fish populations, with less diverse benthic invertebrate communities, when compared to natural reef ledges along the West Florida Shelf.

## 24-37

**Restoration Of *acropora Cervicornis* At The Site Of The M/t Margara Grounding**

**Tom MOORE*[1]**, **Bruce GRAHAM*[2]**, **Sean GRIFFIN*[3]**, Kevin KIRSCH[4], Craig LILYESTROM[5], **Michael NEMETH*[6]**

[1]Restoration Center, NOAA, St. Petersburg, FL, [2]CSA International, Stuart, FL, [3]Lighthouse Technical Consultants, Aquadilla, Puerto Rico, [4]NOAA, St. Petersburg, FL, [5]Puerto Rico DNER, San Juan, Puerto Rico, [6]Lighthouse Technical Consultants, Boqueron, Puerto Rico

The M/T MARGARA, a 228-m (748-ft) tanker went aground on coral reef formation on 27 April 2006. The impacted reef is located approximately 1 mile south-southeast of Bahia de Tallaboa along the south coast of Puerto Rico. The coral reef feature supports a relatively healthy epifaunal assemblage visually dominated by soft corals, sponges, and hard corals. Rapid response by PRDNER, NOAA and the Responsible Party resulted in the salvage and reattachment of over 10,000 hard and soft corals displaced during the grounding.

A unique feature of the grounding location was the presence of a large thicket of *Acropora cervicornis* which has been designated as Threatened under the Endangered Species Act of 1972. Impact to the A. cervcornis thicket produced over 900 fragments ranging in size from 7.7 to 23 cm (3 to 9in) that were available for reattachment.

The *A. cervicornis* restoration strategy utilized various techniques at four distinct locations within the grounding site. Techniques included the reattachment of grouped *A. cervicornis* fragments to 1) stainless-steel bolts projecting from pooled cement, 2) natural coral rubble projecting from pooled cement, and 3) secured frame of plastic-coated wire mesh. In all three reattachment techniques, fragments were secured using plastic cable ties. Additionally, fragments were attached directly in cement and secured with epoxy at some locations.

Over the first year the reattached fragments grew vigorously, formed multiple new branches and generally had a high rate of survival. Branching fragments could be utilized for transplantation within the grounding site and/or as a source of fragments for additional reattachment locations. This talk will discuss initial results and lessons learned concerning these new field-tested techniques for restoring *A. cervicornis* resources.

## 24-38

**Survival Of Coral Recruits in Relation To Substrate Stability Within Ship Grounding Sites.**

**Stuart FIELD*[1]**

[1]University of Notre Dame, Perth, Australia

Ship groundings cause discrete, small scale disturbances with defined boundaries and are characterised by a mosaic of disturbed areas varying in the extent of damage and the stability of the remaining substrate. Following a disturbance resulting from a ship grounding event, recovery of the coral community is dependent on the recruitment of new individuals to the denuded substrate created as a result of the disturbance. In this study juvenile corals were investigated for 24 months at four sites associated with ship grounding sites adjacent to the Straits of Tiran, Egypt. The density of juveniles within and adjacent to areas of disturbance were considered along with the diversity and size distribution of the juvenile coral community at each site. This investigation has enabled a greater understanding of early life history processes in the recovery of disturbed reefs. Increased densities of juvenile corals were recorded in disturbed areas, supporting findings of recruitment to artificial settlement tiles, however, there were also higher rates of juvenile mortality in disturbed areas, particularly in areas with mobile rubble, indicating that smothering and abrasion were likely causes of decreased survivorship in these areas. However, these rates of recruitment and survivorship were variable across the four sites investigated. These results suggest that while we can improve predictions of recovery rates by defining the mosaic of substrate classifications that characterise a ship grounding site, site-to-site variability in settlement and post-settlement mortality prevents predictions based solely on these initial site surveys and long-term monitoring is needed at each site to follow recovery over time.

## 24-39

**Natural Resource Damage Assessment And Restoration in The National Park Service: Coral Reef Vessel Grounding Case Studies in Biscayne National Park**

**Amanda BOURQUE*[1]**

[1]Division of Resource Management, Biscayne National Park, Homestead, FL

Natural Resource Damage Assessment (NRDA) is a process that allows authorized resource trustees to identify injured resources, recover damages from responsible parties, restore habitats and resources to pre-injury/exposure conditions ("primary restoration"), and compensate the public for the loss of ecological and/or visitor use services ("compensatory restoration"). The National Park Service is authorized by several statutes to implement the NRDA process in resource injury cases. Biscayne National Park (BISC) pursues damage recovery in vessel grounding cases under the authority of the Park System Resource Protection Act (PSRPA, 16 USC 19jj). BISC is one of the largest marine parks in the National Park System, and protects the northernmost Florida Keys, seagrass meadows, mangrove forests, clear bay waters, and over twenty miles of the Florida reef tract. Submerged park resources holding significant ecological, cultural, and economic value are frequently impacted by vessel groundings. BISC is unique because it has the highest volume PSRPA cases in the National Park System, and these cases arise from one type of resource injury (i.e. vessel groundings). This presentation will provide an overview of how BISC applies the NRDA process in vessel grounding cases, with an emphasis on those cases that involve coral reef resources. Injury assessment techniques, injury classifications, restoration planning approaches, restoration alternatives for primary and compensatory projects, monitoring protocols, environmental compliance, and policy solutions will be discussed. Examples will be drawn from several BISC cases.

## 24-40

**Coral Reef Metrics And Habitat Equivalency Analysis**

**Shay VIEHMAN*[1]**, Steven THUR[2], Greg PINIAK[1]

[1]Center for Coastal Fisheries and Habitat Research, NOAA, Beaufort, NC, [2]Office of Ocean and Coastal Resource Management, NOAA, Silver Spring, MD

When coral reefs held in United States public trust are injured by anthropogenic injuries such as vessel groundings or oil spills, a natural resource damage assessment process is utilized to quantify the resource loss and determine the amount of restoration required to make the public whole from the injury. Habitat equivalency analysis (HEA) is used to equate resource losses from the injury with benefits from the compensatory project. Ecosystem services are represented in HEA using an indicator metric, typically coral cover for reef injuries. However, depending on the injury and habitat, alternative approaches such as composite metrics incorporating topographic complexity and other coral reef community members, or a resource-scale approach utilizing size-frequency distributions may more comprehensively represent lost services. We examine the robustness, flexibility, and application within HEA of these metrics to predict complex and compound (larger scale) results from the original injury. Careful selection of a metric appropriate to both the degree and extent of injury and of habitat type can serve as a vital link between the damage assessment, recovery modeling, compensatory calculations, and recovery monitoring.

## 24-41

**Scleractinian Coral Relocation From A Coastal Seawall To A Nearshore Hardbottom Habitat in The Northern Florida Keys.**

**Jeff ANDERSON*[1]**, J. Harold HUDSON, PH.D. [2], Bill GOODWIN[3], John ILIFF[4], Tom MOORE[4]

[1]Contractor to Florida Keys National Marine Sanctuary, I.M. Systems Group, Inc., Key Largo, FL, [2]Damage Assessment and Resource Protection, Florida Keys National Marine Sanctuary (Retired), Miami, FL, [3]Damage Assessment and Resource Protection, Florida Keys National Marine Sanctuary, Key Largo, FL, [4]NOAA Restoration Center, St. Petersburg, FL

During a permitted seawall reconstruction project, Scleractinian corals were found growing on the vertical face. For a coastal location, the seawall housed a large quantity, size, and distribution of healthy reef coral species generally found further offshore. Based on the seawall construction date, the corals had been growing in that environment for a maximum of 35 years. A total of 136 whole colonies and live coral fragments, with diameters ranging from 10 cm to 100 cm, representing 13 Scleractinian species, were harvested. Collected corals were temporarily housed in wire-mesh baskets *in situ*. To accommodate the lateral accretion typical for Scleractinians growing on vertical surfaces, the corals were attached to 30 flat-faced cement and fiberglass modules at the removal site, transported to an offshore site approximately one nautical mile east of the original seawall, and cemented on the seafloor. Two of the largest colonies, along with a number of fragments, were cemented directly to the substrate. The relocation site lies in 4 m of water, is comprised of hardground of Pleistocene Key Largo limestone bedrock overlain by a thin veneer of carbonate sediment, and is populated by numerous Octocorals, sponges, and occasional Scleractinian species. State of Florida biologists conducted an inspection and declared the modules were securely cemented to the bedrock and that all relocated corals appeared healthy as evidenced by their normal coloration and overall appearance. Ongoing monitoring of the site has demonstrated the relocated corals have grown new tissue and continue to survive three years after relocation. The project demonstrates that Scleractinian corals can be successfully collected from coastal construction sites and relocated in order that they can continue to contribute to the marine ecosystem.

## 24-42

**Coral Restoration Is Not Merely About Corals: Reef Fish Habitat Use Measures Coral Reef Restoration Success At The Fortuna Reefer Grounding Site, Mona Island, Puerto Rico**

**Ron HILL*[1]**, Michelle SCHÄRER[2], Michael NEMETH[2], Andy BRUCKNER[3]

[1]SEFSC, NOAA/NMFS, Galveston, TX, [2]Dept. of Marine Sciences, Univ. of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, [3]OHC Coral Reef Ecosystem Div, NOAA/NMFS, Sand Spring, MD

A multi-agency emergency restoration reattached over 1800 *Acropora palmata* fragments, following the grounding of the M/V Fortuna Reefer on Mona Island in 1997. Shortly after the grounding, we began monitoring the restoration using coral reattachment, survival, and growth and the recovery of fish assemblages as measures of success. Although no surveys were conducted before the grounding, we have neighboring undisturbed areas for comparison and we can analyze temporal changes within the site. In early surveys reef fish assemblages were significantly different from adjacent control sites. With almost a decade of monitoring complete, we are starting to see increases in species diversity, expansions of size distributions, and increases in abundances and diversity of juvenile haemulids, species known to be habitat selective. Additional monitoring will determine when the conditions can be considered "normative" however experimental approaches might be required to improve restoration of fish habitat and encourage the coral-fish interactions that can contribute to the effectiveness of coral reef restoration.

## 24-43

**Multivariate Responses Of The Coral Reef Fish Community To Artificial Structures And Coral Transplants**

**Sebastian FERSE*[1]**

[1]ZMT Bremen, Bremen, Germany

Reef rehabilitation efforts frequently employ the use of artificial structures or coral transplantation. Although several studies have addressed relationships between artificial structures or the natural habitat and associated fish communities, no attempt has been made to contrast the effects on the fish community of structures used alone and in combination with coral transplantation. In this study, repeated fish census over plots containing rubble [C], artificial structures [S], and structures together with coral transplants [S+C], was conducted over a time of up to two years at three sites in North Sulawesi, Indonesia. The results show an increase in fish abundance and number of species in the [S] plots, and a further increase in the presence of corals at two sites. Principal component analysis (PCA) emphasized differences between the three treatments in terms of fish abundance, number of species, and diversity (H' and H' max). Abundance, number of species and H' in the [S+C] plots was higher than that observed in the surrounding natural reef at one location, but lower at the other two sites. Cluster analysis revealed distinct communities at the three treatments and a low similarity to the natural reef at all three locations. Similarity to natural reefs was lowest in the rubble plots. Spearman-rank correlation of the similarity matrices for each treatment with model similarity matrices revealed increasing similarity among census replicates in the [S] and [S+C] treatments over time at all sites. Crossed three-way ANOVA of the average similarities among census replicates showed significant effects of treatment and the interaction terms location*treatment and location*time. The results underline the role that structures and transplants play in re-shaping and stabilizing the associated fish community, but also demonstrate that the effects differ markedly depending on the ambient reef.

## 24-44

**Effects Of Coral Transplantation And Giant Clam Restocking On The Functional Groups Of Fish On Degraded Patch Reefs**

**Patrick CABAITAN*[1]**, Edgardo GOMEZ[1], Porfirio ALIÑO[1]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines

This study examined the effects of restoration treatments on different functional groups of reef fish that are important to the stability of a community. Fish on 25 degraded patch reefs were monitored monthly for 3 months before and every 1-2 months for 11 months after the application of the restoration treatments. The treatments were: 1) transplantation of *Acropora* spp. and *Pocillopora* spp. corals, 2) restocking of the giant clam *Tridacna gigas*, 3) restocking of *T. gigas* with coral transplantation, 4) deployment of *T. gigas* shells, and 5) control. The fish were categorized into 10 functional groups, defined by feeding habit and the relative size of their territory. For fish with large territory, the coral treatment increased the abundance of Omnivore, Zoobenthivore, and Carnivore, while the clam+coral treatment increased the abundance of Omnivore, Zoobenthivore, and Herbivore relative to the control. The clam treatment increased the abundance of Omnivore and Zoobenthivore. For fish with small territory, the coral treatment increased the abundance of Omnivore, Herbivore, and Carnivore, while the clam+coral treatment increased the abundance of Omnivore and Herbivore relative to the control. The Clam treatment increased the abundance of Carnivore, while the shell treatment increased the abundance of Herbivore. Only Zooplanktivore with small and large territories and Zoobenthivore with small territory did not achieve any significant increase in any of the treatments. This study shows the feasibility to restore reefs, although with different responses from the fish functional groups, which can be summarized into: 1) habitat-linked, 2) trophically-linked, and 3) cascading effects on the increase of certain functional groups.

## 24-45

**Alternate Benthic Assemblages On Artificial Reef Restoration Structures And Their Effects On Coral Larval Settlement**

**Margaret MILLER*[1]**, Abel VALDIVIA[2,3], K. Lindsey KRAMER[4], Benjamin MASON[5], Dana WILLIAMS[3,6], Lyza JOHNSTON[5]

[1]Southeast Fisheries Science Center, NOAA Fisheries, Miami, FL, [2]CIMAS, University of Miami, Miami, FL, [3]Southeast Fisheries Science Center, NOAA Fisheries, Miami, [4]US National Park Service, Hilo, HI, [5]Marine Biology and Fisheries, University of Miami, Miami, FL, [6]CIMAS, University of Miam, Miam, FL

Acute physical reef injuries are sometimes addressed by construction of on-site artificial structures to secure fractured framework and enhance architectural complexity of damaged sites. To characterize benthic assemblages, four restoration structures (RS) along with adjacent natural reef substrates (Reference) in the Florida Keys, USA (age range 6-13 yrs) were sampled via line-intercept transects. Multivariate clustering analysis indicated a high degree of divergence between RS and Reference samples, as well as among sites. RS had significantly higher cover of thick cyanobacterial turfs (up to 30% cover) than Reference substrates. Assemblage differences were primarily attributable to macroalgal and cyanobaterial groups with fast growth and turnover, rather than to slow-growing corals and crustose coralline algae. Thus, divergence of assemblages is not simply attributable to incomplete succession, but appears to be a persistent, possibly stable state.

Since cyanobacteria have known ill effects on adult and larval corals, we tested if exudates of these distinct algal assemblages (RS and Ref) chemically inhibit coral larval settlement. Seawater exudates were prepared from $1m^2$ of macroalgae, including turf, collected from RS and Reference substrates at two sites (Wellwood and Maitland). Competent larvae of three broadcast spawning scleractinian species were exposed to natural substrate in exudates or seawater controls and allowed three days to settle. *Acropora palmata* and *Diploria strigosa* larvae were subject to exudates from a single site (Wellwood) while *Montastraea faveolata* larvae were tested with exudates from both sites. Reference exudates from the Wellwood site displayed greatest settlement inhibition for all 3 species while, for *M. faveolata*, RS exudates from the Maitland site were more inhibitory than Maitland Reference exudates. *A.palmata* larvae displayed greater sensitivity than the other species with 100% mortality in the Wellwood Ref treatment. Both RS and Reference substrates in these locations appear to have compromised 'recruitment potential' for spawning corals.

## 24-46

**Natural And Enhanced Coral Reef Recovery After Injury**

**Alison MOULDING*[1]**, David GILLIAM[1], Vladimir KOSMYNIN[2], Richard DODGE[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [2]Bureau of Beaches and Coastal Systems, Florida Department of Environmental Protection, Tallahassee, FL

The coral reefs of Broward County, southeast Florida, USA are located offshore a highly urbanized area. Because of the close proximity of a major shipping port and its associated anchorage, Broward reefs have been impacted by more than 10 ship groundings over the last 15 years. These injuries usually require restoration to speed recovery and compensate for damage. However, the recovery process on injured sites is not well understood, and even less is known about how restoration aids in recovery. This study examines coral recruitment, growth, and mortality in permanent quadrats on injured sites to asses their potential for natural recovery. It also investigates substrate materials commonly used in reef restoration, including limestone, concrete, and terracotta, to determine their efficacy in attracting and retaining coral recruits. Lastly, transplantation of juvenile corals collected on settlement plates from areas of higher coral recruitment and of corals raised in the lab from the larval stage is examined as a potential method to enhance reef restoration. Preliminary results indicate coral recruitment rates to injured sites were higher compared to reference sites. Mortality rates at the injured sites were also higher than reference sites. After one year of deployment, more corals settled on limestone plates than on concrete or terracotta. Hence, recovery on injury sites may be hampered by high juvenile coral mortality rates, and the choice of substrate materials used in restoration may influence recovery.

## 24-48

**Recruitment Of The Temperate Scleractinian Coral, *oculina Arbuscula*, To Natural And Artificial Substrata On Reefs Of The South Atlantic Bight, U.s.a.**

**Daniel GLEASON*[1]**, Leslie SUTTON[1]

[1]Department of Biology, Georgia Southern University, Statesboro, GA

Similar to their tropical counterparts, temperate reefs have high biodiversity, but are in peril from anthropogenic impacts. Primary threats include commercial trawling, recreational fishing, ocean acidification, and increased sedimentation. *Oculina arbuscula* is a temperate, broadcast spawning coral and is the only structurally complex Scleractinian occurring on hard-bottom reefs of the South Atlantic Bight, U.S.A. *Oculina arbuscula* is an important contributor to reef rugosity in this ecosystem, but can be easily damaged by dredges and trawls. To investigate the sustainability of these coral populations on reefs off the Georgia coast we monitored recruitment of *O. arbuscula* to 30x30 cm plots over 3 years. Treatments consisted of 10 replicates of each of the following: 1) unmanipulated natural substrata, 2) natural substrata initially cleared of all encrusting organisms, and 3) artificial substrata consisting of concrete paving tiles. These plots were photographed at least 13 times between July 2004 and June 2007 using a digital camera mounted to a PVC frame to control for distance and exposure level. These images showed that *O. arbuscula* recruits throughout the year with peak recruitment exhibited in September/October. While recruitment rates were higher than death rates in all treatments and resulted in a net gain of *O. arbuscula* colonies, recruitment to artificial substrata far exceeded that found on natural surfaces. Competition with other sessile invertebrates, such as tunicates and sponges, appeared to contribute little to these differences because recruitment rates were similar on unmanipulated and cleared natural substrata. Likewise, the high recruitment rate observed on the artificial substrata rules out the possibility that maintenance of *O. arbuscula* populations is limited by larval supply. While the reasons are unclear currently, these results suggest that deploying artificial substrata, such as concrete paving tiles, may be useful as a mechanism of enhancing recruitment of *O. arbuscula* to damaged temperate reef structure.

## 24-49

**Brazilian Corals Early Growth And Survival**

**Clovis CASTRO*[1]**, Bruna CASTRO[1]

[1]Departamento de Invertebrados, Museu Nacional, Rio de Janeiro, Brazil

Early growth and survival of coral recruits are crucial for the renewal of coral populations and restoration initiatives. In order to assess these parameters, we set up experiments with different recruitment plates (plastic and ceramic) and environmental conditions (open sea and tanks). In the laboratory, coral spats were recorded using a dissecting microscope. Each individual spat was measured and its position recorded using a coordinate system. Plastic plates were deployed in January, 2004, and initially kept in the Itacolomis Reefs (16°54'S, 039°04'W) for circa 15 months. Censuses occurred in June, 2005 (T0) and March, 2006 (T1 – 9 months). This experiment started with 1762 live spats and ended with 574. Survival rates were higher in tanks (61%, excluding spats in lost plates, vs. 15% in open sea). Survival was also higher in larger spats, both in tanks and open sea. Growth rates were slightly higher in tanks. Larger spats grew faster than smaller ones. Ceramic tiles were deployed in March, 2006, and kept in the "Recife de Fora" (16°24'S, 038°59'W) for circa seven months. Censuses occurred in October, 2006 (T0), March (T1 – 5 months) and October, 2007 (T2 – 12 months). This experiment started with 1078 live spats. The last census showed 206 live spats, 19% of the original spats. Survival rates agreed with those from plastic plates. However, differences between tanks (T0-T1 = 48%; T1-T2 = 34%) and open sea (T0-T1 = 27%; T1-T2 = 5%), as well as in larger spat size classes, were more evident. Growth rates in tanks were substantially higher than in open sea (up to 7 times higher in the same size class). These preliminary results suggest that rearing coral recruits in captivity may become an alternative for coral reef restoration in the long term.

## 24-50

**Gametogenesis in Cultured Versus Wild *acropora Intermedia* Colonies: Fertilization, Survival, And Oxygen Consumption 10 Years After Fragmentation**

**Nami OKUBO*[1]**, Hiromi YAMAMOTO[2], Fumio NAKAYA[3], Ken OKAJI[4]

[1]Yokohama National University (present: Kyoto University), Yokohama, Japan, [2]Okinawa Expo Aquarium, Okinawa, Japan, [3]Ochanomizu University, Tokyo, Japan, [4]CoralQuest Inc, Kanagawa, Japan

In the late 1990s, the once prolific *Acropora intermedia* populations surrounding Okinawa, Japan, dramatically declined because of thermal stress and subsequent bleaching and mortality. Before the bleaching event, 72 fragments of approximately 15 cm in length were collected and transferred to the Okinawa Expo Aquarium. Through growth and repeated fragmentation, these original fragments developed into approximately 100 colonies, which spawned from 1999 to 2006. Here we compare gametogenesis, fertilization, survival, and O2 consumption in the cultured and wild offspring. Cultured *A. intermedia* had larger oocytes (volume), higher fertilization rates, higher embryonic O2 consumption, and higher survival rates compared to samples from wild colonies. These results suggest that the cultured *A.intermedia* and their offspring are more fit than wild colonies.

## 25-1

**Is 500 Ppm $Co_2$ And 2°c Of Warming The 'tipping Point' For Coral Reefs? If So, How Should We Respond?**

**Ove HOEGH-GULDBERG*[1]**

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

The burning of fossil fuels is driving a rapid increase in the concentration of $CO_2$ in the atmosphere which is expected to exceed 500 ppm in the earth's atmosphere within 50 years. At this point, tropical sea temperatures will be 2°C warmer than 150 years ago and tropical carbonate ion concentrations will fall below 200 µmol $kg^{-1}$. These conditions differ markedly from those seen over the past 420,000 years during which time most extant species and communities evolved. Most importantly, the current rate of change in sea temperature and atmospheric $CO_2$ is 70 and 1,000 times faster, respectively, than the highest rates of change seen in the past 420,000 years. This is outstripping biological responses (adaptation, range migration) and is driving major changes in the distribution and abundance of tropical marine organisms. This paper will discuss scenarios associated with the future of coral reefs with the aim of visualizing the challenges that coral reef managers will face over the next few decades as we approach 500 ppm. The weight of evidence suggests that corals will be rare on tropical reefs which will enter a state of net erosion under atmospheric $CO_2$ concentration of 500 ppm or more. As a result, coral reefs are expected to be less diverse and reef frameworks to start to crumble and deteriorate. How can managers respond to these changes? Are there responses that managers should be taking today in preparation for changes projected a few decades from now? Should we contemplate moving vulnerable species or enriching the genetic diversity of species growing at a particular location? These issues will be discussed at the outset of this mini-symposium which anticipates a lively discussion around what is clearly one of the most important issues facing coral reef scientists and managers.

## 25-2

**Implications For Our Coral Reefs in A Changing Climate Over The Next Few Decades – Hints From The Past 22 Years**

**Alan E. STRONG*[1]**, Gang LIU[2], C. Mark EAKIN[1], Tyler R. L. CHRISTENSEN[2], Dwight K. GLEDHILL[2], Scott F. HERON[1], Jessica A. MORGAN[2], William J. SKIRVING[1]

[1]NOAA Coral Reef Watch, Silver Spring, MD, [2]IMSG at NOAA Coral Reef Watch, Silver Spring, MD

The NOAA/NASA Pathfinder sea surface temperature (SST) data from 1985 to 2006 are examined for variability and trends on both sides of the recent 1998 Pacific Decadal Oscillation (PDO) reversal for implications on tropical ecosystems. These twenty-two years of satellite observations reveal some noteworthy shifts that have quite different implications for each major ocean basin. In addition, the data reveal expected increasing SST trends toward higher latitudes, especially in the northern hemisphere, confirming the Intergovernmental Panel on Climate Change (IPCC) projections. Although several regions throughout the tropics have experienced decreasing SSTs over the 22-year timeframe, significantly more regions are showing rising trends. Most notable and worrisome is an obvious shift after the recent PDO reversal from cooling to warming in some specific tropical waters. More promising regions, also identified from our results, are presently experiencing cooling trends and thus decreasing pressure from thermal stress. What will be instructive for the future of our precious coral reef ecosystems is whether the dramatic regional shift in trends since the recent 1998 PDO reversal continues to persist into the second decade of the 21st Century or evolves into a signal of a changing climate.

## 25-3

**The Elephant In The Reef: Committed Warming And Coral Bleaching**

**Simon DONNER*[1]**

[1]Geography, University of British Columbia, Vancouver, BC, Canada

An increase in episodes of mass coral bleaching around the world in recent decades have been attributed to more frequent periods of anomalously warm ocean temperatures. Over the past fifteen years, a number of modeling studies have predicted that, left unchecked, human-induced climate change will further increase the frequency and intensity of these thermal stress events and threaten the survival of most of the world's coral reef ecosystems. As now near the end of the first decade of the 21st century, the questions need to change. Is the future happening now? How much of this projected climate warming can be avoided?

In this presentation, I use analysis of the 2005 coral bleaching event in the Caribbean to discuss the role of human-induced climate change in recent mass coral bleaching events and the effect of "committed" warming on the likelihood of future mass bleaching events. Simulations of background climate variability with the GFDL global climate models suggest that anthropogenic warming may have increased the probability of the 2005 coral bleaching events by an order of magnitude. The thermal stress that cause mass coral bleaching in the eastern Caribbean is expected to become a biannual event in 20-30 years regardless of the emissions scenario, due to the inertia in the climate system and the world economy. Thermal adaptation by corals and their symbionts could delay this forecast until the latter half of the century, possibly enabling time to reduce greenhouse gas emissions and change the climate forecast. Taken together, these results suggest that protecting coral reefs from climate change will require managing local stresses, to increase reef resilience to inevitable future warming, and immediate action to reduce greenhouse gas emissions.

## 25-4

**Climate-Scale Influences On The Development Of Coral Bleaching Conditions in The Great Barrier Reef**

**Scarla WEEKS*[1]**, Ana REDONDO-RODRIGUES[1], Andrew BAKUN[2]

[1]University of Queensland, Brisbane, Australia, [2]Pew Institute for Ocean Sciences, University of Miami, Miami, FL

A suite of available time series indicators of climatic and large-scale oceanographic properties and processes were evaluated with respect to providing (1) an appropriately representative climatological background for studying the factors leading to coral bleaching events, (2) a time-series record long enough to contain multiple independent realisations sufficient for valid hypothesis tests, and (3) a consistent baseline for normalising higher spatial and temporal resolution data obtained from more recent satellite sensors. These indicator series included NOAA OI SST (1° res., 1982-2007), the NCEP series (barometric pressure, wind, water vapor, air temperature, 1948-2007, 2.5° res.), and the NASA "Photosynthetically Active Radiation" product (9km res., 1997-2007). The study focused on three recent coral bleaching events in the GBR, the 1997-1998 "El Niño"-associated event, the 2005-2006 mild "La Niña"-associated event, and the most severe of the three, the 2001-2002 "ENSO-neutral" event.

Preliminary findings include: La Niñas (2005-06 in particular) are characterized by high regional-scale SST, while El Niños (1997-98 in particular) are typified by high solar radiation (PAR) incident on the sea surface. Accordingly, bleaching in the GBR may occur in either ENSO phase. The intense 2001-2002 event featured unusually high levels of both SST and PAR. The "linking factor" in all three major bleaching events was anomalously low wind mixing of the near-surface water column. The actual spatial variability of severe bleaching tends to be on scales smaller than resolved by the available climatic series, and seems to be governed by meso-scale and sub-meso-scale ocean flow. Examples are illustrated with 1-km MODIS satellite imagery.

An emerging consensus among climate models suggests that the Pacific trade wind circulation may slow and the Pacific system become chronically more El Niño-like. Thus besides direct greenhouse heating, there are additional El Niño-related possibilities of enhancement of PAR and reduction of near-surface wind mixing.

## 25-5

**Going, Going, Gone? Are 1998 And 2005 Signs Of The Future For Coral Reefs?**

**C. Mark EAKIN*[1]**, Jessica A. MORGAN[2], Scott F. HERON[2], Janice M. LOUGH[3], William J. SKIRVING[2], Gang LIU[2], Tyler R. L. CHRISTENSEN[2], Dwight K. GLEDHILL[2], Alan E. STRONG[4]

[1]Coral Reef Watch, National Oceanic and Atmospheric Administration, Silver Spring, MD, [2]Coral Reef Watch, IMSG at National Oceanic and Atmospheric Administration, Silver Spring, MD, [3]Australian Institute of Marine Science, Townsville MC, QLD, Australia, [4]Coral Reef Watch, AJH Environmental at National Oceanic and Atmospheric Administration, Silver Spring, MD

The 2005 Caribbean coral bleaching event was the most extensive and devastating on record for this basin. The greatest bleaching and mortality were seen along the Antillean Arc where the thermal stress exceeded any seen in the Caribbean during the previous 21 years of satellite data and 100 years of gridded, in situ temperature reconstructions. Coral bleaching exceeded 90% at many sites, and extended across most of the wider-Caribbean region; mortality exceeded 40% at many sites. The 2005 Caribbean bleaching rivals that seen in the Indo-Pacific in 1998.

Climate change is rapidly modifying the environmental envelope of coral reefs through both increased thermal stress and ocean acidification. Both the thermal and chemical limits that control coral survival and reef growth will likely be passed before 2100 assuming even conservative projections reported in the 4th Assessment Report of the Intergovernmental Panel on Climate Change. While local stresses currently dominate, coral reefs are increasingly confronted with global-scale changes due to rising greenhouse gas concentrations. The 1998 and 2005 bleaching events showed one of the key problems that climate change poses to coral reefs: warming oceans can kill corals in even the best-managed or most remote coral reefs. Global action to curb greenhouse gas emissions is certainly needed. However, because of the time delay between emission reductions and climate stabilization, emission curbs are not sufficient by themselves. Steps need to be taken to increase the resilience of coral reefs to survive bleaching, ocean acidification, and other climate change threats.

## 25-6

**Forecasting Storm-Mediated Changes in Reef Coral Assemblages**

**Joshua MADIN*[1,2]**, Michael O'DONNELL[3], Sean CONNOLLY[4]

[1]Department of Biological Sciences, Macquarie University, New South Wales, Australia, [2]National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, Santa Barbara, [3]Marine Science Institute, University of California, Santa Barbara, Santa Barbara, CA, [4]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

Reef corals build physical structures that provide essential ecosystem services including substrate for settlement, protection from predators, and shelter from disturbances. Restricted to shallow-water equatorial regions, corals continually experience moderate wave forces and intermittent bombardment by severe hydrodynamic disturbances. Predicted increases in severity of tropical storms and hypothesized weakening of reef carbonate materials through seawater acidification will necessarily affect the ability of corals to mechanically withstand hydrodynamic disturbances, but how and to what extent these will change coral community assemblages remains unclear.

We use field measurements of colony mechanical vulnerability and an existing mathematical model to forecast changes in coral assemblage structure following tropical storms under two reef strength scenarios: present-day reef strength measurements and future estimates assuming a 50% weakening due to acidification. There are dramatic, morphological-specific differences in the expected numbers of remaining colonies. Larger disturbances result in dramatic decreases in the median size of the competitively dominant species. As a consequence, relative cover of the other species increases. At some point over the continuum of disturbance intensities each species dominates the post-disturbance assemblage both in relative cover and mean colony size, but absolute numbers of remaining colonies become sparse for all populations. Hypothetical halving substrate strength exacerbates these differences: certain populations lose up to 20% more colonies than present-day conditions and the dominance hierarchy shifts at lower disturbance intensities.

Both colony size and proportion cover have consequences for recovery following disturbances. For example, larger colonies tend to be more resistant physical abrasion and disease, have greater competitive and reproductive potential, and command greater proportions of limited substrate space. The number of associated species supported by a colony scales with both colony size and morphological complexity. Therefore, the forecasted dominance of mechanically robust, morphologically simple coral species in future reef environments will lead to decreases in whole-reef biodiversity.

## 25-7

**Seasonal To Decadal Changes in The Carbonate System Of The North Pacific Ocean**

**Richard FEELY*[1]**, Chris SABINE[2], Kathryn FAGAN[3]

[1]OCRD, PMEL/NOAA, Seattle, WA, [2]PMEL/NOAA, Seattle, WA, [3]University of Washington, Seattle, WA

The addition of fossil fuel carbon dioxide to the atmosphere is rapidly changing seawater chemistry and the calcium carbonate saturation state of the world's oceans as a result of the acidifying effects of CO2 on seawater. This acidification makes it more difficult for corals to build their skeletons. Repeat hydrographic and coastal cruises in the North Pacific show direct evidence for ocean acidification. The dissolved inorganic carbon increases, of about 10-15 µmol kg-1 in surface and intermediate waters over the past 15 years, are consistent with corresponding pH decreases of approximately 0.025 units over large sections of the northeastern Pacific. These dramatic changes can be attributed, in most part, to anthropogenic CO2 uptake by the ocean over the past decade. These data verify earlier model projections that the oceans are undergoing ocean acidification as a result of the uptake of carbon dioxide released as a result of the burning of fossil fuels. From these results we have estimated an average upward migration of the aragonite saturation horizon of approximately 1 m yr-1 in the North Pacific. Such shoaling is due to the effects of anthropogenic CO2, ventilation and biological respiration processes in the surface and intermediate waters. We have also instrumented a Coral Reef Instrumented Monitoring and CO2 Platform (CRIMP-CO2) in southern Kaneohe Bay in December 2005 and have been collecting data almost continuously since that time. The CO2 mooring collects air pCO2 and pO2 and surface water pCO2, pO2, temperature, and salinity data every three hours. The results show a seasonal trend in the pCO2 data with higher levels occurring during the summer months and lower levels occurring during the winter. Changes in water temperature had a small effect on surface water pCO2 levels and seasonal changes in pCO2 are driven mainly by changes in calcification.

## 25-8

**Marine Biocalcifiers Exhibit Mixed Responses To Co2-Induced Ocean Acidification**

**Justin RIES*[1]**, Anne COHEN[1], Daniel MCCORKLE[1]

[1]Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA

We have conducted 6-month laboratory experiments to investigate the effect of $CO_2$-induced reductions in seawater $CaCO_3$ saturation state on biocalcification by 21 aragonitic and calcitic (low-high Mg) taxa representing eight of the major marine calcifying groups: Chlorophyta; Rhodophyta; Crustacea; Bivalvia; Gastropoda; Annelida; Cnidaria; and Echinodermata. The $CaCO_3$ saturation states of the experimental seawaters, constrained by intercalibrated determinations of pH, alkalinity, and DIC, were attained with bubbled air-$CO_2$ mixtures of 380 (ambient), 560, 840, 2240 ppm $CO_2$, yielding $\Omega_{arag}$ of 3.2 (ambient), 2.4, 1.8, 0.8, respectively. Net calcification/dissolution rates obtained from buoyant weighing reveal that nearly half of the species exhibited reduced calcification, and even dissolution, in the elevated-$CO_2$ seawaters. However, each of the major taxonomic groups that we investigated contained at least one species (9 species in total) that exhibited increased calcification in the moderately (560 ppm) or extremely (840 or 2240 ppm) elevated $CO_2$ conditions. This surprising observation runs counter to the conventional belief that $CO_2$-induced ocean acidification necessarily reduces calcification rates in marine organisms. Rather, some calcifying organisms appear to benefit from the elevated DIC, either directly through photosynthesis or indirectly through calcification, which requires conversion of $HCO_3^-$ to $CO_3^=$ via proton-pumping from the organism's internal calcifying medium. No single trait governed the pattern of responses amongst the organisms. A confluence of factors, including skeletal mineral polymorph solubility, proton-pumping efficiency, and the utilization of photosynthesis, appears determinant of each organism's response.

## 25-9

**Carbonate Dissolution By Euendolithic Microorganisms Increases With Rising pCO2**

**Aline TRIBOLLET*[1]**, Marlin ATKINSON[2], Chris LANGDON[3]

[1]IRD, Marseille, France, [2]HIMB, Kaneohe, HI, [3]University of Miami, Miami, FL

Six months-old experimental blocks of the coral *Porites lobata* colonized by natural epilithic and endolithic organisms from an offshore oceanic site in Kaneohe Bay (Hawaii) were placed in experimental tanks with similar water quality as the oceanic site. After a further two months of acclimation, blocks were exposed to 2 different aqueous pCO2 treatments, one at ambient pCO2 (400 ppmv) and another at 750 ppmv (predicted pCO2 by the year 2100) for another 3 months. Before and after treatment, euendolithic microorganisms (i.e. boring cyanobacteria, algae and fungi), their distribution, abundance and bioeroding activity were determined using thin sections, scanning electron microscopy and image analysis. At the beginning of the pCO2 experiment, euendolithic communities comprised of 65-80% chlorophyte *Ostreobium quekettii,* and increased to 90% at the end of the experiment. There were no differences in the relative abundance of euendolithic species, nor any differences in bioeroded area at the surface of blocks (27%) between pCO2 treatments. The depth of penetration of euendolithic filaments of *O. quekettii* was however significantly higher under elevated pCO2 (1.4 mm) than ambient pCO2 (1 mm). Consequently, higher microbioerosion rates (biogenic carbonate dissolution) were measured under elevated pCO2 than ambient pCO2 (0.63 kg m-2 of planar reef y-1 versus 0.45 kg m-2 y-1). Based on these results, we estimate that carbonate dissolution by *O. quekettii* can increase by 30% with a doubling atmospheric pCO2. We conclude that biogenic dissolution by euendoliths can be a dominant mechanism of carbonate dissolution in a more acidic ocean and could have major negative consequences on the maintenance of coral reefs in a close future.

## 25-10

**Coral Reef Response To Climate Change – Addressing Complex Problems With A Simple Model**

**Robert BUDDEMEIER*[1]**

[1]Kansas Geological Survey, University of Kansas, Lawrence, KS

The COMBO model is a spreadsheet-based tool designed to be used by managers, conservationists, and biologists for projecting the effects of climate change on coral reefs at local-to-regional scales. The model calculates the effects on coral growth and mortality, and ultimately on coral reef cover, from changes in average sea-surface temperature and carbon dioxide concentrations, and from episodic high temperature mortality (bleaching) events. The model uses a probabilistic assessment of the frequency of high temperature events under a future climate to allow development and testing of local scenarios. COMBO offers data libraries and default factors for three selected regions (Hawai'i, Great Barrier Reef, Caribbean), but it is structured with user-selectable parameter values and data input options, facilitating modifications to reflect local conditions or to incorporate local expertise. Results of parameter sensitivity analyses and comparison of future scenarios for different regions in the North and South Pacific are used to demonstrate model applications to the complexities of assessing the relative importance of high temperature events, increased average temperature, and increased carbon dioxide concentration to the future status of coral reefs at local and regional scales.

## 25-11

**Scleractinian Corals Response To Ocean Acidification Conditions**

**Maoz FINE*[1,2]**, Dan TCHERNOV[3,4]

[1]Faculty of Life Sciences, Bar-Ilan University, Ramat-Gan, Israel, [2]Interuniversity Institute for Marine Science in Eilat, Eilat, Israel, [3]Department of Evolution, Systematics and Ecology, The Hebrew University, Jerusalem, Israel, [4]The Interuniversity Institute for Marine Science, Eilat, Israel

Anthropogenic-driven accumulation of CO2 in the atmosphere, and projected ocean acidification, has raised concerns regarding the eventual impact on coral reefs.

Little is known however about the physiological response of corals to increased pCO2 and ocean acidification and hence it is difficult to predict what shifts these ecosystems will experience. This study demonstrates that skeleton-producing corals grown in experimental acidified conditions are able to sustain basic life functions, in a sea anemone-like form and will resume skeleton-building when reintroduced to normal modern marine conditions. Coral species from the temperate Mediterranean and tropical Red Sea were subjected to pH 7.3-7.6 and 8.2 (ambient) for 3-18 months in an open flow-through system. Corals in decreased pH conditions demonstrated morphological changes such as dissociation of the colony form followed by complete skeleton dissolution. In encrusting corals the polyps remained attached to the undissolved substrate whereas living polyps of branching species descended to the aquarium bottom. Biomass of the solitary polyps under decreased pH conditions was 1.5 to 3-fold higher than the biomass of polyps in the control colonies. This may be explained by the higher primary productivity (Net and Gross Photosynthesis) that was measured in corals under higher pCO2. Changes in photosynthesis and calcification as a response to decreased pH were species specific with some species responding earlier than others. Gametogenesis in control and experimental corals developed similarly. Soft bodied corals calcified and reformed colonies when transferred back to ambient pH conditions. Hence, in the absence of conditions supporting skeleton-building, corals maintain basic life functions as a skeleton-less ecophenotype. This has far reaching implications for the understanding of the natural history of corals and their near future in an increasingly changing environment.

## 25-12

**Impacts Of Ocean Acidification And Warming On Calcifying Coral Reef Organisms**

**David I. KLINE*[1]**, Kenneth R. N. ANTHONY[1,2], Guillermo DIAZ-PULLIDO[1,2], Sophie DOVE[1,2], Selina WARD[1], Ove HOEGH-GULDBERG[1,2]

[1]Centre for Marine Studies, The University of Queensland, St Lucia, QLD, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, The University of Queensland, St Lucia, QLD, Australia

The world's oceans are predicted to become warmer and more acidic over the next century with potentially dramatic consequences for coral reef ecosystems. However, there is little known about the combined impacts of temperature and pH on coral reef organisms or about which species will be most vulnerable to these changed environmental conditions. Using a large custom-built, flow-through aquarium system we simulated 3 projected levels of CO2 concentrations at two ocean temperatures to simulate future reef conditions under high-emission scenarios. We compared a series of physiological responses (including growth rate, photosynthesis/respiration, and survivorship) of four major calcifying coral reef organisms from the southern Great Barrier Reef (massive corals, branching corals, calcareous algae and foraminiferans) to temperature and CO2 conditions in a highly replicated factorial design. Our results suggest that different reef calcifying organisms have varying susceptibilities to climate change with calcareous algae and branching corals projected to reach their physiological thresholds as early as 2050. Reefs of the future will likely undergo large ecological changes as some of the first species likely to be impacted by climate change are important coral reef framework builders.

## 25-13

**Combined Effects Of Elevated Temperature And Pco2 On The Photo-Physiology Of *symbiodinium* Spp. in Two Scleractinian Coral Species**

Andrew BAKER[1], **Paul JONES*[1]**, Ranjeet BHAGOOLI[2], Herman WIRSHING[1], Tom CAPO[1], Christopher LANGDON[1]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Department of Biosciences, University of Mauritius, Reduit, Mauritius

Few studies have investigated how reef corals respond to the combined effects of thermal stress and elevated pCO2, yet these conditions are likely to be an environmental reality of the 21st century. To better understand how these factors interact, we undertook a 14-week pilot experiment using two Caribbean coral species, *Porites furcata* and *Montastraea faveolata*. We exposed replicate nubbins of each species to three pCO2 levels (360, 550 and 800ppm) and three temperatures (28, 30 and 32oC); conditions were maintained using CO2 bubblers and a computer-controlled heater-chiller system. Additionally, we used an outdoor system and neutral density screens to expose corals to ambient or 50% solar irradiance. Prior to the start of the experiment, coral nubbins were acclimated to different pCO2 levels at ambient temperature (28oC) for four weeks, before being heated at a rate of 0.3oC per day to the experimental temperatures (30 and 32oC). Temperatures were maintained (+/- 0.2oC) for nine weeks before being returned to ambient levels at the same rate. Corals were then monitored for five weeks during a recovery phase. Elevated pCO2 levels were maintained throughout the acclimation, exposure and recovery phases. Every 2-4 weeks chlorophyll fluorescence was analyzed using an Imaging-PAM (Walz, GmbH), and coral tissue samples were taken to determine algal symbiont densities, pigment concentrations, and *Symbiodinium* identity. Color-scaled photographs documented temporal changes in tissue pigmentation and health. Corals in the highest temperature and light treatments exhibited the most severe bleaching, regardless of CO2 levels. However, at control temperatures (28oC), elevated CO2 resulted in healthier corals, as evidenced by symbiont counts, photographs and fluorescence properties. *P. furcata* bleached more readily than *M. faveolata*, although these species also hosted different *Symbiodinium*. Together, these results suggest temperature and CO2 interact in unexpected ways to influence coral health.

## 25-14

**Ocean Acidification Changes The Early Life History Of Scleractinian Corals.**

**Selina WARD*[1]**, Sophie DOVE[2], david KLINE[2], kenneth ANTHONY[2], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, The University of Queensland, Brisbane, Australia, [2]Centre for Marine Studies, The University of Queensland, brisbane, Australia

Predictions of doubling preindustrial carbon dioxide levels by the middle of this century create serious concerns for the future state of coral reefs. Reproduction and the early life history stages of corals have been shown to be particularly sensitive to adverse conditions. In experiments with four species of acroporid corals, settlement of larvae and early calcification of the newly settled corals were detrimentally affected by seawater with reduced pH. Gametes from these species were collected, fertilised and larvae reared at One Tree Island on the Great Barrier Reef, Australia in spring 2007. Eight thousand *Acropora millepora* larvae were placed in ambient seawater or sea water of pH 7.8 or 7.6 with preconditioned terracotta tiles for the settlement period. pH was maintained by bubbling carbon dioxide in to the seawater. Settlement success was significantly reduced at pH 7.6 and 7.8 compared to that in ambient seawater. In a separate experiment, larvae of four species were settled on terracotta tiles in ambient seawater. As soon as most of the larvae had metamorphosed, the tiles were scored for the number of larvae that had settled, calcified or were attached but not metamorphosed. Over 16 000 settled corals were used in the experiment. The tiles were then transferred to 250L chambers of either ambient seawater, pH of 7.8 or 7.6 for five days. Tiles were then rescored in a similar manner but stage of calcification was also recorded. Most coral spat in the pH 7.8 and 7.6 treatments did not calcify past the very early stages of calcification in all four species. These results represent crucial information for the future of recruitment on coral reefs.

## 25-15

**Effects Of Climate Change On Coral Reef Algae: Will Algae Be The Winners?**

**Guillermo DIAZ-PULIDO*[1]**, Kenneth R.N. ANTHONY[2], David I. KLINE[2], Laurence MCCOOK[3], Selina WARD[2], Ove HOEGH-GULDBERG[2], Sophie DOVE[2]

[1]Centre for Marine Studies and ARC Centre of Excellence for Coral Reef Studies, University of Queensland, Brisbane, St Lucia, Australia, [2]Centre for Marine Studies and ARC Centre of Excellence for Coral Reef Studies, University of Queensland, St Lucia, Brisbane, Australia, [3]Great Barrier Reef Marine Park Authority, Townsville, Australia

Climate change predictions imply that intensified levels of thermal bleaching and ocean acidification will lead to increasing rates of coral mortality. A general perception is that such coral reef degradation will result in a phase shift from coral to macroalgal dominance. However, the effects of ocean acidification and warming on tropical coral reef algae have rarely been studied and the vulnerabilities of this key group of organisms to climate change are poorly known. Here we explore the impacts of warming and ocean acidification due to rising atmospheric carbon dioxide emissions on a range of coral reef macroalgae, including crustose coralline algae (CCA) and fleshy macroalgae. We used controlled experimental conditions to simulate acidification and warming scenarios for the Great Barrier Reef, Australia (GBR) in the years 2050 and 2100. Preliminary results from the southern GBR indicate that both groups of benthic algae (calcareous and fleshy) are highly sensitive to climate change. Rates of calcification, photosynthesis, survivorship and recruitment of the CCA *Porolithon onkodes* were severely reduced with increasing CO2 levels and temperature. Similarly, the fleshy macroalga *Lobophora variegata* showed a 50% growth reduction under high levels of CO2 and temperature representative of levels predicted for 2100. Further experiments performed on Lizard Island (northern GBR), confirmed that other species of coral reef macroalgae have relatively low temperature thresholds for physiological stress. Our results suggest that the coral reef macroalgae studied are at least as vulnerable to ocean acidification and global warming as are corals. The high vulnerability of CCA is likely to lower the reef's recovery and cementation capacity, while a reduction in fleshy macroalgae may affect primary productivity with consequences for trophic relations and ecosystem function.

## 25-16

**Climate Change Thresholds And Coral Reef Degradation**

**Kenneth ANTHONY*[1]**, Guillermo DIAZ-PULIDO[1]

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

The healthy functioning of coral reefs is underpinned by processes operating at organism, population, community and ecosystem levels. Current reef-resilience models provide excellent insight into the role of coral-algae-herbivore interactions. However, predictions of how coral reefs will behave under unprecedented climate conditions require information about stress responses across all organizational levels. Here, we explore coral community responses along gradients of ocean acidification and thermal stress using a new dynamic coral community model parameterized by organism and population responses to climate-change variables from experimental studies. Model runs for years 2050 and 2100 indicate that key framework builders such as crustose coralline algae and Acroporid corals will gradually diminish in reef communities on the Great Barrier Reef. Contrary to general assumptions, transitions from healthy to degraded reefs are not triggered by the exceedence of distinct threshold values, but show a gradual decline to depauperate states. Whether corals will be replaced by macroalgae depends on the physiological responses of the algal species, and model runs based on recent data suggest that shifts to barren rather than algal-dominated reefs are likely outcomes.

## 25-17

**Climate Change And Reef Development in The Tropical Eastern Pacific**

**Richard ARONSON*[1]**, Ian MACINTYRE[2], Steven VOLLMER[3], Jennifer HOBBS[4], Anke MOESINGER[1]

[1]Dauphin Island Sea Lab, Dauphin Island, AL, [2]Department of Paleobiology, Smithsonian Institution, Washington, DC, [3]Marine Sciences Center, Northeastern University, Nahant, MA, [4]School of Marine and Atmospheric Science, Stony Brook University, Stony Brook, NY

Understanding how biotic turnover controls the development of coral reefs will be critical to projecting their future in a rapidly changing world. How well reefs keep up with rising sea level will determine the extent to which they protect adjacent land masses from coastal erosion. In the tropical eastern Pacific, populations of *Pocillopora damicornis*, the dominant constructor of reef framework, were bleached on a regional scale by the 1982–83 El Niño event. Subsequent coral mortality and bioerosion suggested that centennial-scale recurrences of extreme thermal anomalies associated with the El Niño–Southern Oscillation have slowed accretion rates of eastern Pacific reefs by killing *Pocillopora* episodically. Off the Pacific coast of Panamá, *Pocillopora* recovered rapidly after 1983 in some places but not in others. Where it did not recover, the *Pocillopora* rubble was colonized by another coral species, *Psammocora stellata*, which is not a framework-builder. Coring studies in the Gulf of Panamá showed that *Pocillopora* kills and shifts to *Psammocora* occurred episodically over the past 6000–7000 years; however, *Pocillopora* growth was suppressed for centuries to millennia, depressing vertical reef accretion for intervals far longer than the return time of strong El Niño events. These protracted intervals of suppressed coral growth can be used to parameterize models of reef accretion under scenarios of biannual to annual coral bleaching, predicted to commence in the next several decades. Oceanic acidification will further inhibit reef accretion, especially in the tropical eastern Pacific where upwelled waters already expose *Pocillopora* populations to elevated concentrations of dissolved carbon dioxide.

## 25-18

**Fragile Reefs Of The Eastern Pacific: A Model For Reefs in A High $Co_2$ World**

**Derek MANZELLO*[1]**, Joanie KLEYPAS[2,3], David BUDD[4], Mark EAKIN[5]

[1]Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School, University of Miami, Miami, FL, [2]Institute for the Study of Society and Environment, National Center for Atmospheric Research, Boulder, CO, [3]Institute for the Study of Society and Environment, National Center for Atmospheric Research, Boulder, [4]Dept. of Geological Sciences, Univ. of Colorado, Boulder, CO, [5]Coral Reef Watch, NOAA NESDIS, Silver Spring, MD

Ocean acidification describes the progressive, global reduction in seawater pH that is currently underway due to the oceanic uptake of increasing atmospheric $CO_2$. Acidification is expected to reduce coral reef calcification and increase reef dissolution, and the relative rates of change will likely be a function of $pCO_2$ (the partial pressure of $CO_2$) in seawater, which is directly proportional to $pCO_2$ in the atmosphere. Little is known about the effects of acidification on syndepositional processes that affect the persistence and preservation of carbonates (i.e., early marine diagenesis). Newly analyzed samples agree with previous studies showing that only trace amounts of inorganic cements occur in modern day coral reefs that exist naturally under low ambient pH in the eastern Tropical Pacific (ETP). The variation in cement abundance and rates of bioerosion between sites in Panamá and Galápagos appears to be related to differences in the saturation state of $CaCO_3$ ($\Omega$); suggesting a link between $\Omega$, inorganic cementation and coral reef development in the ETP. ETP reefs may thus provide a real-world model of coral reef growth in low $\Omega$ waters and provide insights into the role of decreasing $\Omega$ on reefs beyond the prediction of reduced $CaCO_3$ production.

## 25-19

**Phase Shifts in Coral Reefs – Comparative Investigation Of Corals And Benthic Algae As Ecosystem Engineers**

**Christian WILD*[1]**, Andreas HAAS[1], Malik NAUMANN[1], Christoph MAYR[2]

[1]Coral Reef Ecology (CORE) Work Group,GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany

Global climate change and direct anthropogenic stress factors do strongly affect the benthic community structure in coral reefs. It is reported from the literature that hermatypic corals are gradually replaced by benthic micro- and macro-algae at many reef locations around the world, a process which is commonly referred to as phase shift. Recent research showed that hermatypic corals via the release of organic matter and concomitant effects on cycles of matter can act as engineers of reef ecosystems. There are strong indications that reef associated benthic algae do also affect reef ecosystem functioning via organic matter release, but all relevant information is lacking. To gain a better understanding of the biogeochemical consequences such phase shifts from corals to algae entail, a series of comparative studies with hermatypic corals and benthic algae were conducted in reefs of the Northern Red Sea during four seasonal expeditions in 2006-2008. These investigations primarily focused on the quantity and quality of the organic matter released by both groups of organisms involving dissolved organic carbon (DOC), particulate organic carbon (POC) and particulate nitrogen (PN). Supplementary mass spectrometric analyses were conducted in order to analyse stable isotope signatures of coral- or algae-derived organic matter. Finally, planktonic and benthic degradation of the respective organic matter were investigated in the field using bottle incubation experiments and stirred benthic chambers, respectively. Our data show clear differences between organic matter release by benthic reef algae or corals for most of the measured parameters, thus, suggest a massive influence of the described phase shifts onto biogeochemical cycles and processes in warm water coral reefs.

## 25-20

**Long-Term, Regional-Scale Patterns in Caribbean Coral Bleaching Responses**

**Allison L. PERRY*[1,2]**, Isabelle M. CÔTÉ[3], John D. REYNOLDS[3], Andrew R. WATKINSON[4,5]

[1]WorldFish Center, Bayan Lepas, Penang, Malaysia, [2]School of Biological Sciences, University of East Anglia, Norwich, United Kingdom, [3]Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada, [4]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, [5]Tyndall Centre for Climate Change Research, Norwich, United Kingdom

Coral bleaching is one of the most serious and immediate ecological impacts of climate change, with bleaching events increasing in frequency, severity and extent with rising sea surface temperatures (SSTs). Given the geographically widespread nature of this phenomenon, there is a need to understand patterns and drivers of bleaching over multiple spatial and temporal scales. We take a regional-scale approach, and examine long-term trends in the occurrence of coral bleaching in the Caribbean region, and in the SST anomalies associated with bleaching. Using data over a 24-year period, we assess whether corals may be adjusting to rising temperatures, and examine the regional-scale relationship between the geographic extent of bleaching and rising SST anomalies. At both local and regional scales, there is little evidence to support the possibility that Caribbean reefs are keeping pace with rising sea temperatures, while the geographic extent of bleaching in the region is accelerating with rising sea temperatures even more rapidly than previously known. In combination, our results emphasise the particular vulnerability of reefs to climatic warming.

## 25-21

**Right Of Disaster: Understanding, Predicting And Accelerating The Adaptive Response Of Reef Coral Symbioses To Climate Change**

**Andrew BAKER*[1,2]**

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Marine Program, Wildlife Conservation Society, Bronx

Reef-building coral symbioses are increasingly threatened by the effects of climate change, and it is not yet known whether these organisms will be able to adapt or acclimatize quickly enough to avoid large-scale loss of reef ecosystems. A variety of mechanisms have been identified by which corals, their algal symbionts, and other microbial partners might compensate for these environmental changes. Most research to date has focused on the ability of corals to flexibly associate with diverse algal symbionts ("zooxanthellae" in the genus *Symbiodinium*) whose specific identity results in different environmental optima for the coral host. However, the potential importance of this mechanism is limited by: (1) the timescales over which flexibility might act; (2) ontogenetic restrictions, environmental prerequisites and host systematic constraints on flexibility; and (3) physiological tradeoffs of hosting different symbionts. Despite these considerations, symbiosis flexibility remains the most promising mechanism identified to date by which corals might survive climate change. Consequently, as we move into an era of unavoidable climate impacts, knowledge of symbiosis flexibility might be used to understand declines, forecast future effects, and prioritize species and areas of special conservation. Moreover, despite the limitations on symbiosis flexibility outlined above, artificial manipulation of symbiont communities at the larval or adult coral stages may have conservation benefit and should be attempted. These interventions can be employed to: (1) create stocks of thermally tolerant corals for restoration purposes; (2) protect the largest and oldest corals on reefs of special value; and (3) create species survivorship networks in targeted areas of special concern whose persistence may help preserve ecosystem function. Symbiosis flexibility has probably played a critical role in the evolution and success of reef corals, and triage-based conservation strategies that leverage these natural adaptive mechanisms to mitigate climate change effects should be attempted whenever possible.

## 25-22

**Proliferation Of An Opportunistic Symbiodinium Sp. During The 2005 Eastern Caribbean Mass Coral 'bleaching.'**

**Todd LAJEUNESSE*[1,2]**, Jennifer FINNEY[3], Robin SMITH[4], Hazel OXENFORD[3]

[1]Biology, Florida International University, North Miami, FL, [2]Biology, Pennsylvania State Universtiy, University Park, [3]Center for Resource Management and Environmental Studies, University of the West Indies, Bridgetown, Barbados, [4]Biology, Florida International University, Miami, FL

Corals of the Eastern Caribbean underwent their worst recorded bleaching and mortality in the fall of 2005. The resident dinoflagellate endosymbionts were examined in coral species from Barbados during the summer before signs of stress were evident. Sampling was repeated in early winter one month following a return to normal sea surface temperatures, but before recovery. The reefs were revisited 5 months and two years later to assess the state of Symbiodinium populations. A partial or complete change in the resident population to a putatively stress-tolerant opportunist, Symbiodinium D1a, occurred in colonies of several coral species over the course of this event. Low-abundance resident background populations of D1a were detected using rtPCR before signs of stress were evident and proliferated in many colonies during the late summer and fall. The differential growth and/or persistence of this background symbiont in response to thermal stress 'saved' many colonies from bleaching. Many colonies that bleached experienced partial or total mortality in the months that followed. While the prevalence of Symbiodinium D1a remained high months later, the symbiont populations in most colonies reverted back to their normal symbiont species after two years. The distribution patterns before, during and after this event clearly indicate that Symbiodinium D1a is a weedy species generalized to numerous host taxa and opportunistic during times of physiological stress.

## 25-23

**A Community Change in The Symbionts Of A Scleractinian Coral Following A Natural Bleaching Event: Field Evidence Of Acclimatization**

**Alison JONES*[1]**, Ray BERKELMANS[2], Madeleine VAN OPPEN[2], Jos MIEOG[3], William SINCLAIR[1]

[1]Biosystems and Resources, Central Queensland University, Rockhampton, Australia, [2]Environmental Change and Impacts, Australian Institute of Marine Science, Townsville, Australia, [3]Marine Benthic Ecology and Evolution, University of Groningen, Haren, Netherlands

It has been hypothesized that reef corals can change their Symbiodinium community populations dramatically by up-regulating low levels of more stress tolerant types in their tissue after bleaching. In this study, we quantify the change in symbiont community in colonies of a common reef-builder Acropora millepora after a natural bleaching event in the Keppel Islands (Great Barrier Reef). By late February 2006 when bleaching was at its most intense, the relative difference in bleaching susceptibility between corals predominated by C2 and D was clearly evident, with the former bleaching white and the latter normally pigmented. The symbiont community change in surviving colonies was dramatic (71% changed predominance from C2 to D or C1 (n=58) however selective mortality of C2 colonies also played a substantial role in shifting the symbiont community in the post-bleaching coral population. We suggest that this change in symbiont community structure occurred mainly as a result of background symbionts proliferating in recovered colonies. If these backgrounds symbionts are present in other structurally important coral species, coral reefs may have considerably more acclimatization potential through symbiont shuffling than previously thought.

## 25-24

**Shifts in *symbiodinium* Communities Following Bleaching in The Panamic Eastern Pacific: Insights From Quantitative Pcr**

**Adrienne CORREA*[1,2]**, Andrew BAKER[3], Danielle MCDONALD[3], Peter GLYNN[3]

[1]Ecology, Evolution & Environmental Biology, Columbia University, New York, NY, [2]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, [3]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

The extent to which reef corals can adapt and/or acclimatize to increasing sea surface temperatures is highly debated within climate change science. It is hypothesized that physiological differences among the genetically diverse dinoflagellate endosymbionts of corals (*Symbiodinium* spp.) may prove critical to the survival of reefs. This could occur in two ways: (1) the differential proliferation of coral colonies that specifically host thermally tolerant symbionts; and/or (2) shifts favoring heat tolerant *Symbiodinium* in colonies that flexibly host multiple symbiont types. Some shifts in symbiont dominance have already been documented on recently bleached reefs, within individual bleached colonies, and seasonally within healthy colonies. These shifts may be "host-driven", such as when differential host mortality indirectly results in community-wide changes in *Symbiodinium* prevalence; or they could be symbiont-driven, representing the outcome of ecological processes such as competition among symbionts within hosts. We are using quantitative PCR (qPCR) to explore: (1) the prevalence of mixed *Symbiodinium* communities; (2) changes in symbiont community structure; and (3) the potential evidence for symbiont competition within a long-term (1995-2006) dataset of two Panamanian coral species (*Pocillopora damicornis* and *Pocillopora elegans*) in the eastern Pacific, and also within experimentally bleached colonies. This approach allows us to explore the degree to which fine-scale changes occur between years in the average dominant *Symbiodinium* clade on reefs, as well as changes in the relative abundance of *Symbiodinium* clades within individual coral colonies before, during, and after bleaching. Since cryptic diversity may function as a 'safety net' during times of environmental change, *Symbiodinium* community dynamics, especially following disturbance, may be critical to predicting the potential future survival trajectories of coral reefs.

## 25-25

**Can Scleractinians Take Up Exogenous Symbionts After A Bleaching Event?**

**Mary Alice COFFROTH*[1]**, Eleni PETROU[2], Daniel POLAND[2], Lyndsey HOLLAND[1]

[1]Geology, University at Buffalo, Buffalo, NY, [2]Biology, University at Buffalo, Buffalo, NY

With reports of coral bleaching on the rise, it is ever more important to understand how corals will respond to bleaching events and to assess their ability to recover. One large unknown is the manner in which bleached corals recover their symbiont populations. Can corals acquire zooxanthellae from the environment or is recovery dependent on surviving *in hospite* symbionts? Acquisition of symbionts from the environment could be an important mechanism for acclimatization to an altered environment. We examined the ability of *Porites divaricata*, a scleractinian coral found throughout the Caribbean, to secondarily acquire algal symbionts after an experimentally induced bleaching event. *Porites divaricata* colonies in the Florida Keys typically harbor *Symbiodinium* B170 (based on sequence variation in the chloroplast 23S rDNA). Using elevated temperature, colonies of *P. divaricata* were induced to bleach and then exposed to *Symbiodinium* strains not typically found in the adult host (*Symbiodinium* strains A198, B211, B 224 and D206). At 19 d and 38 d after exposure to the atypical strain, most of the colonies only harbored the symbiont type originally found in the host prior to bleaching (i.e. B170). However, after 19d all colonies exposed to strain B224 harbored the non-native strain in addition to the strain normally found in *P. divaricata* (B170). In the other treatments, the inoculated strain was only rarely detected (7% of samples). This suggests that corals may secondarily obtain new symbionts from the environment, but like the primary infection, host-symbiont specificity restricts the plasticity of the symbiosis.

## 25-26

**Environmental Controls on the Establishment and Development of Symbiosis in Corals**

**Vivian CUMBO*[1]**, Andrew BAIRD[2], M.H. VAN OPPEN[3]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]ACR Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]Australian Institute of Marine Science, Townsville, Australia

The initial establishment of symbiosis is critical for coral that acquire their zooxanthellae via horizontal transmission because it gives them an opportunity to associate with different, more beneficial strains of zooxanthellae. Corals can associate with many different species of zooxanthellae, some which are more tolerant of high temperature. Consequently, one possible way for corals to cope with projected increases in sea surface temperature attributed to global warming is to initially associate with heat tolerant symbionts. This study tested this mechanism by determining whether environmental conditions affect the establishment and development of symbiosis for the coral, *Acropora monticulosa*. Coral larvae were exposed to 25, 28 or 31°C and given either *Symbiodinium* clades A, C or D. Some strains of *Symbiodinium* clade D are known to be heat tolerant, while clade C is generally considered heat sensitive. Symbiosis was established with all clades of zooxanthellae under every temperature treatment. The proportion of larvae infected with clade C decreased as temperatures increased, while the proportion of larvae infected with clade A peaked at 28°C then decreased. In contrast, the proportion of larvae infected with clade D increased as temperature increased. Additionally, the density of zooxanthellae within the larvae decreased significantly for clade A and C but increased for clade D as temperature increased. These results suggest that as seawater temperatures increase, the coral host may be able to shift to more heat tolerant clades of zooxanthellae and potentially aid coral's ability to cope with global warming.

## 25-27

***My Name Is Legion, For We Are Many*: The Ecological And Evolutionary Significance Of Population Structure in Symbiotic Dinoflagellates (*symbiodinium*, Dinophyta)**

**Scott R. SANTOS*[1]**

[1]Department of Biological Sciences, Auburn University, Auburn, AL

*Symbiodinium* represents a genus of unicellular dinoflagellate symbionts that associate with a variety of marine protists and invertebrates. Over the last 15 years, eight divergent clades, designated A to H, with numerous subcladal "types" comprising each lineage, have been recognized within the genus. Although the diversity and phylogenetics of the *Symbiodinium* complex is now well established, there has been surprisingly few data on fine-scale population structure and biogeography in these dinoflagellate symbionts. Since populations represent the fundamental unit of evolution, understanding patterns and processes at this level is paramount toward furthering our knowledge on the basic biology of *Symbiodinium* as well as how anthropogenic-driven global climate change may impact these symbionts and their host associations. Here, I present a synopsis of population-level characteristics for *Symbiodinium* distilled from published and unpublished data. These include: 1) the symbiont population of a host is typically comprised of a multitude of individuals belonging to a single genetic entity or clone; 2) for a given host species, the majority of individuals at a site harbor an identical *Symbiodinium* clone, indicating low symbiont population diversity per host species per site; 3) strong genetic structure is common between symbiont populations of a host species across sites, suggesting low genetic connectivity between populations due to poor dispersal capability of clones, and; 4) all clones associating with a particular host species over a widespread geographic range belong to the same phylogenetic "species", implying high specificity in the pairing of host species and *Symbiodinium*. By unifying these characteristics in a single framework, a series of hypotheses, testable via experiments and/or modeling, are synthesized regarding the ecology and evolution of *Symbiodinium* and their important symbiotic associations.

## 25-28

**Coral Holobiont Community Structure: How Much Have We Missed By Focusing Only in The Coral Host?**

**Juan ORTIZ*[1]**, Maria GOMEZ CABRERA[1]

[1]Centre for Marine Studies, The University of Queensland, St Lucia, Australia

Coral community structure has been studied in depth for the past fifty years. However, the identity of symbiotic dinoflagellates that live within the coral colonies, their life-history, and specificity to different hosts is poorly understood. While the number of identified symbiont types increases, we are left with the task of recognizing functional differences between these groups. Several studies have established the symbiont community structure in individual coral colonies, but little is known about how we should interpret the role of the symbiotic dinoflagellate communities in the ecosystem. The aims of this study is: To quantify the contribution of the symbiont identification to the community response to environmental variables by comparing the response of the coral host community structure and the holobiont community structure to the same environmental gradient. The coral community structure and the symbiont community structure were studied in 5 coves with different environmental conditions along the central coast of Venezuela using photo-transects and ITS2 to identified symbionts. 77 % of the variability of the coral community structure can be explain by distance from the closest reef, while 92% of the variability in holobiont community structure can be explain by a combination of 4 environmental variables. The 15% increases in the proportion of the variability explained by the environmental variables is the contribution of the symbiont identity in the model. Following this analysis a holobiont niche segregation was evident having different hots-simbiont combinations associated to different environmental conditions. This study shows quantitatively for the first time how much information can be gain by including the symbiont ID in classical coral community ecology, demonstrating that the study of coral holobiont community structure is the natural next steep forward in the study of changes in coral communities.

## 25-29

**Prevalence Of Background Populations Of An Opportunistic Symbiodinium Among Caribbean Coral Communities.**

**Robin SMITH*[1]**, Todd LAJEUNESSE[1]

[1]Florida International University, Miami, FL

The ecology of *Symbiodinium D1a* in Caribbean corals is different than other symbionts. Distribution surveys indicate that the prevalence of *Symbiodinium D1a* may increase on reefs experiencing irradiance and/or thermal disturbance. Some species within this lineage demonstrate physiological tolerance of irradiance fluctuations while others display increased thermal tolerance. It is therefore important to delineate the natural distribution patterns of this species to gain a better understanding of the acclimation and/or adaptation potential of coral reefs. The fine spatial distribution of *Symbiodinium D1a* in a wide diversity of coral taxa from Caribbean reefs was evaluated using real-time PCR to detect it's presence as a background population. For comparison, host communities in Hawaii and the eastern Pacific were analyzed. Results show that these *Symbiodinium* spp., namely D1a, exist in many corals in the absence of environmental stress; often in low abundance and below the detection limits of conventional fingerprinting techniques. These findings suggest that the rise of population shifts to D-type *Symbiodinium* following environmental disturbance are most readily explained as the disproportionate growth of resident *Symbiodinium D* populations that otherwise exist at low concentrations. *Symbiodinium D1a* appears to be a globally distributed host-generalist capable of associating with most coral genera as a background population during periods of environmental stability with the potential to become opportunistically dominant during periods of physiological stress.

## 25-30

**Symbiont Specificity Within And Among Soft Coral Genera During The 1998 Gbr Mass Coral Bleaching Event**

**Tamar GOULET*[1]**, Todd LAJEUNESSE[2], Katharina FABRICIUS[3]

[1]Biology, University of Mississippi, University, MS, [2]Biology, Pennsylvania State University, University Park, PA, [3]Australian Institute of Marine Science, Townsville, Australia

Coral bleaching (the loss of symbiotic intracellular dinoflagellates, *Symbiodinium* spp.) is not restricted to scleractinian corals but also occurs in soft corals. In the 1998 mass coral bleaching event, soft coral species were severely affected, with considerable variability in bleaching within and among soft coral taxa. In the midst of the bleaching event on the central Great Barrier Reef (GBR), tissue samples were taken from bleached and unbleached colonies representative of 17 soft coral genera in the order Alcyonacea (Octocorallia: Cnidaria). The *Symbiodinium* types in these samples were determined using PCR-denaturing gradient gel electrophoresis (DGGE) fingerprinting analysis of the internal transcribed spacer (ITS) regions 1 and 2. Alcyonaceans from the GBR exhibited a high degree of symbiont specificity. Nine different *Symbiodinium* clade C types occurred. Clade B (*B1n* and *B36*) symbiont types were only recorded from *Nephthea* sp. and a rare clade D type (*D3*) was found only associated with *Clavularia koellikeri*. *Symbiodinium* clade populations were homogenous in all but one colony. Colonies with a bleached appearance hosted symbiont types that were genetically indistinguishable from those in non-bleached conspecifics. These data suggest that parameters other than the resident endosymbionts play an important role in determining bleaching susceptibility within and among soft coral species.

## 25-31

**Coral Physiology: The Interaction Between Symbiodinium Genotype And Environment**

**Jos MIEOG*[1]**, Madeleine VAN OPPEN[2], Ray BERKELMANS[2], Bette WILLIS[3], Wytze STAM[1], Jeanine OLSEN[1]

[1]University of Groningen, Haren, Netherlands, [2]Australian Institute of Marine Science, Townsville, Australia, [3]James Cook University, Townsville, Australia

The influence of different *Symbiodinium* types on the physiology of corals has been difficult to study as coral host x environment interactions interfere when comparing different coral species or populations harboring different algal types. To address this, offspring of the same *Acropora millepora* parental colonies were infected with three different types of algal symbionts found at the Great Barrier Reef (GBR) of Australia: one rare clade A-type found mostly in cooler areas, one common, generalist clade C-type, and one clade D-type that is common in warm and turbid habitats. All groups were grown out at a warm, turbid (Magnetic Island) and a cold, clear (Keppels Islands) inshore location of the GBR. Their growth and survival was monitored and after seven months their heat-tolerance was determined.

At Magnetic Island, C-corals grew 2-3 times faster and survived 2-4 times better than D-corals. Corals with A either died here or changed to D within the first two months. At the Keppels Islands, growth of C-corals was only slightly better compared to D-corals, while A-corals showed the slowest growth. D-corals survived about 2 times better here than A- or C-corals. A-corals were highly susceptible to heat-stress, while D-corals were the most heat-tolerant at both locations.

This study demonstrates that physiological characteristics can differ strongly between conspecific corals in the same environment harboring different algal types, and that changes in the dominant symbiont type of a coral may represent a trade-off (e.g. growth vs. heat-tolerance). The relative fitness of each coral-algal association (as estimated from growth, survival and heat-tolerance), however, was found to vary with environmental factors.

## 25-32

**Can Hosting Different *symbiodinium* spp. Lead To Thermal Adaptation Within *pocillopora Verrucosa* Around Guam?**

**Lisa CHAU*[1]**, Robert ROWAN[1]

[1]Marine Laboratory, University of Guam, Mangilao, Guam

During moderate bleaching events on Guam coral reefs, caused by increased irradiance and sea temperatures, corals hosting *Symbiodinium* genotype C typically bleach, while corals hosting *Symbiodinium* D do not. *Symbiodinium* D corals are thought to be adapted to high temperatures, whereas *Symbiodinium* C corals, though more common, are thought to be temperature-sensitive. In this study corals were challenged by reciprocally transplanting them between two reefs that varied in mean temperature by 0.5oC. This temperature difference was not extreme enough to cause bleaching but provided enough stress to stimulate a potential change in zooxanthellar community structure. In this year-long field study, transplanted colonies of *Pocillopora verrucosa* with known zooxanthellar genotypes (C, D, or a mixture of C and D) were sampled periodically and examined for genotypic changes in their zooxanthellar populations. Results from PCR and restriction fragment length polymorphisms (RFLPs) showed that 40% of transplants retained the same proportion of genotypes after transplantation to a different temperature regime. However, 20% of corals from both sites changed genotypes from C to D or D to C, and 30% remained mixed proportions of C and D throughout the experiment. Ten percent of our transplants died during the experiment; all contained genotypes that were mixed or had shifted. We showed that *Symbiodinium* populations within some corals have the ability to vary their symbiont community structure with changing sea temperatures. However, this mechanism of change through adaptation, shuffling, or recombination is unknown and poorly studied. The coral-algal symbiosis is a dynamic system that requires more investigation to elucidate the mechanisms of change so that we can comprehend the adaptability of corals to increasing sea surface temperatures.

## 25-34

**Relationship Between Historical Sea-Surface Temperature Variability And Climate Change-Induced Coral Mortality in The Western Indian Ocean**

**Mebrahtu ATEWEBERHAN*[1]**, Tim MCCLANAHAN[1,2]

[1]Coral Reef Conservation Project, Wildlife Conservation Society, Mombasa, Kenya, [2]Marine Programs, Wildlife Conservation Society, New York

Coral reefs have become one of the major casualties of climate change. Many of the world's coral reefs suffered high coral mortality during the 1998 ENSO, with the highest mortality in the western Indian Ocean (WIO). We present results of a meta-analysis of field data on change in coral cover across the 1998 ENSO event for 36 major reef areas in the WIO. Average coral cover declined by ~40 % across the event with the highest mortality in the central and northern regions, with the exception of the Red Sea and Gulf of Aden. Based on multivariate analysis of SST properties, WIO reefs were categorized into 3 major groups of differing coral mortalities. Basin-wide change was highly variable and related to historical sea-surface temperature (SST) variability. Mortality was negatively associated with standard deviation (SD) SST until SD ~2.3, with increasing flatness of the SST frequency distributions. It increased with further increase in SD as the SST distributions became strongly bimodal. The predictable environmental patterns associated with the mortality suggest that future change during a warmer and more variable climate can be predicted and management priorities directed accordingly.

## 25-35

**Corals Resisting Warming – The Importance Of Experience**

**Thomas OLIVER*[1]**, Stephen PALUMBI[2]

[1]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [2]Hopkins Marine Station, Stanford Unveristy, Pacific Grove, CA

Studies have demonstrated that corals hosting certain genotypes of the dinoflagellate symbiont *Symbiodinium sp.* better resist the negative effects of temperature increases. However, the role of these resistant genotypes and the relative importance of other mechanisms of adaptation are little known. Perfomed on Ofu Island, American Samoa, this study compared resistance to temperature stress among groups of the coral *Acropora hyacinthus* that not only hosted distinct symbionts but also were sampled from two distinct habitats –a lagoonal pool with extreme swings in its temperature profile and a more moderate pool. Replicate branches were taken from 32 corals, and housed in either a tank held at ambient temperature, or a tank held ~2.5 degrees C higher. Sublethal effects were monitored using a proxy for the photosynthetic health of the symbionts, the maximum quantum yield (MQY) of PSII, measured before dawn. Visual bleaching was recorded using a color reference card, and mortality was indicated by coral tissue sloughing off the skeleton. The experiment ran until ~50% of corals in the elevated tank experienced mortality (4-6 days), and was repeated 3 times. MQY measurements showed that there was both a genotype and pool effect: corals fared better either if they hosted a resistant genotype, or came from the variable pool. However, with regard to both color loss and mortality, the only discernable effect was higher resistance of the corals from the variable pool. As the coral populations in our experiment were not genetically distinct, these results highlight the importance of acclimatization and suggest that bleaching thresholds can vary considerably depending on a coral's environmental experience.

## 25-36

**The Effect Of Thermal History On The Susceptibility Of Reef-Building Corals To Thermal Stress**

**Rachael MIDDLEBROOK*[1]**

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia

Thermal stress causes the breakdown of the relationship between corals and their symbionts (bleaching). This symbiosis may acclimate to changes in the environment, thereby potentially modifying the environmental threshold at which they bleach. While a few studies have examined the acclimation capacity of reef-building corals, our understanding of the underlying mechanism is still in its infancy. This research focuses on the role of recent thermal history in influencing the response of both corals and symbionts to thermal stress, using the reef-building corals *A.aspera* and *A.formosa.* Symbionts of *A.aspera* corals that were exposed to 31 ºC for 48 h one or two weeks prior to a six-day simulated bleaching event (when corals were exposed to 34 ºC) were found to have more effective photoprotective mechanisms. These mechanisms included changes in non-photochemical quenching and xanthophyll cycling. These differences in photoprotection were correlated with decreased loss of symbionts, with those corals that were not prestressed performing significantly worse, loosing over 40% of their symbionts and having a greater reduction in photosynthetic efficiency. Significant differences were also found in the performance and short-term recovery of *A.formosa* corals exposed to a rapid and a slow progressive heating rate. A slow build up in temperature induced acclimation seen through lipid concentrations, symbiont densities, respiration and photoprotective mechanisms. These results are important as they show that thermal history, in addition to light history, can influence the response of reef-building corals to thermal stress and therefore have implications for the modeling of bleaching events. However, whether acclimation is capable of modifying the thermal threshold of corals sufficiently to cope as sea temperatures increase in response to global warming has not been explored fully.

## 25-37

**Bleaching, El Nino, And El Nina: 13 Years Of Seasonal Analysis Of Reef-Building Corals in Florida, The Bahamas, And The Caribbean**

**William FITT*[1]**, Dusty KEMP[1], Xavier HERNANDEZ-PECH[2], Roberto IGLESIAS-PRIETO[2], Jennifer MCCABE[1], Tom SHANNON[1], Brigitte BRUNS[3], Gregory SCHMIDT[3]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]Universidad Nacional Autónoma de México, Puerto Morelos, Mexico, [3]Plant Sciences, University of Georgia, Athens, GA

Six species of coral were monitored approximately every three months for 13 years in the Florida Keys, 11 years in the Bahamas, and 4 years in Puerto Morelos , Mexico. Generally all species exhibited peaks in ash-free dry weight (AFDW) and density of zooxanthellae (Symbiodinium) during the winter/spring and lowest values in the late summer.

Certain generalities include: shallow water (1-4 m) species showed higher AFDW and densities of symbionts compared to deep water populations (13 m). Many of the species of corals had one type of Symbiodinium in shallower colonies, and a different type of Symbiodinium in deeper colonies. The trends of AFDW of the tissues from corals follow the density of Symbiodiinium, some three-months later.

Each species of coral appears to have a minimum value of AFDW, below which the coral tends to die. For instance, the AFDW of 2 mg/cm2 appears to be a minimum for Acropora cervicornis, with two populations dying when they went below this level in the Bahamas, compared with one population that is alive and above the minimum AFDW.

During the 1997/8 El Niño the AFDW and symbiont densities were extremely low, but the next winter (1999) there was a spike in the density of symbionts followed by a slow recovery in AFDW. There were smaller spikes after the El Niño's of 2002 and 2005. During La Niña the temperature extremes were less than normal, and the corals showed values for AFDW and density of Symbiodinium well above the minimum levels. Visible bleaching was only observed for a few of the coral species, occurring at the end of El Niño events.

## 25-38

**The Future Of Specific Symbioses Within The Reef Coral Pocillopra in The Eastern Pacific: Investigating The Impacts Of Thermal Anomalies in Western Mexico**

**Mark WARNER*[1]**, Todd LAJEUNESSE[2], Hector REYES-BONILLA[3], Matt ASCHAFFENBURG[1], Mike MCGINLEY[1], Robin SMITH[4], Tye PETTAY[4]

[1]University of Delaware, Lewes, DE, [2]Pennsylvania State University, University Park, PA, [3]University of Southern Baja California, La Paz, Mexico, [4]Florida International University, Miami, FL

Many sources have pointed to the endosymbiotic dinoflagellates within the genus *Symbiodinium* as a primary cellular target of damage during coral bleaching. However, the genetic and physiological diversity of these symbionts, coupled with the fact that some corals may harbor multiple symbiont types, has led to the idea that such plasticity could provide an axis for acclimatization or adaptation to climate change if corals can retain and/or acquire thermally tolerant algae. In particular, it is thought that symbionts within the "D" lineage may serve this role, yet our knowledge of the ecological distribution and physiological detail of this and other groups of *Symbiodinium* is largely incomplete. The eastern Pacific provides an excellent venue to test these ideas of symbiont change and coral resilience, as it encompasses regions that have been differentially impacted by thermal anomalies and coral bleaching. Here we present the initial findings of a three year study that is investigating the distribution of "C" and "D" *Symbiodinium* within the coral *Pocillopora* in several regions of western Mexico. In addition, the impact of short-term thermal stress experiments on the photobiology, as well as long-term analysis of bleaching recovery, coral growth and fitness in *Pocillopora* harboring dominant populations of either "C" or "D" *Symbiodinium* in the southern Gulf of California will be presented. Initial results from experimental bleaching suggest that D1 symbionts may possess a slightly higher degree of tolerance to elevated temperature and/or light as compared to type C1b-c algae, yet significant damage to photosystem II can result. The long-term implications for recovery and response to future warming events in the northeastern Pacific will be addressed.

## 25-39

**Annual Summer Mass Bleaching Of A Multi-Species Coral Community in American Samoa**

**Douglas FENNER*[1]**, Scott HERON[2]

[1]Marine & Wildlife Resources, American Samoa Government, Pago Pago, American Samoa, [2]Coral Reef Watch, NOAA, Townsville, Australia

Widespread annual summer mass coral bleaching has been predicted to begin in about 30-50 years, due to increasing global temperatures. Annual mass bleaching has been reported for two individual coral species, one in the Mediterranean and one in Florida, but this study is the first known annual bleaching report for a multi-species coral community. Bleaching levels have been recorded in two back-reef pools on Tutuila, American Samoa on a biweekly to monthly basis since late 2003. Mass bleaching of several species has occurred in all four summers during this period. Most *Acropora*, one of two species of *Millepora*, and one small area of *Porties cylindrica* have repeatedly bleached but little mortality has been observed so far. During this period, there was little or no bleaching on the reef slopes. The back-reef pools have limited circulation, and get hotter on sunny summer days than the adjacent ocean, with sea surface temperature (SST) reaching about 32°C in these pools. The two summers previous to the start of recording were reported to have bleaching on reef slopes. About 50% of all staghorns in the pools were dead at the start of observations, which likely were caused by the more intense bleaching in those 2 years. This suggests that bleaching has occurred every summer for at least 6 years in a row. The record of the intensity of bleaching in the pools over the 4 years follows SST's quite closely. This appears to be the first detailed record of the time course of repeated multi-species bleaching available. Ongoing annual mass bleaching of a multi-species community provides a window into the future and an opportunity for examining the effects on corals of climate change.

## 25-40

**Bleaching Damage And Recovery Potential Of Coral Reefs in Dubai, Uae**

John BURT[1,2], **Andrew BAUMAN*[3]**, Aaron BARTHOLOMEW[4], Peter SALE[5,6]

[1]Natural Science and Public Health, Zayed University, Dubai, United Arab Emirates, [2]Department of Biological Sciences, University of Windsor, Windsor Ontario, Canada, [3]International Network on Water, Environment and Health, United Nations University, Dubai, United Arab Emirates, [4]Department of Biology and Chemistry, American University of Sharjah, Sharjah, United Arab Emirates, [5]Department of Biological Sciences, University of Windsor, Windsor, ON, Canada, [6]International Network on Water, Environment and Health, United Nations University, Windsor, Canada

Documenting long-term changes to coral reef communities following large-scale bleaching events is necessary for predicting changes to coral community composition and their recovery potential to climate change. Such information is necessary to successfully predict how bleaching events may affect the composition and recovery potential of coral communities. In the Arabian Gulf increasing frequencies of elevated sea surface temperatures (1996, 1998, and 2002) have caused extensive coral reef mortality in Dubai United Arab Emirate. Here, we surveyed coral communities within Dubai, examining the composition of the coral assemblages present in 2007, and compared this with information on coral community composition from 1996. We characterized five distinct coral communities in 2007 and compared with previously published accounts of the same communities. In 1996, extensive coral mortality in Dubai, primarily affected *Acropora* dominated communities, reducing their abundance by almost 90%. Our research showed that within the same areas, *Acropora* communities had nearly doubled in abundance, from 22% to 42%. Despite this strong recovery of *Acropora* communities, both *Faviid* and *Poritid* assemblages, which only suffered negligible mortality in 1996, dominated remaining communities. However, minimal change in percent coral cover of both *Faviid* and *Poritid* between 1996 and 2007 suggested assemblages were shifting towards *Acropora* dominated pre-bleaching communities. We also investigated the recovery potential of coral communities by surveying coral recruitment. Recruitment densities were consistently low throughout coral assemblages, with community composition highly dependent on the surrounding adult communities. However, the prevalence of relatively fast growing *Acropora* juveniles throughout communities indicated that recovery of *Acropora* dominated communities was occurring. This study shows that despite recurring mass coral bleaching events, coral communities throughout Dubai are able to rapidly recover suggesting that these assemblages may be acclimatized to the extreme conditions found throughout the Arabian Gulf.

## 25-41

**Can Symbiont Diversity Help Coral Reefs Survive Climate Change?**

**Marissa BASKETT*[1]**, Steven GAINES[2], Roger NISBET[2]

[1]National Center for Ecological Analysis and Snythesis, University of California, Santa Barbara, Santa Barbara, CA, [2]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

Given climate change, thermal stress-related mass coral bleaching events present one of the greatest anthropogenic threats to coral reefs. While corals and their symbiotic algae may respond to future temperatures through adaptation and shifts in community compositions, the climate may change too rapidly for coral response. Here we develop a model of coral and symbiont ecological dynamics and symbiont evolutionary dynamics. Model results without variation in symbiont thermal tolerance predict coral reef collapse within decades under multiple future climate scenarios, consistent with previous threshold-based predictions. However, model results with genetic or community-level variation in symbiont thermal tolerance can predict coral reef persistence into the next century, provided low enough greenhouse gas emissions occur. Therefore, the level of greenhouse gas emissions will have a significant effect on the future of coral reefs, and accounting for biodiversity and biological dynamics is vital to estimating the size of this effect.

## 25-42

**Factors Affecting The Evolution Of Bleaching Resistance in Corals**

**Julian CALEY*[1]**, Troy DAY[2,3], Laura NAGEL[4], Madeleine VAN OPPEN[1]

[1]Australian Institute of Marine Science, Townsville, Australia, [2]Dept. of Mathematics and Statistics, Queen's University, Kingston, ON, Canada, [3]Dept. of Biology, Queen's University, Kingston, Canada, [4]Dept. of Biology, Queen's University, Kingston, ON, Canada

We present a mathematical model of coevolutionary interactions between partners in a coral-algae mutualistic symbiosis. Our goal is to better understand factors affecting the potential evolution of bleaching resistance in corals, in response to increased average sea temperatures. We explore the evolutionary consequences of four factors: (i) tradeoffs among fitness components, (ii) different proximate mechanisms of coral bleaching, (iii) the genetic determination of bleaching resistance, and (iv) the mode of sexual reproduction. We show that traits in mutualistic symbioses, such as thermal tolerance in corals, are potentially subject to novel kinds of evolutionary constraints, and that these constraints are mediated by ecological dynamics. We also show that some proximate mechanisms of bleaching yield faster evolutionary responses to temperature stress, and that the nature of interspecific control of bleaching resistance and the mode of sexual reproduction interact to strongly influence the rate of spread of resistance alleles. These qualitative theoretical results highlight important future directions for empirical research in order to quantify the potential for coral reefs to evolve resistance to thermal stress.

## 25-43

**Estimating Potential For Adaptation Of Corals To Climate Change**

**Nikolaus CSÁSZÁR*[1,2]**, Peter RALPH[1], Richard FRANKHAM[3,4], Ray BERKELMANS[2], Madeleine VAN OPPEN[2]

[1]Department of Environmental Sciences, University of Technology, Sydney, Sydney, Australia, [2]Australian Institute of Marine Science, Townsville, Australia, [3]Macquarie University, Sydney, Sydney, Australia, [4]Australian Museum, Sydney, Sydney, Australia

Climate models predict rising global sea-surface temperatures accompanied by increasing frequencies of coral mortalities and shifts in ecosystem structure throughout the 21st century. Today, it is well known that geographically different coral populations display substantial intra-specific variation in thermal tolerance. This suggests local adaptation to different temperature regimes. The ability of the coral/algal symbiosis to adapt to further increasing sea-surface temperatures in an evolutionary sense will depend on the extent of the underlying genetic variation in thermal tolerance. We investigated the genetic- and environmental variation in two phenotypic traits that are directly linked to thermal tolerance in corals. A controlled temperature experiment was conducted on a predominantly clade D zooxanthellae harbouring population of the widely abundant scleractinian coral species *Acropora millepora* from the Great Barrier Reef, Australia.

Under sub-bleaching (31 ºC) and bleaching (32 ºC) conditions, the proportion of the observed phenotypic variation that was due to genetic factors (i.e. the heritability in the broad-sense; $h^2$) was high for both traits: the decrease in maximum capacity of photosystem II (Fv/Fm) for *in hospite* zooxanthellae, and the increase in coral growth rates. Under control conditions (27 ºC), however, the phenotypic performance of these traits was determined to a lesser extent by genetic factors. This suggests that under high temperatures, there is an underlying heritable component for both the maximum efficiency of photosystem II in the zooxanthellae, and coral growth rates. Additional thermal-stress related phenotypic traits for this particular population are currently under investigation.

This is the first study to show that thermal tolerance in corals has an underlying genetic component, and provides direct insight into the evolutionary potential of this species to adapt to climate change.

## 25-44

**Coral Mortality From Bleaching: Pre-Adaptation Of Host Corals To Increased Seawater Temperatures With Dependence Upon Rapidly Adapting Zooxanthellae**

**Kevin STRYCHAR*[1]**, Paul SAMMARCO[2]

[1]Texas A&M University - Corpus Christi, Corpus Christi, TX, [2]Louisiana Universities Marine Consortium, Chauvin, LA

Bleaching in corals is the loss of obligate symbiotic zooxanthellae (required for growth and survival) from their tissue. Increased sea-surface temperatures (SSTs) associated with climate change have caused mass coral bleaching on a global basis. This in turn has caused widespread coral mortality, increasing in frequency through time. Some studies suggest that the host 'ejects' the symbiont during these stressful periods, but the mechanism(s) by which this occurs is still unknown. Recent evidence suggests that processes of cell death, apoptosis and necrosis, associated with zooxanthellae cells increase within host tissues as temperatures increase and may be the primary causes of zooxanthellar loss. The host response to increased temperatures is not known, however, nor is the fact of "who releases whom" during the bleaching process. Here we determine whether the host coral or the zooxanthellae symbionts are more temperature-sensitive and which is being subjected to higher selection pressure due to temperature. Assessment of two types of cell death, apoptosis and necrosis, of cell and tissue states was done by flow cytometry, fluorescent microscopy, and transmission electron microscopy. We examined the temperature resistance properties of three scleractinian coral hosts - Acropora hyacinthus, Porites solida, and Favites complanata - and their zooxanthellae by exposing them to experimental temperatures of 28, 30, 32, and 34C for 48 hrs. Coral host cells did not exhibit any signs of apoptosis until exposed to temperatures of 34C. Zooxanthellae cells, however, exhibited apoptosis at temperatures as low as 30C, and this effect increased markedly in the symbionts as temperature increased. These findings suggest that the host corals are pre-adapted to temperature increases and not suffering mortality from this stress but from the loss of their zooxanthellar endosymbionts – a process driving natural selection in Symbiodinium and necessitating their rapid adaptation to a changing environment.

## 25-45

**Climate Change Can Supersensitise Corals To Natural Levels Of Ultra Violet Radiation**

**Ruth REEF*[1]**, Sophie DOVE[1], Maya CARMI[1], Ann MOONEY[1], Paulina KANIEWSKA[1], Oren LEVY[1], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, The University of Queensland, St Lucia QLD, Australia

Corals are exceptional for their ability to tolerate ultra violet radiation (UVR) intensities that can be lethal to many reef organisms. Their sessile nature combined with their obligatory symbiosis with the photosynthetic dinoflagellate Symbiodinium means exposure to solar radiation, five percent of which is harmful UVR, is high. While some of the UVR protection associated with corals comes from the previously documented UVR screening compounds in the tissue, we find that this is complemented by unique properties of the coral skeleton that reduce the intensity of UVR in the overlying tissue. This property becomes even more important during heat stress, when we demonstrate that a vast and rapid reduction in the UVR screening ability of the tissue occurs and that this leads to a significant increase in the amount of UVR induced DNA damage in the cells. However, when grown under high levels of carbon dioxide (and hence low concentrations of carbonate ions) some of the ability of the skeleton to reduce the levels of UVR in the overlying tissue is lost. Thus, the remarkable ability of corals to thrive in the UVR levels of shallow tropical waters might be greatly lessened by the predicted changes to sea surface temperature and carbon dioxide levels. This research therefore indicates yet another subtlety associated with the change in environmental conditions surrounding coral reefs associated with rapid anthropogenic climate change.

## 25-46

**Analysis of Fish Abundance in the Gulf of California, and Projection of Changes by Global Warming**

**Arturo AYALA BOCOS*[1]**, Hector REYES BONILLA[1]

[1]Biologia Marina, Universidad Autonoma de Baja California Sur, La Paz, Mexico

The Gulf of California is considered as a key area for conservation worldwide, and has high endemism and diversity of its reef fish fauna. This group might be affected by global warming, because they are ectotherms and temperature may increase several degrees by 2100. This study analyze the latitudinal patterns of abundance of the 20 most abundant reef fishes in the Gulf of California, and evaluate possible changes caused by the temperature increment. Stationary censuses of fishes (N= 147) were done in six regions, from Los Angeles Bay (28°N) to Los Cabos (22°N). For each region we obtained the following information: mean, minimum and maximum surface temperature, photosynthetic pigments, and nitrate, phosphate and silicate concentrations. These factors were included in stepwise regressions to evaluate its influence on each species, and the equations were used to project change in numbers as a result of warming, by changing the coefficients linked to mean temperature in 1°, 2° and 3° C. The results of the models indicated that as temperature increases, four species reduce their abundance, fourteen became very similar in numbers along the gulf, and two were unaffected. Ten species will extend its range to areas where they are currently absent. Finally, richness and diversity (H´) of the "future" communities will increase significantly; the highest value occurred in the 1°C increase model, but afterwards the values reduce gradually. Our conclusions are: a) the Gulf of California reef fish fauna will not react homogeneously to temperature increase; b) some species may change their distribution; c) ecological indices reflect the predicted qualitative shift in assemblage composition; and d) the differential responses of the species may cause an ecological imbalance in teleost assemblages of the gulf in following decades.

## 25-47

**Climate Change And The Future For Coral Reef Fishes**

**Philip MUNDAY*[1,2]**, Geoffrey JONES[2,3], Morgan PRATCHETT[3], Ashley WILLIAMS[4]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Towwnsville, Australia, [2]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [3]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [4]Fishing and Fisheries Research Centre, James Cook University, Townsville, Australia

We review and predict the likely impacts of climate change on coral reef fishes. Changes to ocean temperature, pH, currents, and extreme weather events will affect reef fishes through impacts on individual performance, trophic linkages, recruitment dynamics, population connectivity and other ecosystem processes. The most immediate and identifiable impacts will be changes in the composition of reef fish communities and loss of biodiversity as a result of coral bleaching. Coral-dependant fishes suffer the most rapid declines in abundance following coral bleaching. However, we predict that many other species will exhibit longer-term declines due to loss of settlement habitat and erosion of the structural complexity of reef habitats. Continued degradation of coral reefs from climate change will lead to impoverished reef fish communities. Increased ocean temperature will affect the physiological performance and behaviour of reef fishes, especially during the larval phase. Small increases in temperature might tend to favour larval survival, but this could be counteracted by negative effects on reproduction. We predict that already variable recruitment will become more unpredictable, with more good recruitment events and more recruitment failures, especially in locations where food supply is patchy or unreliable. A substantial number of species could exhibit range shifts, with potential implications for extinction risk of small-range species near reef margins. Finally, the potential for adaptation to climate change needs more consideration. Many coral-reef fishes have geographical ranges spanning a wide temperature gradient and many have short generation times. These characteristics are conducive to acclimation and local adaptation to climate change, and provide some hope that resilient species might adapt to climate change if immediate action is taken to stabilise Earth's climate.

## 25-48

**Increased Predation Rates On Coral-Dwelling Fishes Associated With Bleached Coral Hosts**

**Darren COKER*[1]**, Morgan PRATCHETT[1], Philip MUNDAY[1]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

Climate-induced coral bleaching frequently leads to declines in the abundance and diversity of coral associated fishes, though the proximate causes of these declines remain largely unknown. More specifically, it is unclear why coral-dwelling fishes rapidly disappear from bleached coral hosts, even though these corals continue to provide effective physical habitat structure. The purpose of this study was to test whether fishes that remain on bleached coral hosts are more susceptible to predation. Using controlled aquaria-based experiments, we compared predation rates on coral-dwelling fishes (*Dascyllus aruanus, Pomacentrus moluccensis*) associated with i) healthy, ii) bleached, iii) dead and iv) algal covered colonies of the coral, *Pocillopora damacornis*. Experiments were conducted by placing two prey fish of each species with one of the four different habitat types in large glass aquaria. After 1 hour, a single predator (*Pseudochromis fuscus*) was introduced and survivorship of prey was recorded over 75 hours. This study revealed a 75% survivorship of coral-dwelling damselfishes in tanks with healthy coral colonies, wheras only 67% and 63% of damselfishes survived in tanks with bleached versus dead coral hosts, respectively and 58% with algal covered corals. It is possible therefore that the loss of coral healthy coral tissue and pigmentation influenced the ability of prey to elude predation.

It is apparent therefore, that as coral habitat degrades from healthy to algal cover, survivorship of associated fish decreases by 17% due to predation. It is apparent therefore that healthy coral plays an important role in moderating predation interactions among coral reef fishes. We conclude that increasing susceptibility to predation may provide significant motivation for coral-dwelling fishes to rapidly vacate recently bleached coral hosts. Moreover, increased predation may contribute greatly to declines in abundance of coral-dwelling damselfishes following widespread coral bleaching.

## 25-49

**Effects of climate-induced coral bleaching on coral reef fishes.**

**Morgan PRATCHETT*[1]**, Philip MUNDAY[1], Shaun WILSON[1], Nicholas GRAHAM[2], Joshua CINNER[1], David BELLWOOD[1], Geoff JONES[1], Nicholas POLUNIN[2], Tim MCCLANAHAN[3]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]School of Marine Science & Technology, University of Newcastle, Newcastle-upon-Tyne, United Kingdom, [3]Wildlife Conservation Society, New York, NY

Global climate change is having devastating effects on habitat structure in coral-reef ecosystems, owing to extreme environmental sensitivities and consequent bleaching of reef-building scleractinian corals. Coral bleaching and loss of live coral may also lead to longer-term declines in topographic complexity. This review identifies coral cover and topographic complexity as critical and distinct components of coral-reef habitats that shape communities of coral-reef fishes. Coral loss has the greatest and most immediate effect on fishes that depend on live corals for food or shelter, and many such fishes may face considerable risk of extinction with increasing frequency and severity of bleaching. Coral loss may also have longer-term consequences for fishes that require live corals at settlement, which are compounded by devastating effects of declining topographic complexity. Topographic complexity moderates major biotic factors, such as predation and competition, contributing to the high diversity of fishes on coral reefs. Many coral-reef fishes that do not depend on live coral are dependent on the topographic complexity provided by healthy coral growth and will be adversely affected by long-term degradation of coral reef habitats following severe coral bleaching. Urgent action on the fundamental causes of climate change and appropriate management of critical elements of habitat structure (coral cover and topographic complexity) are key to ensuring long-term persistence of coral-reef fishes.

## 25-50

**Sublethal Response Of Reef Fishes To Low Coral Cover**

**David FEARY*[1]**, Mark MCCORMICK[2], Geoffrey JONES[2]

[1]United Nations University-INWEH, Dubai, United Arab Emirates, [2]James Cook University, Townsville, Australia

Although the global decline in coral reef health is likely to have profound effects on reef associated fishes, these effects are poorly understood. While declining coral cover can reduce the abundance of reef fishes through direct effects on recruitment and/or mortality, recent evidence suggests that individuals may survive in disturbed habitats, but may experience sublethal reductions in their condition. To test this, we examined the response of 2 coral associated damselfishes (Pomacentridae), Chrysiptera parasema and Dascyllus melanurus, to varying levels of live coral cover. Growth, persistence and the condition of individuals were quantified on replicate coral colonies in 3 coral treatments: 100 % live coral (control), 50 % live coral (partial) and 0 % live coral (dead). The growth rates of both species were directly related to the percentage live coral cover, with individuals associated with dead corals exhibiting the slowest growth, and highest growth on control corals. Differences in the growth of individuals between treatments occurred after 29 days. There was no significant difference in the numbers of fishes persisting or the condition of individuals between different treatments on this time-scale. We argue that slower growth in disturbed habitats will delay the onset of maturity, reduce lifetime fecundity and increase vulnerability to gape-limited predation. Hence, immediate effects on recruitment and survival may underestimate the longer-term impacts of declining coral on the structure and diversity of the coral-associated reef fish communities.

## 25-51

**Climate Warming And The Ocean-Scale Integrity Of Coral Reef Ecosystems**

**Nick GRAHAM*[1]**, Tim MCCLANAHAN[2], Aaron MACNEIL[3], Shaun WILSON[4], Nick POLUNIN[5], Simon JENNINGS[6], Pascale CHABANET[7], Susan CLARK[8], Mark SPALDING[9], Yves LETOURNEUR[10], Lionel BIGOT[11], Rene GALZIN[12], Marcus OHMAN[13], Kajsa GARPE[13], Alasdair EDWARDS[5], Charles SHEPPARD[14]

[1]School of Marine Science & Technology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]Wildlife Conservation Society, New York, NY, [3]Panama City Laboratory, NOAA, Panama City Beach, FL, [4]James Cook University, Townsville, Australia, [5]Newcastle University, Newcastle upon Tyne, United Kingdom, [6]Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom, [7]Institut de Recherche pour le Developpement, Noumea, New Caledonia, [8]Natural England, Newcastle upon Tyne, United Kingdom, [9]The Nature Conservancy, Newmarket, United Kingdom, [10]Universite de la Mediterranee, Marseille, France, [11]Universite de La Reunion, Saint-Denis, Reunion, [12]Universite de Perpignan, Perpignan, France, [13]Stockholm University, Stockholm, Sweden, [14]University of Warwick, Coventry, United Kingdom

Coral reefs have emerged as one of the ecosystems most vulnerable to climate variation and change. While the contribution of climate warming to the loss of live coral cover has been well documented across large spatial and temporal scales, the associated effects on fish have not. Such information is important as coral reef fish assemblages are the most species dense vertebrate communities on earth, contribute critical ecosystem functions and provide crucial ecosystem services to the burgeoning human societies in tropical countries. Here we assess the impacts of the 1998 mass bleaching event on coral cover, reef structural complexity, and the functionality and abundance of reef fishes across the Indian Ocean. Using Bayesian meta-analysis we show changes in the size structure, diversity and trophic composition of the reef fish community have followed coral declines. Furthermore, using Bayesian predictive intervals we predict how different components of the fish community will respond to any future changes to coral cover across the region. Although ocean scale integrity of these coral reef ecosystems has been lost, it is positive to see the effects are spatially variable at various scales with impacts and vulnerability affected by geography, oceanography and management regime. Existing no-take marine protected areas still support high biomass of fish, however they had no positive affect on the response of the ecosystem to large-scale disturbance. This suggests that it is imperative that future planning identifies regional refugia from climate change as priorities for protection.

## 25-52

**Relating Patterns in Coral Bleaching And The Extrinsic Environment Over Multiple Scales: Opportunities For Prioritizing Resource Management in Florida in Response To Climate Change**

**Eric MIELBRECHT*[1]**, Daniel WAGNER[2], Alex SCORE[3], Lara HANSEN[4]

[1]Emerald Coast Environmental Consulting, Washington, DC, [2]Biological Sciences, Florida Institute of Technology, Melbourne, FL, [3]World Wildlife Fund, Marathon, FL, [4]World Wildlife Fund, Washington, DC

Coral reefs were one of the first ecosystems where the effects of climate change were readily apparent. As a result of their high vulnerability to climate change, Florida's stakeholders and decision-makers urgently need targeted research, clear communications, and accessible tools to better understand the impacts of climate change and coral bleaching to the Florida Keys National Marine Sanctuary so they can develop and implement successful management efforts. The Climate Change: Linking Environmental Analysis to Decision Support (LEADS) initiative brought together scientists and stakeholders to analyze patterns in coral resilience to climate change and transform these findings into effective management strategies. Quantitative landscape ecology techniques were combined with GIS tools to perform a multi-scale meta-analysis of the relationships between extrinsic environmental factors, coral community structure and bleaching response to suggest patterns of resilience within the Florida Keys National Marine Sanctuary. Data from a wide range of coral surveys, water quality monitoring and other environmental monitoring efforts were obtained through 2007 from institutions cooperating with the Florida Reef Resilience Program and validated for use in testing relationships at both ecological and bleaching event temporal and spatial scales. Resulting patterns of potential resilience provide a new way of prioritizing management efforts in order to respond to climate change within the Florida Keys National Marine Sanctuary.

## 25-53

**Using Climate Information To Improve Coral Reef Management**

**Elizabeth MCLEOD*[1]**, Rodney SALM[1], Axel TIMMERMANN[2], Russell MOFFITT[3]

[1]The Nature Conservancy, Honolulu, HI, [2]International Pacific Research Center, School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI, [3]JIMAR/Univ. of Hawaii & NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

Climate change is challenging marine protected area (MPA) managers to build adaptability into their conservation strategies. Managers need tools to identify coral communities at low risk of succumbing to thermal stress both to protect existing MPA investments, and to guide decisions about the location and design of new MPAs. We used available data from remote sensing and other monitoring systems to generate maps of the Coral Triangle indicating reefs of higher and lower thermal stress now and projected into the future. Using 4 km Pathfinder 5.0 Sea Surface Temperature data, we analyzed intra- and inter-annual variation in sea surface temperature and identified reef areas with reliably stable conditions and others that are more likely to suffer anomalous temperature increases leading to thermal stress. Weekly Pathfinder SST composites from 1985 through the present were compared to 1° C over the expected summertime maximum, recording those that exceeded this level and tallying accumulated Degree Heating Weeks. The analysis determined which locations sustained levels of high potential thermal stress ("hot spots") or little to no thermal stress ("cool spots") and compared those to known bleaching events. We used Coupled General Circulation models (CGCM) to provide estimates of future climate change at a global scale. These models used different climate forcing scenarios from the Intergovernmental Panel on Climate Change. For regional estimates, the CGCM simulations disagree considerably, hence we used a probabilistic multi-model ensemble forecasting approach for future climate change. This approach allowed us to identify areas in the Coral Triangle which are "optimal" in a probabilistic sense which helps decision makers and planners to include uncertainty estimates in their planning efforts. Maps of reef vulnerability provide marine conservation planners with a tool to help identify coral reefs for conservation purposes that are well positioned to survive climate-related increases in temperature.

## 25-54

**Incorporating Anticipated Patterns Of Coral Bleaching Into The Design Of Marine Protected Areas**

**Will WHITE*[1]**, Louis BOTSFORD[1], Philip MUNDAY[2], Jeffrey MAYNARD[3], Geoffrey JONES[2]

[1]Dept. of Wildlife, Fisheries, and Conservation Biology, University of California - Davis, Davis, CA, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]Climate Change Response Programme, Great Barrier Reef Marine Park Authority, Townsville, Australia

Networks of marine protected areas (MPAs) can ensure the persistence of fish and invertebrate populations on coral reefs by providing spatial refuges from overexploitation and habitat destruction. However, MPAs do not afford reefs any protection against coral bleaching. Moreover, if corals inside an MPA do not recover from an intense bleaching event, the ensuing coral mortality can drastically reduce the diversity and complexity of habitats inside that MPA. Since many fished species rely on complex reef habitats for shelter, especially as juveniles, bleaching can impair the ability of MPAs to safeguard the persistence of those species. Prior theoretical work has shown that the success of MPA networks hinges on maintaining a size and spacing among protected habitat patches that is sufficient to sustain population connectivity. Several authors have noted the need to set aside larger reef areas in MPAs in order to buffer against habitat losses caused by bleaching, but none have offered quantitative guidelines for doing so. We address this need by incorporating spatially and temporally autocorrelated patterns of coral bleaching (inferred from recent satellite-derived estimates of sea surface temperate on the Great Barrier Reef) into models of fish metapopulation dynamics within marine reserve networks. By explicitly accounting for the expected spatial pattern of habitat loss, we are able to evaluate the relative performance of MPA networks with different spatial configurations. Our results suggest guidelines for incorporating the possibility of bleaching into sizing and spacing guidelines for marine reserve design in order to minimize the detrimental impact of future bleaching events.

## 25-55

**Quantifying The Synergistic Interaction Between Thermal Stress And Water Quality in Determining The Differential Bleaching Susceptibility Of Coral Communities On The Gbr**

**Scott WOOLDRIDGE*[1]**, Terry DONE[1]

[1]Australian Institute of Marine Science, Townsville, Australia

In this presentation, the potential for the ambient water quality regime at a particular reef site to act as a 'preconditioning' determinant of coral bleaching susceptibility is considered for the 1998 and 2002 mass bleaching events on the Great Barrier Reef, Australia. In the first instance, a simple empirical approach is utilised to highlight the strong spatial coherence that exists between zones of known water quality and the differential bleaching susceptibility (per unit temperature increase) of the resident coral communities. In particular, reef areas that are regularly exposed to terrestrial runoff events with high inorganic nitrogen loads are shown to display enhanced susceptibility (~ factor 2) to thermal stress. To test the robustness of this relation, a mechanistic model is developed which implicitly captures the biological attribute of bleaching 'resistance' to thermal stress. Again, poor regional water quality is shown to be a strong determinant of bleaching resistance – potentially lowering the thermal bleaching thresholds by 1 -1.5$^{o}$C compared to reefs in highly oligotrophic waters. The implications for siting of no-take areas and for water-quality protection initiatives are discussed

## 25-56

**Are Refugia Based on Triage Principles the Last Hope for Reef Systems?**

**Donald POTTS*[1]**

[1]Institute of Marine Sciences, University California, Santa Cruz, Santa Cruz, CA

Current human population growth and industrialization ensure that climatic, oceanographic and other changes affecting reef systems will continue accelerating, and probably lead to major reef degradation and species extinctions within decades. Because coral reefs exist at land-sea-air interfaces, they are exposed simultaneously to direct and indirect impacts of many atmospheric, oceanographic and terrigenous factors. While research tends to concentrate on primary impacts (e.g. coral bleaching from heating; declining calcification with ocean acidification), the same factors often have secondary effects on many other physiological and ecological processes (e.g. larval development and survival may be particularly sensitive to pH). When multiple factors with multiple effects act simultaneously but at different rates, on different scales, and with variable time-lags, they are likely to generate non-linear, synergistic interactions with cumulative impacts much greater than the sum of the individual processes, and which may reach disaster levels much earlier than the primary effect alone.

The rapidity of projected environmental changes suggests time available for averting the worst impacts is very limited. Nevertheless, impacts should vary in space and time, creating opportunities to maximize chances of persistence of some reef systems by focusing resources on the most sustainable systems. This will require three goals for research and managerial planning.

1. Identification of refugia (geographic, ecological, or genetic) where ecosystems and individual species are most resistant to environmental changes.

2. Development of science-based management for longterm maintenance of refugia as geographic, ecological and genetic reservoirs to provide eventual sources for re-establishing reef viability elsewhere.

3. Application of triage principles holistically to entire reefs and systems to determine priorities and urgency for research and management of reefs.

This paper outlines criteria for identifying sustainable refugia, proposes some management goals, and compares examples of marginal oceanic (Midway Atoll) and central continental (Great Barrier Reef) sites as potential refugia.

## 26-1

**The Marine Biodiversity of Cuba**

Rodolfo CLARO[1], Pedro ALCOLADO[1], **Kenyon LINDEMAN*[2]**

[1]Instituto de Oceanologia, CITMA, La Habana, Cuba, [2]Dept. of Marine and Environ. Systems, Florida Institute of Technology, Melbourne, FL

The marine biodiversity of Cuba is highly influenced by coral reefs; however, a comprehensive summary of the main attributes of Cuban marine biodiversity has been unavailable. The objective of this work was to produce a book-length digital compendium that summarizes and integrates primary knowledge of the biodiversity of Cuban reefs and associated ecosystems. This study is based on analyses by over 30 authors of the existing bibliographical information (published or in archives) and recent unpublished data from diverse studies. Primary focal points included the identification of main marine resources, current and potential stressors, key indicators of conservation status, and options for improved management. The results are presented in a digital book available by CD and the World Wide Web that summarizes and integrates fundamental knowledge about organismal diversity and ecological processes of coastal Cuba. The book includes: a paleogeographic analysis of the origin and evolution of primary regions, habitats and biota; ecological and biogeographic evaluations of coastal and ocean systems; and summaries of ecological and economic resource importance. The substantial Cuban marine protected area system is also described. Existing information is collated by phylum and lower systematic categories for all groups of fauna, flora, and microorganisms. All recorded marine species are listed: approximately 7300 in 23 lists from bacteria to mammals. The species total includes 5700 and 1030 species of invertebrates and fishes, respectively. Prominent goods and services of Cuban marine biological diversity are also described (fisheries, tourism, bio-products, etc). Significant threats are identified and institutional management frameworks are outlined. Major gaps in knowledge and coordinated research needs are identified. A substantial array of hierarchical actions is summarized for the conservation, rehabilitation, and sustainable use of the marine biological diversity of Cuba.

## 26-2

**Rhodolith Beds Diversity in A Gradient From 3 To 60 Meters Depth At The Brazilian Continental Shelf**

**Gilberto AMADO-FILHO*[1]**

[1]Programa Zona Costeira, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

Rhodoliths beds are one of the most extensive benthic communities of the Brazilian continental shelf, but their structure and associated communities are poorly known. In this work we described the structure of rhodoliths beds along the Espírito Santo and Bahia State coast. The study areas were 3 to 45 kilometers offshore. Samples were obtained by SCUBA diving in three depths zones: 4 to 18 m, 25 to 30 m and 50 to 55 m during the years of 2005-2007. Transect lines and video images were used to determine rhodoliths density. Diameters and sphericity were measured from at least 60 individuals from each zone. Rhodoliths size increased (5.1 ± 0.2 cm to 10.9 ± 4.1 cm), and density decreased (125 ± 86 to 32 ± 12 rhodoliths.m2) from the shallow to the deeper zone. Spheroidal was the typical shape throughout the depth zones. Ten rhodolith forming coralline species were identified belonging to the genera: Hydrolithon, Lithophyllum, Lithothamnion, Mesophyllum, Neogoniolithon, Spongites and Sporolithon. One species of kelp Laminaria abyssalis is associated to rhodolith beds at the depth of 50-55 m. A flora of 160 macroalgae species were identified in studied area. Epibenthic biomass seasonal changes over rhodoliths from summer (116 ± 68 g.m2) to winter season (62 ± 25 g.m2) were seen and can be related to the instability caused to the beds by the higher frequency of typical storm disturbance in the winter period. Although rhodoliths beds are subject to movement caused by water motion and bioturbation the obtained results indicates that the studied rhodoliths beds present a similar benthic diversity to that found in Atlantic tropical reef forming communities.

## 26-3

**Reef And Mangrove Sponge Fauna: A Systematic Comparison, And An Evolutionary Hypothesis.**

**Maria C. DIAZ*[1]**, Klaus RUETZLER[2]

[1]Department of Research, Museo Marino de Margarita, Boca del Rio, Venezuela, [2]Invertebrate Zoology, National Museum of Natural history, Smithsonian Institution, Washigton D.C., VA

Comparing sponge communities from reefs and offshore mangrove islands at various Caribbean sites we find that, despite similar geographic distribution, they are strikingly different in systematic composition and biological properties. Taxonomically we find that families that flourish in one ecosystem are absent or rare in the other. Such is the case within the species-rich order Haplosclerida where the family Petrosiidae (genera Xestospongia, Petrosia) dominates on the reef, while the family Chalinidae (Haliclona , Chalinula) prevails in the mangroves. At least eight other Demospongiae families and two orders reflect this disjunct pattern of occurrence; these taxa represent approximately 50 % of the sponge diversity known from the two systems. Morphologically, we find a separation in terms of shape and size among the major representatives of the group, with much larger sizes on the reef, dominated by tube-, vase-, rod-shaped, or massive amorphous sponges. On Mangroves, thin or thick crusts and some massive-amorphous shapes predominate, although any shape can be found, except it is restricted to small size categories. Regarding sexual reproduction, a prevalence of oviparous broadcasters is found on the reef, viviparous brooders are common in the mangrove. Ecologically, we find certain symbiotic consortia common on reefs but practically absent in mangroves. We correlate the distribution of these important biological traits with the physical properties of the reef and mangrove environments. A hypothesis is presented of how these two sponge faunas are historically related and how they interact at the present time. We discuss how taxonomy enlightens the ecological and evolutionary connectivity of these faunas and make recommendations for future study and environmental evaluation.

## 26-4

**Diversity Of Soft Corals (Octocorallia) in Kenya And The Adjacent Pemba Island (Tanzania) With Reference To Other South Equatorial East African Reefs**

**Yehuda BENAYAHU*[1]**, Michael H. SCHLEYER[2], Shimrit PERKOL-FINKEL[1], Alex SHLAGMAN[1]

[1]Zoology, Tel Aviv University, Tel Aviv, Israel, [2]Oceanographic Research Institute, Durban, South Africa

The coral reefs of East Africa are of particular biogeographical interest and some of them are known for their flourishing soft coral communities. Intrigued by the lack of taxonomic and ecological reports on the soft corals from Kenya and Pemba Island (4-50S), we conducted comprehensive soft coral surveys at various sites there. We investigated their species diversity, also in comparison to previously studied south equatorial East African reefs. Collecting trips were conducted during 2000-2005 and approximately 900 samples were obtained. The distributional patterns of the different taxa on the reefs were determined and in some areas their live coverage was measured. Overall, the collections yielded 85 species belonging to 28 genera. Some of the Nephtheidae are still being examined, as are several new species that have yet to be described. The most specious genera on the surveyed reefs were *Sinularia* (26 species), *Sarcophyton* (10) *Cladiella, Lemnalia* and *Lobophytum* (5 each). Interestingly, some genera of the family Xeniidae that were represented by only one or two species (i.e., *Cespitularia, Efflatounaria* and *Sympodiu*m) monopolized large reef areas locally. The reef habitats richest in soft corals were found below 7-8 m depth, including steep walls (25-35 m). The soft coral assemblages growing on sea-grass beds in shallow lagoons and aggregations of *Studeriotes* on silt bottoms are of special interest. The studied reefs display a higher soft coral diversity compared to Mafia Is. (Tanzania, $7^0$S), the northern coast of Mozambique (12-$16^0$S), Bazaruto Is. (Mozambique, $21^0$S) and KwaZulu-Natal (South Africa, $28^0$S). The current findings further demonstrate the distinct latitudinal diversity pattern on south equatorial African reefs, with the highest diversity found on the near-equator reefs. The findings also reinforce the need to implement effective conservation policies and management programs in order to promote preservation of these diverse soft coral communities.

## 26-5

**Soft Coral Biodiversity And Distribution In The Western Indian Ocean: Gradients, Function And Significance**

**Michael SCHLEYER*[1]**, Yehuda BENAYAHU[2]

[1]Oceanographic Research Institute, Durban, South Africa, [2]Department of Zoology and The Porter School of Environmental Studies, Tel Aviv, Israel

Soft corals (Octocorallia: Alcyonacea) constitute important reef benthos in the WIO, yet relatively little is known of their distributional gradients, function or significance. Integrated results of published surveys and of material recently collected as far afield as the Chagos Archipelago manifest interesting gradients in their diversity, abundance and apparent function. Reef disturbance may result in them becoming dominant, eliciting an alternative stable state in some coral communities. While certain tropical taxa attenuate from north to south, others attain their highest abundance at high latitude; the latter appears to be related to their ability to tolerate more swell-driven turbulence. Once established, soft corals appear to be persistent and long-lived, a characteristic also reported in the literature. A long-term monitoring study has nevertheless revealed that they appear to be vulnerable to climate change.

## 26-6

**Vagile Coelobites Of Eastern Pacific Coral Reefs: Structurally Homogenous Reef Environments And The Importance Of Substrate in Shaping Community Composition**

**Ian ENOCHS*[1]**, Gena HOCKENSMITH[1]

[1]Marine Biology and Fisheries, University of Miami, Miami, FL

Coral reef framework structures are complex three-dimensional habitats occupied by diverse taxa. The term cryptofauna (coelobites) specifically applies to those organisms that live within the interstices of coral reef framework. The remarkably diverse assemblage of cryptic biota is poorly understood relative to that of the epibenthic and nektonic reef species. It has been postulated that the biomass of this cryptic component of the reef ecosystem is extremely high, possibly exceeding that of the surface biota, and it is likely that coelobites are integral to reef nutrient dynamics. Furthermore, cryptic animals that inhabit reef pore spaces may degrade coral skeletons, playing an important role in bioerosion; the biogenic loss of reef framework. Thus, evaluating the interaction of nutrient dynamics, bioerosion, habitat structure, cryptic biomass and biodiversity is essential to understanding coral reef community responses to a changing climate. Previously, the strong dependence of cryptic community composition on the size and shape of the void-space habitat has limited extrapolation of studies to the "whole reef" level. *Pocillopora* reefs of the eastern Pacific are structurally complex yet relatively homogenous across a horizontal plane. This unique physical composition allows for the possibility of replicate sampling of the coelobite community and a subsequently broader scale analysis. In order to evaluate the dependency of cryptic community structure on the nature of the substrate it occupies, both living and dead *Pocillopora* colonies were defaunated and returned to the reef. After one year *in situ*, associated coelobites were identified, weighed, and counted. Substrate preference (live vs. dead coral) was found to be species specific. Biomass and abundance of vagile coelobites was significantly higher in living coral colonies when compared to dead coral framework. These findings have important implications for how reef communities may respond to coral mortality.

## 26-7

**Coastal Fish Communities of the Socotra Archipelago: "Pseudo-Reefal" Diversity and Ecology Without Coral Reefs.**

**Uwe ZAJONZ*[1]**, Dr. Friedhelm KRUPP[1]

[1]Ichthyology, Senckenberg Research Institute and Natural History Museum, Frankfurt a.M, Germany

Between 1999 and 2007 shallow water fish communities of the Socotra Archipelago (Gulf of Aden, NW Indian Ocean) were studied with the objective of assessing patterns of diversity and abundance, community composition, trophic structure and biogeographic affinities. The Archipelago hosts very diverse, varied and biogeographically unique coral and fish communities. About 730 fish species in 110 families have been recorded from the Archipelago as yet. The structure of the dominant shallow water fish community types, as inferred from species composition, trophic analysis and correlation analysis of fish and benthic communities, is comparable with typical "reef fish" assemblages of the Western Indian Ocean. Despite the fact that the Archipelago has only few biogenic reefs, the species numbers within certain reef fish taxa exceed those known from the entire neighbouring Red Sea. Research on tropical marine communities typically focus on reef habitats with high cover of scleractinian corals and the presence of so-called "reef-associated" fish species, based on the postulate that these are dominating factors in determining coastal diversity in the tropics. Results of the present study suggest that, besides classical coral reef assemblages, equally diverse benthic and associated fish communities can evolve, if the local "mix" of abiotic and biotic variables is suitable. These include mesoscale habitat heterogeneity and complexity, i.e. availability, connectivity among these habitats and among wider biogeographic units, and probably productivity. Being exposed to a harsh monsoon regime, Socotra's coastal ecosystems are heterogeneous and dynamic in space and time, giving rise to a great variety of ecological niches and thus supporting corals and fishes from many different 'walks of life'. Consequently, more consideration needs to be given to studying population dynamics, connectivity and biogeography of such marginal "pseudo-reefal" communities.

## 26-8

**Molecular Data Suggest An Indo-Pacific Origin Of The Invasive Snowflake Coral (Carijoa Riisei) in The Hawaiian Archipelago And Refute A Caribbean Introduction**

**Gregory CONCEPCION*[1]**, Samuel KAHNG[2], Marc CREPEAU[1], Erik FRANKLIN[1], Steve COLES[3], Robert TOONEN[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, [2]Oceanography, University of Hawaii at Manoa, Honolulu, HI, [3]Natural Sciences, Bishop Museum, Honolulu, HI

The first published report of the invasive snowflake coral in Hawaii comes from Pearl Harbor in 1972. Subsequent identification of this species as the Caribbean octocoral *Carijoa riisei* led to the general conclusion that it was introduced via contemporary maritime vectors. In an attempt to confirm the source of the Hawaiian population, we used mitochondrial ($h$ = 0.8379; $\pi$ = 0.0022) and nuclear (H = 0.8904; $\pi$ = 0.0299) data to compare Hawaiian specimens with *Carijoa* samples collected worldwide (n=248). In addition, vessel traffic patterns for the Pacific Ocean were examined for 1940-1979 to determine maritime connectivity to and from Hawaii during the assumed time of introduction. Combined mitochondrial and nuclear data show both higher and considerable unique genetic diversity within the Indo-Pacific compared to samples from throughout the Caribbean-Atlantic, suggesting that the species is native to the Indo-Pacific. Further, isolation-by-distance (IBD) analysis indicates a significant correlation between genetic and geographic distance in both the Indo-Pacific and Hawaii, but not for the Atlantic, and coalescent estimates for the Atlantic are the lowest of the three populations. Finally, *C. riisei* sampled from throughout Hawaii (n=96) share none of the Caribbean mtDNA haplotypes (29 unique haplotypes) and only a single nDNA allele (of 29 unique alleles), indicating that the Hawaiian populations derive from Indo-Pacific rather than Caribbean-Atlantic origins. Despite an active commercial vessel route between Hawaii and the Panama Canal, we find no evidence to support a maritime introduction of *Carijoa riisei* from the Caribbean-Atlantic.

## 26-9

**Biodiversity Of Reefs: Inferring From Sparse Data**

**Daphne FAUTIN*[1]**

[1]University of Kansas, Lawrence, KS

Data on occurrences of a particular organism from publications and museum specimens can be used to infer occurrence of members of that species in places where sampling has not been done and at times in the past and future. Programs to make such inferences are based on knowledge of the habitat correlates of the species and determining where else in the world those habitat parameters occur. Precision of such an inference depends on 1) accurate and precise knowledge of the species' habitat requirements, 2) detailed spatially-explicit environmental data, and 3) comprehensive taxonomic and nomenclatural information. Such inferential tools can be important in understanding biogeographic consequences of climate change, in predicting where invasive species might persist, and in recognizing invasive species.

## 26-10

**Standardized Sampling And Molecular Approaches For Assessing Marine Biodiversity Of Coral Reefs**

**Laetitia PLAISANCE*[1]**, Christopher MEYER[2], Gustav PAULAY[3], Russell BRAINARD[4], Amy HALL[4], Julian CALEY[5], Nancy KNOWLTON[1]

[1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, [2]University of Berkeley, Berkeley, CA, [3]Florida Museum of Natural History, University of Florida, Gainesville, FL, [4]Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, HI, [5]Australian Institute of Marine Science, Townsville, Australia

Coral reefs are the most diverse and among the most threatened of all marine ecosystems. Unfortunately, we lack the taxonomic expertise and the time needed to characterize this diversity, as well as the extent of biodiversity loss related to human impacts, using traditional methods. However, the revolution in molecular genetics dramatically changes the potential for reef scientists to make progress in this area, particularly in poorly characterized groups for which taxonomic expertise is limited (e.g. very small cryptic organisms). As exhaustive inventories of reef-associated fauna are impractical, standardized sampling methods are the best option for estimating and comparing patterns of diversity for these communities. In this study, we employed a DNA barcode approach (cytochrome oxidase subunit I) to characterize the biodiversity of marine crustaceans associated with coral reefs in Moorea (French Polynesia), the northern Line Islands, French Frigate Shoals (Hawaii) and Lizard Island (Australia). We sampled the small cryptic fauna in two different habitats: in dead Pocillopora heads (most sites) and Autonomous Reef Monitoring Structures (ARMS) deployed for one year at four sites around French Frigate Shoals. Results to date suggest that current estimates greatly underestimate reef biodiversity as rarefaction curves reveal that they will increase significantly with additional sampling. Moreover, comparison of crustacean diversity between Moorea and the Line Islands showed little overlap, as only 11 OTUs (Operational Taxonomic Unit) out of 135, were found in both localities, 44% of the total diversity being singletons and 33% being found only in one locality. Moreover, none of the Moorea taxa matched at the species level with any record in GenBank. Nevertheless, these methods have great potential when they are globally deployed with adequate replication, something that is now possible given the ease of obtaining sequence data.

## 26-11

**Autonomous Reef Monitoring Structures (Arms): A Tool For Monitoring Indices Of Biodiversity**

**Amy HALL*[1]**, Russell BRAINARD[2], Julian CALEY[3], Scott GODWIN[4], Leslie HARRIS[5], Nancy KNOWLTON[6], Tito LOTUFO[7], Joel MARTIN[5], Kaylyn MCCOY[8], Megan MOEWS[1], Russell MOFFITT[1], Gustav PAULAY[9], Laetitia PLAISANCE[10]

[1]JIMAR Univeristy of Hawaii, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [2]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [3]Australian Institute of Marine Science, Queensland, Australia, [4]Hawaii Institute of Marine Biology, Kaneohe, HI, [5]Natural History Museum of Los Angeles County, Los Angeles, CA, [6]Smithsonian Institution, National Museum of Natural History, Washington, DC, [7]Instituto de Ciencias do Mar, Laboratorio de Ecologia Animal, Fortaleza, Brazil, [8]State of Hawaii, Division of Aquatic Resources, Honolulu, HI, [9]Florida Museum of Natural History, Gainesville, FL, [10]Scripps Institution of Oceanography, La Jolla, CA

Coral reefs are high diversity ecosystems, but methods to assess this diversity can be problematic, particularly for small and cryptic organisms. Autonomous Reef Monitoring Structures (ARMS) have been developed and are being tested as a standard method to mimic the structural complexity of coral reef habitats and attract colonizing non-coral invertebrates. It is currently difficult to find non-subjective methods of assessing invertebrate biodiversity on coral reefs. With an increasing scarcity of trained invertebrate taxonomists globally, ARMS will enable researchers to obtain indices of invertebrate biodiversity utilizing molecular techniques that would otherwise be challenging and time consuming using traditional morphological analyses alone. In October 2006, ARMS were deployed in a preliminary study at French Frigate Shoals in the Papahanaumokuakea Marine National Monument, Northwestern Hawaiian Islands, and subsequently recovered and analyzed in October 2007. ARMS were deployed at sites selected on the basis of habitat characterization: a backreef site, a lagoon patch reef site, and two forereef sites, from 1 to 14 m. Analyses were designed to look at the effectiveness of the instruments across the range of habitats and taxa collected. ARMS were most productive in sampling molluscs (28%), ascidians (24%), crustaceans (19%), and bryozoans (11%) in forereef and lagoon patch reef habitats. In addition, DNA barcode analyses were conducted to characterize crustacean biodiversity associated with ARMS in comparison to dead *Pocillopora* heads from other sites in the Pacific. These results suggest that coupling ARMS with taxonomic and molecular analyses can be an effective method to assess and monitor understudied coral reef invertebrate biodiversity. Additional ARMS deployments occurring around the Hawaiian Islands, Pacific remote island areas, American Samoa, Australia, Brazil, and Panama will enhance our ability to monitor coral reef ecosystem change globally and build capacity for ecosystem-based management.

## 26-12

**Biodiversity Census at French Frigate Shoals, A Baseline Diversity Study**

**Russell MOFFITT*[1]**, Russell BRAINARD[2], Julian CALEY[3], Scott GODWIN[4], Amy HALL[1], Leslie HARRIS[5], Elizabeth KEENAN[6], Nancy KNOWLTON[7], Tito LOTUFO[8], Jim MARAGOS[9], Joel MARTIN[5], Sea MCKEON[10], Megan MOEWS[1], Gustav PAULAY[10], Cory PITTMAN[11], Alison SHERWOOD[12], John STARMER[13], Brian ZGLICZYNSKI[1]

[1]Coral Reef Ecosystem Division, JIMAR/Univ. of Hawaii & NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [3]Australian Institute of Marine Science, Townsville, Australia, [4]Hawaii Institute of Marine Biology, Kaneohe, HI, [5]Natural History Museum of Los Angeles County, Los Angeles, CA, [6]NOAA/NOS/PMNM, Honolulu, HI, [7]Dept. of Invertebrate Zoology, Smithsonian Institution, National Museum of Natural History, Washington, DC, [8]Laboratorio de Ecologia Animal, Instituto de Ciencias do Mar, Fortaleza, Brazil, [9]USFWS, Honolulu, HI, [10]Florida Museum of Natural History, University of Florida, Gainesville, FL, [11]Camp Olowalu, Lahaina, HI, [12]Botany Department, University of Hawaii at Manoa, Honolulu, HI, [13]CNMI Coastal Resources Management Office, Saipan, Northern Mariana Islands

With increasing concerns about climate change, there is clear danger that much coral reef diversity could be lost before it is documented and managers will be left with a limited understanding of undisturbed reef communities on which to base future decisions. To effectively manage and conserve these ecosystems, it is first necessary to obtain baseline data of existing biodiversity and enhance understanding of changes over time. As part of the Census of Coral Reef Ecosystems (CReefs) of the Census of Marine Life, a multi-institutional team of taxonomists surveyed cryptic, poorly known, and understudied organisms, particularly invertebrate, algal and microbial species at French Frigate Shoals in the relatively pristine Papahanaumokuakea Marine National Monument in the Northwestern Hawaiian Islands. This open atoll has the highest reported shallow coral reef biodiversity in the Hawaiian Archipelago and has been hypothesized to be a diversity pathway for the spread of species from three directions, most notably Johnston Atoll. During a 16-day field survey, 15 diverse habitat types were sampled utilizing an array of methods designed to target key ecological niches and minimize ecological impacts, including hand collecting, rubble extraction, rubble brushing, sand sampling, Yabbie pump, microbial collections, algal collections, suction/vacuum, baited traps, Ekman grabs, sand dredges, plankton tows, and Autonomous Reef Monitoring Structures. At least 1600 morphospecies were documented and photographed, including >100 new species and/or regional records. New records include 7 species of algae, 33 decapod crustaceans, 48 opistobranch molluscs, and 1 family of ascidians. Greater than 20% of the known Hawaiian marine invertebrate diversity was encountered, reflecting on the effectiveness of methods and the poorly known nature of tropical reef biodiversity. In addition 1,279 DNA subsamples, representing 40% of the overall specimens, were collected to sequence for inclusion in the Barcode of Life.

## 26-13

**Age And Origin Of Hawaiian Endemic Fishes in The Papahânaumokuâkea Marine National Monument**

Zoltan SZABO[1], John RANDALL[1], Randall KOSAKI[2], **Brian BOWEN*[3]**

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]Papahânaumokuâkea Marine National Monument, Honolulu, HI, [3]University of Hawaii, Hawaii Institute of Marine Biology, Kaneohe, HI

The Hawaiian Archipelago has one of the highest levels of marine endemism (25% for fishes) and is among the most isolated reef habitats in the world. In this research program, we are examining the age and source of colonization events that enhance Hawaiian biodiversity, especially in the new Papahânaumokuâkea Marine National Monument. Three of these Hawaiian endemics (HE) are blennies with an unambiguous sister species in the Indo-West Pacific (IWP) which allowed us to resolve the age of colonization events. Based on a 659 bp fragment of mitochondrial cytochrome b, we observed approximately d = 7% sequence divergence between Cirripectes vanderbilti (HE) and C. variolosus (IWP) and about the same level of divergence between Plagiotremus ewaensis (HE) and P. rhinorhynchos (IWP). Between Plagiotremus goslinei (HE) and P. tapeinosoma (IWP) we observed d = 0.3% (2 bp differences) indicating a very recent arrival. A conventional molecular clock for fishes places the first two colonization events at approximately 3.5 million years ago, and the third event at approximately 150,000 years ago. Ongoing research will indicate whether Johnston Atoll, 800 km south of Hawaii, is the essential gateway into the archipelago, and whether a pulse of colonization occurred at 3.5 million years before present. Our finding for P. goslinei may prompt a re-examination of taxonomic status.

## 26-14

**How Useful Is Panbiogeography in Deconstructing Philippine Coral Reef Biogeography?**

**Benjamin VALLEJO JR*[1]**

[1]Institute of Environmental Science and Meteorology, University of the Philippines, Quezon City, Philippines

The Philippines is considered at the center of global coral reef biodiversity. Recent studies indicate that the Verde Island Passage in Southwestern Luzon has extremely high taxonmic diversity per unit area. More recent research indicate that several areas in the central Philippines have similar levels of taxonomic richness most notably in molluscs. The existence of several diversity massings within archipelagic seas or basins in the Philippines is a major biogeographic pattern that strenthens the theory that these seas are important biogeographic regions. These patterns are coincident with major tectonic features. As island integration seems to be the most parsimonious theory to explain Philippine biogeography, this necessitates a more integrative theory to explain these spatial patterns of marine biodiversity. A panbiogeographic hypothesis is thus presented.

## 26-15

**Atlantic Reef Fish Biogeography And Evolution**

**Sergio FLOETER*[1]**, Luiz ROCHA[2], Ross ROBERTSON[3]

[1]Ecologia e Zoologia, UFSC, Florianopolis, Brazil, [2]HIMB, University of Hawaii, Kaneohe, HI, [3]Smithsonian Tropical Research Institute, Panama, Panama

How and when areas of endemism of the tropical Atlantic Ocean were formed? How do they relate to each other? What are the spatio-temporal components of diversification? We tried to shed light into these questions by analyzing the distributions of 2605 reef fishes in 25 areas of the Atlantic and southern Africa and a collection of 27 recently published phylogenies of various Atlantic reef fish taxa. Phylogenetic (proportion of sister species) and distributional patterns (number of shared species) are generally concordant with recognized biogeographic provinces. The highly uneven distribution of species in certain genera appears to be related to their origin, with highest species richness in areas with the greatest phylogenetic depth. Diversity buildup in the Atlantic involved (1) diversification within each province, (2) isolation as a result of biogeographic barriers, and (3) stochastic accretion via dispersal between provinces. The timing of cladogenesis is not concordant among taxonomic groups, indicating that no single vicariant event explains the observed divergences. The three soft (non-terrestrial) inter-regional barriers (mid-Atlantic, Amazon, and Benguela) clearly act as "filters" by restricting dispersal but at the same time allowing occasional crossings that eventually become new species. Fluctuations in the effectiveness of these filters, combined with ecological differences among provinces, apparently provide a mechanism for much of the recent diversification of reef fishes in the Atlantic. Fish life history attributes like spawning mode, body size and depth range are differentially affected by the soft barriers as revealed by the analyses of trans-barrier species. Our dataset indicates that both historical events (e.g. Tethys closure) as well as relatively recent dispersal (with or without further speciation) have had a strong influence on Atlantic tropical marine biodiversity and have contributed to the biogeographic patterns we observe today, however, examples of the latter process outnumber the former.

## 26-16

**A Regional Scale Diversity-Environment Relationship For Pacific Coral Reef Fish Communities**

**Laurent VIGLIOLA*[1,2]**, Serge ANDREFOUET[3,4], Michel KULBICKI[5], Christine KRANENBOURG[6], Pierre LEGENDRE[7], Pierre LABROSSE[2,8], Samasoni SAUNI[2,9], Pierre BOBLIN[2]

[1]Institut de Recherche pour le Développement (IRD), Plouzane, France, [2]Secretariat of the Pacific Community (SPC), Noumea, New Caledonia, [3]Institut de Recherche pour le Développement (IRD), Noumea, New Caledonia, [4]Institute for Marine Remote Sensing (IMaRS), St. Petersburg, [5]Institut de Recherche pour le Développement (IRD), Perpignan, France, [6]Institute for Marine Remote Sensing (IMaRS), St. Petersburg, FL, [7]Université de Montréal, Montreal, QC, Canada, [8]Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Nouadhibou, Mauritania, [9]Pacific Islands Forum Fisheries Agency (FFA), Honiara, Solomon Islands

Predicting the response of biodiversity to ongoing global and local changes in the environment is a challenging, yet necessary step to identify the most effective schemes for conservation and sustainable use. The present study combines *in situ* and remotely sensed data across 10 Pacific Island Countries and estimates a diversity-environment relationship for coral reef fish communities across this 5500 km longitude by 2500 km latitude region. Reef fish diversity and 32 associated environmental variables were recorded by underwater visual censuses following a stratified sampling design. The environmental matrix was augmented with an additional 40 variables derived from remotely sensed geomorphologic maps. Measurements were made within a moving window, effectively collecting information at multiple spatial scales. A general linear model revealed that the combination of nine environmental variables accounted for 69% of species richness variability. Fish diversity increased with depth, habitat complexity, reef diversity at 200-m scale, and variation in reef composition at 20-km scale. Diversity was greater on reef slopes than on flats and decreased with the amount of land within a 2 $km^2$ area, reef connectivity at 2-km scale, variation in reef composition within a 200 $km^2$ area, and the distance to the Indo-Australian centre of biodiversity. Contemporary distribution patterns of biodiversity are a function of species origin, dispersal, and survival. By combining proxies of these factors at multiple spatial scales, this study indicates that good predictions of biodiversity can be made for coral reef fishes of the Pacific region.

## 26-17

**Commonness, Rarity, And Biodiversity On Indo-Pacific Coral Reefs**

**Sean CONNOLLY*[1,2]**, Maria DORNELAS[2,3], Terry HUGHES[2], David BELLWOOD[1,2]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, QLD, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD, Australia, [3]Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife, United Kingdom

Patterns in the commonness and rarity of species are a fundamental characteristic of ecological assemblages, and are frequently used to test alternative models of biodiversity. However, attempts to test between alternative models for such patterns often lead to inconclusive results, leading to calls for a greater diversity of approaches to testing species-abundance models. Here, we examine patterns of commonness and rarity in tropical reef fishes and corals from a 10,000-km transect across the Pacific Ocean, and we assess their concordance with species-abundance models based on lognormal, gamma, and neutral model distributions. To overcome problems with previous analyses, we develop a new goodness-of-fit test that explicitly treats individuals, rather than species, as the units that are sampled. We find that the lognormal provides substantially better fit to patterns of commonness and rarity than the alternatives, deviates from the data by less than 1%, on average, and produces far better estimates of metacommunity diversity than the alternatives. Neutral and gamma-based alternatives perform poorly because our data exhibit a combination of many very rare species and a few highly abundant species, which these models cannot simultaneously capture. It is likely that interspecific differences, such as those implicit in models generating lognormal distributions, will be required to explain this kind of heterogeneity in species abundances.

## 26-18

**Coral Species Abundance Distribution: Patterns Of Commonness And Rarity**

**Maria DORNELAS*[1]**, Sean CONNOLLY[1]

[1]ARC Centre of Excellence for Coral Reef Studies, Townsville, Australia

Species abundance distributions portray the patterns of species rarity and commonness in ecological communities, and therefore are important measures of biodiversity. However, the abundances of rare species, which are often particularly important for conservation, require large samples to be confidently estimated. Here, we present the species abundance distribution for a sample of >40,000 coral colonies from a single bay in Lizard Island. This exceeds existing samples of coral assemblages by over an order of magnitude. Although species abundance distributions are widely accepted to follow a lognormal distribution, our data have a multimodal distribution. Three different model selection procedures all indicate that the underlying community abundance distribution has at least three modes. Thus, the multiple modes in our data are a real feature of community abundance distributions, rather than stochastic sampling effects. We hypothesize that this pattern may be caused by variability in species spatial distributions.

## 26-19

**The Stability Of Clonal Lineages Over Space And Time**

**Daniel PETTAY*[1]**, Todd LAJEUNESSE[1], Dustin KEMP[2]

[1]Pennsylvania State University, University Park, PA, [2]University of Georgia, Athens, GA

Recent use of molecular techniques has revealed that the dinoflagellate genus *Symbiodinium*, once believed to be one pandemic species, includes many highly divergent clades, each containing numerous species or "types" (based on rDNA ITS1 & 2 fingerpinting). While much research has been conducted to determine the specificity between host and symbiont, little is known about the clonality of a particular symbiont "type" over a single colony and within a colony over time. To examine the clonal diversity of clade B types over space and time, nine polymorphic microsatellite loci were amplified and sequenced to yield a multilocus genotype. While certain host and symbiont taxa appear to be more flexible in their ability to associate with numerous partners, a majority of the data indicate strong specificity between host and symbiont. Even the Caribbean coral *Montastrea faveolata*, which can associate with symbionts belonging to clades A through D, shows specificity for only a small subset of subcladal types that correlate with both bathymetry and geography. Hosts like the coral *Meadrina meandrites* epitomize this specificity by associating with only one ITS2 type throughout the Caribbean. Analyzing samples collected from hosts like the two described above enable comparisons to be made between both symbioses which appear to be more flexible and symbioses which are quite specific. Host species known to display a range of specificity (i.e. low specificity = *M. faveolata*, high specificity = *M. meandrites*) were sampled repeatedly to determine clonal diversity spatially. To examine the longevity of clonal lineages, a subset of colonies were also sampled seasonally. To date, the data indicate that a majority of the colonies host a single symbiont lineage over the entire colony. Continued research in this area will also allow species boundaries to be determined and provide insight into the evolutionary processes of *Symbiodinium*.

## 26-20

**Diversity Dynamics Of Reefs And Level-Bottom Communities Compared: Paleontological Evidence For Reefs As Sources Of Biodiversity Over The Last 240 Myr**

**Wolfgang KIESSLING*[1]**

[1]Museum of Natural History, Humboldt University, Berlin, Germany

The fossil record of Mesozoic-Cenozoic reefs is used to evaluate the role of evolutionary origin versus ecological maintenance in the biodiversity of living and ancient reefs. Data from the Paleobiology Database (http://paleodb.org) were analyzed to compare the diversity dynamics of taxa with a statistically significant preference for reefs with those having a preference for non-reef marine habitats.

After standardizing for different sample sizes (reef data are more limited than other data) the results suggest that reefs have significantly greater rates of speciation than level-bottom communities. Except for mass extinction episodes, in which reef taxa are more substantially affected than level-bottom taxa, there is no evidence for generally greater or smaller extinction rates of reef taxa. Therefore reefs can be viewed as cradles of evolution over long stretches of time, whereas there is no evidence for reefs preserving diversity better than other ecosystems.

Although these results strictly apply to only those taxa that are readily fossilized (corals, hypercalcified sponges, bivalves, gastropods, echinoderms and brachiopods), there is no reason to assume that other taxa should not follow the same basic trends.

## 26-21

**Diversity And Diversification in The Southwest Indian Ocean (Program Anr Biotas)**

**J. Henrich BRUGGEMANN*[1]**, Gustav PAULAY[2], François MICHONNEAU[2], Nicolas HUBERT[1], Mireille M.M. GUILLAUME[1,3]

[1]ECOMAR, Université de la Réunion, Saint-Denis, Reunion, [2]Florida Museum of Natural History, University of Florida, Gainesville, FL, [3]Milieux et Peuplements Aquatiques, UMR 5178 CNRS UPMC MNHN, Muséum National d'Histoire Naturelle, Paris, France

Biological diversity is unevenly distributed across the world. Both species richness and endemism vary greatly across land and sea and often show localized peaks in geographically restricted "hotspots". Eight of 10 marine hotspots lie adjacent to terrestrial hotspots, suggesting that similar processes may be responsible for their origin and/or maintenance. The Southwest Indian Ocean (SWIO) region is both a marine and terrestrial biodiversity hotspot. It represents a varied terrain for evolutionary processes, encompassing old as well as young island groups (e.g. Madagascar, the Mascarenes, Seychelles and Comoros). We are examining patterns of diversity, differentiation, and diversification in this region using integrative taxonomy and phylogenetic analysis of rapidly evolving DNA markers in marine (invertebrates and fish) as well as terrestrial organisms. Field work begun on Reunion Island, where new collections include ~400 species of molluscs, ~250 crustaceans, ~100 echinoderms, ~250 reef fishes, and ~100 species in other phyla. Approximately 30% of species collected are new records for Reunion. An estimate based on echinoderms suggests that >5% represent new species. About 60% of the species collected at Reunion are also represented by the same form or sister species in recent collections from Pacific Oceania, allowing fauna-level comparisons of differentiation on the scale of ocean basins. Species that show differentiation on this scale will be subjected to detailed phylogeographic analysis within the SWIO. Such a taxonomically-wide approach allows us to test what factors are associated with different types and levels of differentiation.

## 26-22

**Patterns Of Diversity, Endemism, Origination And Extinction On Coral Reefs: Stomatopod Crustaceans**

**Marjorie REAKA*[1]**

[1]Biology, University of Maryland, College Park, MD

Reef-dwelling stomatopods show roughly similar contours of Indo-Pacific diversity as corals, reef fishes and cowries, having a very strongly accentuated peak in the Indonesian area of the Indo-Australian Archipelago but also high diversity along the western Indian Ocean shelf and especially Madagascar. The degree to which endemism corresponds to this pattern depends upon the scale examined, with local endemics occurring everywhere but regional endemics occurring disproportionately in the Indo-Australian Archipelago and on the periphery of the wider Indian and Pacific Ocean realms. Like the greatest proportion of coral reef organisms, the size frequency distribution of reef-dwelling stomatopods is skewed toward small body sizes with restricted reproductive output, dispersal and geographic range sizes. Small species, speciation and extinction are concentrated in the central "hotspot" but also at the periphery of the regions, supporting a "Merry Go Round" rather than a "Cradle" or a "Museum" hypothesis for the generation and maintenance of Indo-Australian Archipelago diversity. However, the areas of high diversity in the Indo-Australian Archipelago and in the western Indian Ocean also contain species of large body size with greatly enhanced reproductive output, dispersal potential and sizes of geographic ranges. The West to Central Pacific region appears to operate as a "Sink", where extinction likely outpaces origination, leading to declining diversity but considerable endemism.

## 26-23

**Are Echinoderms From Mars? Insights Into Diversification And Biogeography From The "most Bizarre" Animal Phylum.**

**Gustav PAULAY*[1]**

[1]Florida Museum of Natural History, University of Florida, Gainesville, FL

While all animal phyla are defined and distinguished by the distinctiveness of their bioplans, echinoderms are more distinct than most. Arguably echinoderms are the most apomorphic, "bizarre" group of free-living animals. Their unusual morphological and physiological features include major reorientations of body symmetry, loss of cephalisation, development of multiple, complex, coelomic "plumbing" systems, mutable connective tissue, and a unique calcareous endoskeleton. These apomorphies coexist with plesiomorphic metazoan features such as a reliance on external fertilization and a diffuse, intra-epidermal nervous system. The resulting, unusual bioplan has made echinoderms highly successful: they are among the largest, most conspicuous, and ecologically important mobile invertebrates in a wide variety of marine habitats, ranging from the abyss to coral reefs. Our knowledge as well as lack thereof of echinoderms is striking, and has influenced thinking in other fields. For example echinoids have served as model systems in molecular biology and marine speciation, yet like many echinoderms, they have unusual diversification dynamics that do not generalize well to other phyla. Most reef surveys focus in large part on echinoderms when attempting to document "invertebrate diversity", yet many if not most of the taxa enumerated in these represent cryptic species complexes, making survey data not meaningful at the species level. Here I will explore faunistic, taxonomic, and phylogenetic studies of echinoderms to ask whether and how these animals differ in their evolutionary and distributional dynamics from other taxa on reefs. Lessons learned from these bizarre animals improve our understanding of the biodiversity and diversification of reef biota.

## 26-24

**New Insights Into The Biodiversity And Evolution Of Aspidochirotid Holothurians**

**François MICHONNEAU*[1,2]**, Kris NETCHY[3], John STARMER[1,2], Alexander KERR[3], Gustav PAULAY[1]

[1]Florida Museum of Natural History, Gainesville, FL, [2]Department of Zoology, University of Florida, Gainesville, FL, [3]Marine Laboratory, University of Guam, Mangilao, Guam

Understanding and management of coral reefs depend fundamentally on our ability to distinguish and identify species, in conjunction with knowledge on their origin, distribution and biological characteristics. Yet available information on reef biota remains often inadequate and difficult to access. Aspidochirotid sea cucumbers are a case in point: they include the largest and most conspicuous motile invertebrates on reefs, and are often severely overfished because of their economical value. Identification of some harvested species, even though common, is problematic. We are undertaking a revision of these organisms. Here we present results from a molecular phylogeny on 200+ taxa, based on 2 mitochondrial gene regions. Results provide insight into macroevolutionary transitions, diversification, and species limits. Holothurians show substantial niche conservatism in latitudinal distribution, depth range, and feeding mode. Heavy reliance on ossicles has led to a confused taxonomy: in some groups ossicles evolve rapidly, possibly in response to variation in carbonate saturation levels, in others they are conserved and mask substantial cryptic diversity. The latter is exemplified by the circumtropical "species" *Holothuria impatiens*. This species complex revealed to consist of at least a dozen reciprocally monophyletic, well-defined, evolutionary significant units (ESUs). Each major tropical region has at least one endemic ESU, the East Pacific and Indo-West Pacific (IWP) host multiple taxa. The latter include peripheral, archipelagic endemics as well as ESUs that range across the entire IWP. Broad overlap in the range of some in combination with recent divergence indicate the rapid evolution of reproductive isolation barriers among these ESUs. Morphological distinctiveness of ESUs vary: some show differences in ossicle morphology, others in live coloration, yet others show no morphological differences that we have been able to discern to date. These results are leading to a better understanding of the varied diversity and diversification mechanisms of reef organisms.

## 26-25

**Diversity And Speciation Of Coral-Dwelling Barnacles in The Genus *trevathana* (Balanomorpha: Pyrgomatidae): A Case Of Host-Race Speciation?**

**Maria Celia MALAY*[1]**

[1]Dept of Zoology & Florida Museum of Natural History, University of Florida, Gainesville, FL

The Pyrgomatidae is a unique, understudied family of balanomorph barnacles that has very successfully radiated as epizootic symbionts on living corals. Pyrgomatid barnacles show remarkable morphological trends in specialization for symbiosis, including highly derived and reduced skeletal elements and coral parasitism in at least one lineage. In this study my goal is to elucidate species diversity and mechanisms of speciation in the Indo-Pacific pyrgomatid genus *Trevathana*. *Trevathana* is morphologically apomorphic, has the widest geographic range of all pyrgomatid genera, and lives exclusively on faviid corals. In these respects it contradicts earlier hypotheses that proposed an inverse relationship between pyrgomatid morphological apomorphy and geographical and host ranges. Phylogenetic (DNA sequence) and morphological data from new collections of pyrgomatids have uncovered at least 6 previously-undescribed evolutionarily significant units (ESUs), effectively doubling species diversity in this genus. Moreover almost all *Trevathana* ESUs are specific to a single coral host, and multiple ESUs are sympatrically distributed. This talk will explore the possibility that *Trevathana* diversification has proceeded through sympatric host-switching events.

## 26-26

**Molecular Diversity And Specificity Of Waminoa Sp. Worms Associated With Corals in The Gulf Of Eilat (Red Sea).**

**Orit BARNEAH*[1]**, Eitan BEN-DOV[1], Yehuda BENAYAHU[2], Itzchak BRICKNER[2], Ariel KUSHMARO[1]

[1]1Department of Biotechnology Engineering, Ben-Gurion University P. O. Box 653, Be'er-Sheva 84105 Israel, Be'er-Sheva 84105, Israel, [2]Departmrnt of Zoology, Tel-Aviv University Ramat Aviv, Tel Aviv 69978, Israel., Tel Aviv, Israel

Acoel worms belonging to the genus *Waminoa* are known to be epizoic on 14 coral species in Eilat's reefs. A single species named *Waminoa brickneri* was identified from this location according to morphological features of the sexual reproduction system. *Waminoa* worms found on various coral hosts differed in size and possessed different sub-clades of *Symbiodinium* symbionts, thus suggesting the existence of different species. The main objectives of the present research were to study the diversity of *Waminoa* worms and to reveal the specificity of the relationship with their coral hosts. We constructed 9 DNA clone libraries, originating from worms that were removed from 5 different species of stony corals. 74 sequences of the 18S rRNA gene were obtained and a phylogenetic tree was constructed. All the sequences displayed high similarity (≥97%) to each other. The data shows 2 clusters of sequences: one containing 7 sequences from the library originated from the coral *Echinophyllia* sp. and the second containing the rest of the sequences which comprise a mixture of sequences from all other libraries. In addition, algal 18S rRNA gene sequences retrieved from 3 DNA libraries were identified as belonging to the genus *Amphidinium*, thus corroborating our previous morphological findings regarding this algal symbiont.

Our results suggest that the 18S rRNA gene might not be sufficient for species-level classification in the genus *Waminoa* and it is therefore suggested to use additional sequences (e.g. ITS region) in order to obtain an improved resolution.

## 26-27

**Host Specificity, Spatial Niche Diversity And Adaptations Of Coral-Associated Gobies in The Northern Red Sea**

**Juergen HERLER*[1]**, Markus DIRNWOEBER[1], Lucie SCHIEMER[1], Simone NIEDERMUELLER[1]

[1]University of Vienna, Vienna, Austria

There are numerous specialized fishes that exploit a variety of spatially restricted habitats in coral reefs, for example gobiids which live in association with live corals or coral rock. In the Gulf of Aqaba (northern Red Sea), 21 species belonging to seven genera of tiny reef-associated gobies were found, occupying a great range of spatial niches. Four genera (*Gobiodon*, *Paragobiodon*, *Bryaninops* and *Pleurosicya*) are coral-associated among which *Gobiodon* is the most prominent one. Coral growth forms constrain fish morphology and drive adaptations. Differences in body shape and growth patterns were investigated in *Gobiodon* by geometric morphometrics and related to interbranch width of preferred *Acropora* corals. Restricted interbranch width provide fitness advantages for species that grow more compress, because they attain larger body size in the same corals by being thinner. The swimming performance, as tested in aquarium experiments by simulating different coral interbranch spaces, was better in *Gobiodon histrio* than in *G. rivulatus*, two species which differ in shape but overlap in habitat use and compete for host corals. Different shapes may even be reflected in internal characters, such as the head skeleton. Specific microhabitat characteristics may thus have driven adaptive radiation among these habitat specialists. Niche width (degree of specialization) and different competitive abilities among species result in differential consequences for species if coral colonies or entire communities become degraded. This was shown by effects on the frequency of goby breeding pairs found in reefs of very different conditions, where heavily damaged corals were up to 80% less frequently occupied. As post-settlement movement experiments have revealed, breeding pairs build stable relationships and prefer certain coral colonies and are thus extremely sensitive to coral degradation and habitat loss.

## 26-28

**Ribosomal Rna Reveals Phylogenetic Conservatism in The Evolution Of Host Associations in Caribbean Symbiotic Zoanthids**

**Timothy SWAIN*[1]**

[1]Department of Biological Science, Florida State University, Tallahassee, FL

Symbiotic zoanthids (Cnidaria, Anthozoa, Hexacorallia, Zoanthidea, Macrocnemina) form associations with a diverse group of invertebrates (representing at least 5 phyla) in most major benthic habitats with a bathymetric range from mangrove roots to the deep sea. The currently accepted morphology-based taxonomy arranges zoanthid species with dissimilar host associations into the same higher taxa, apparently challenging patterns of phylogenetic conservatism often observed in the evolution of symbiotic associations. Shallow-water Caribbean symbiotic zoanthids (10 species representing 2 families and 3 genera) form associations with a single hydroid species and approximately 100 species of coral reef sponges (representing 6 orders, 21 families, and 33 genera). The taxonomy of Caribbean symbiotic zoanthids results in congeneric zoanthid species forming associations dissimilar hosts and heterogeneric zoanthid species forming associations similar hosts.

The complete internal transcribed spacer region of the ribosomal RNA nuclear gene was PCR amplified from multiple individuals representing each symbiotic zoanthid species collected from 11 locations spanning the entire greater Caribbean region. Phylogenetic analyses resulted in topologies that are paraphyletic for all zoanthid genera and families included in the analysis. The clades of zoanthid species recovered by the phylogenies have similar host associations, suggesting phylogenetic conservatism in zoanthid-host association evolution. A single example of a zoanthid species switching hosts was detected within a clade where all other members shared the same sponge hosts. The host switch was away from symbioses with sponges that generally host photo-endosymbionts to symbioses with sponges that generally do not host photo-endosymbionts and was accompanied by a loss of photosynthetic dinoflagellate symbionts (*Symbiodinium*) of the zoanthid. The loss of *Symbiodinium* coinciding with a host switch on the phylogeny maintains the match in photo-endosymbionts first detected by examining the specificity of sponge hosts and zoanthid symbionts.

## 26-29

**Evolution Of The Zoanthid Genus *zoanthus* (Hexacorallia: Anthozoa) And Associated *symbiodinium* in The Atlantic And Pacific Oceans**

**James REIMER*[1,2]**, Frederic SINNIGER[1], Kiyotaka TAKISHITA[2]

[1]Department of Chemistry, Biology and Marine Science, University of the Ryukyus, Nishihara, Okinawa, Japan, [2]Extremobiosphere Research Center, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Kanagawa, Japan

Zooxanthellate zoanthids (=Order Zoantharia) of the order *Zoanthus* are commonly found in coral reef ecosystems throughout the world's tropical and sub-tropical oceans, but until recently remained relatively neglected in terms of research. Recent work using a combination of molecular and more traditional morphological and ecological techniques have led to a more concise understanding of true levels of *Zoanthus* species diversity. In this study DNA sequences (cytochrome oxidase subunit I, 16S ribosomal DNA, and internal transcribed spacer of ribosomal DNA) from *Zoanthus* spp. specimens from numerous locations in the Atlantic and Pacific were obtained in order to investigate evolutionary patterns in this genus. The results show two separate clades of apparently "ancient" species groups that existed before the separation of the Atlantic and Pacific by the Isthmus of Panama. Within each clade are two species of *Zoanthus*, one from each ocean. Additionally, both species within each of the clades associate with the same unique subclade of *Symbiodinium* (zooxanthellae), suggesting that in *Zoanthus* associations with *Symbiodinium* may be apparently stable over relatively long (~millions of years) periods of time. Attempts to estimate the age of the divergence of these two "ancient" species clades using molecular clock calculations will be introduced.

## 26-30

**Phylogenetical Analysis Of Zoanthus (Zoanthidea) Morphotypes From Brazilian Coast**

**Leila LONGO*[1]**, Erika SCHLENZ[2], Maria Cristina ARIAS[3]

[1]Genética e Biologia Evolutiva, Instituto de Biociências USP, São Paulo, Brazil, [2]Zoologia, Instituto de Biociências USP, São Paulo, Brazil, [3]Genética e Biologia evolutiva, Instituto de Biociências USP, São Paulo, Brazil

The Zoanthidae (Anthozoa) presents morphological plasticity which constitute a constraint for species identification. This study presents the morphological variability within the genus Zoanthus and an evaluation of the taxonomical status of different morphotypes, by the association of morphological and molecular data. Twenty one morphological atributes were analysed from 235 samples comprising 20 collecting sites along Brazilian coast, and submitted to a cluster analysis to detect the morphological similarities. A canonical correspondence analysis was conducted to evaluate the morphological character contribution to each group. These data were submitted to phylogenetic analysis. Tissues from these morphotypes were used for molecular analysis of 16S and COI mitochondrial genes using heterologous primers for PCR amplification. The sequences were submitted to a phylogenetic analysis. The cluster analyses resulted in 12 different morphotypes. The correspondence analysis showed three most important characters distinguishing the morphotypes. The phylogenetic analysis based on morphological data evidenced the following three clades grouping: one - morphotypes 1, 2, 3, 4 and 5; two – morphotypes 6, 7, 8 and 9; three - 10 and 12, once they always clustered together. However the morphotype 11 did not cluster in any of the former groups. Molecular analysis from the 16S gene corroborates the cluster number and composition based on the morphological traits, except for morphotype 12. The data from COI gene showed two major clades, and high genetic divergence between the sequences from morphotype 7 and 8. Our morphological and molecular results were congruent and enabled us to stablish the following: morphotypes 1, 2, 3, 4 and 5 constitute morphological variations of Zoanthus sociatus species; morphotypes 6, 7, 8 and 9 represent intraspecific polymorfism of Zoanthus solanderi; morphotypes 10 and 12 are variations of Zoanthus nymphaeus; and morphotype 11 must be consider a new Zoanthus species.

## 26-31

**Coral Geographic: A Progress Report**

**J. VERON*[1]**, L. DEVANTIER[2], E. TURAK[3], S. KININMONTH[4]

[1]Coral Reef Research, Townsville, Australia, [2]private, Noosaville, Australia, [3]private, Paris, France, [4]AIMS, Townsville, Australia

Coral Geographic is a GIS database that has been in the building for a decade, during which time it has been used extensively for reef conservation planning. The extent of this usage prompted a major revision, which will remain on-going. The first product was a composite global map of coral diversity that delineated a revised "Coral Triangle". This, in turn, became the basis for "The Coral Triangle Initiative", a multi-million dollar international conservation effort, launched at the Bali summit on climate change in December, 2007. Coral Geographic is continuing towards a target product which will allow all users to download coral distribution and environmental data in GIS format. These products will be amenable to detailed interrogation and interfacing with other datasets.

## 26-32

**"Species Richness and Morphological Diversity of the Genus Porites in the Pacific Ocean"**

**Alonso MOHEDANO - NAVARRETE*[1]**, Hector REYES-BONILLA[2], Ramon Andres LOPÉZ-PÉREZ[3,4]

[1]Biologia Marina, Universidad Autonoma de Baja California Sur, La Paz, Mexico, [2]Biologia Marina, Universidad Autonom de Baja California Sur, La Paz, Mexico, [3]Instituto de recursos, Universidad del Mar, Oaxaca, Mexico, [4]Universidad del Mar, Oaxaca, Mexico

Biological diversity has been usually measured using species richness, but unfortunately this parameter only shows a partial view of the communities. Studies on fossil and recent species showed that morphological diversity can reflect functional aspects of the system more efficiently than richness. The objective of this paper was to compare patterns of species richness and morphological diversity in the genus Porites, recognized for its ecological relevance and skeletal plasticity. Distribution data of 52 species were arranged in quadrants of 20° of latitude and longitude, covering the entire Pacific Ocean (N=48). Nine morphological characters were measured or considered for each species (maximum and minimum corallite diameter, presence/absence of collumella, presence/absence of pali, proportion between wall width and maximum diameter of corallites, type of septa, proportion between depth and maximum diameter of corallites, presence/absence of ramifications, presence/absence of triplet). The set of measurements was standardized and processed with a principal component analysis, and estimation of the morphospace occupied by Porites at each quadrant was obtained by calculation of the geometric mean of the morphological eigenvalues of the species. The results show that there is no lineal relationship between species richness and diversity of forms for the genus Porites along the Pacific Ocean; this occurs because in areas with mid to high richness (from 20 to 31 species), morphological diversity is almost stable. We propose that the detected morphospace limitations may indicate saturation in niche availability, or is caused by phyletic limitations in this genus. In contrast, regions with low richness (16 to 6 species) have the highest morphological diversity, and are usually located in peripheral areas such as Japan and the eastern Pacific. Finally, there is no difference in morphological variability between hemispheres or among latitudes.

## 26-33

**Phylogeny of Faviidae Corals Based on Molecular and Morphological Data**

**Danwei HUANG*[1]**, Rudolf MEIER[2], Peter A. TODD[2], Hironobu FUKAMI[3], Loke Ming CHOU[2]

[1]Scripps Institution of Oceanography, La Jolla, CA, [2]National University of Singapore, Singapore, Singapore, [3]Seto Marine Biological Laboratory, Wakayama, Japan

Corals in the family Faviidae constitute one of the most important taxa of hermatypic corals in Indo-Pacific reefs. Several genera in this group are taxonomically difficult and little is known about the phylogenetic relationships at the species level. In order to reconstruct the evolutionary relationships within this family, 42 faviid species were sequenced for two mitochondrial genes (cytochrome oxidase subunit I and a mitochondrial non-coding region). Based on these genes and 18 morphological characters, including morphometric measurements, we present the first species-level phylogeny of the family. Maximum parsimony analysis was carried out separately on the molecular and morphological data using both dynamic (optimization alignment) and static homology (ClustalX). The datasets were also combined and analyzed under parsimony, maximum likelihood and Bayesian likelihood. Analyses based on both data types did not recover traditional taxonomic classification. Of the eight genera with more than one species examined using molecular data, only two are monophyletic (i.e. *Cyphastrea* and *Platygyra*). Furthermore, the outgroup *Scapophyllia cylindrica* (Family Merulinidae) is deeply nested within the Faviidae, while the Indo-Pacific *Montastraea* spp. are clearly distinct from the Atlantic *M. annularis* complex. Our data support the hypothesis that some congeneric species that span both marine provinces are less closely related to one another than to taxa from other families. Reconstructions based on DNA sequence data and morphological characters are also incongruent. We discuss the implications of our results for the evolution of Scleractinia and highlight the significance of our findings for biodiversity estimates and reef management.

## 26-34

**Reconciling Morphologic And Molecular Data: Corallite Wall And Microstructures Of Radial Elements In The Scleractinian Coral Family Faviidae**

**Ann BUDD*[1]**, Jaroslaw STOLARSKI[2]

[1]University of Iowa, Iowa City, IA, [2]Instytut Paleobiologii PAN, Warszawa, Poland

Recent molecular-based phylogenies conflict with traditional scleractinian classsification at ranks ranging from suborder to genus, challenging morphologists to discover new characters that better agree with molecular data. Such characters are essential for including fossils in analyses and tracing evolutionary patterns through geologic time. We examine the internal structure of the corallite wall and associated costosepta, focusing on arrangements of calcification centers and fibers in transverse thin section. The taxa are a molecular (cytB, COI) clade consisting of: (a) Pacific members of 12 genera (*Barabattoia, Caulastraea, Cyphastrea, Echinopora, Favia, Favites, Goniastrea, Leptoria, Montastraea, Oulophyllia, Platygyra, Scapophyllia*) and one Atlantic taxon (*M. annularis* complex) in the traditional family Faviidae; (b) five genera (*Hydnophora, Merulina; Pectinia, Mycedium; Trachyphyllia*) in three allied families. For comparison, we treat two Pacific (*Diploastrea, Plesiastrea*) and three Atlantic (*Colpophyllia, Diploria, Manicina*) genera that have traditionally been assigned to the Faviidae but do not belong to the clade. Our observations reveal that members of the clade possess two commonly recognized wall types: parathecal (formed by dissepiments) and septothecal (formed by septal thickening). They also possess a third wall type, trabeculothecal (formed by trabecular elements), as well as combinations of wall types. Costosepta consist of: (a) distinct vertical units with central calcification centers, (b) fibers radiating from a well-defined medial septal line, lacking well-defined centers, (c) fibers radiating from a poorly-defined mid-septum line, with well-defined centers. The effectiveness of the new microstructural characters as phylogenetic markers is evaluated by mapping their states onto the molecular tree using parsimony, and calculating tree statistics. Although maps of traditional macromorphological characters have low consistency indices, maps of the new characters have higher consistency indices, reveal less homoplasy, and are diagnostic of subclades within the group. Phylogenetic trees constructed using the new characters have relatively high bootstrap support, and are congruent with molecular trees.

## 26-35

**Resolving The Taxonomy Of Favia Corals From Thai Waters Using Morphological And Molecular Data**

**Narinratana KONGJANDTRE*[1]**, Mauricio RODRIGUEZ-LANETTY RODRIGUEZ-LANETTY[1], Tyrone RIDGWAY[1], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, The University of Queensland, Brisbane, Australia

Traditional taxonomy and systematics is central to our understanding of the biodiversity of ecosystems such as coral reefs. This role has become more important as coral reefs worldwide have begun to be influenced by the activities of humans such that, despite their persistence in geological time, coral reefs have begun an unprecedented decline in abundance and community composition. Given the potential losses to coral reefs due to disturbance and climate change, the need for knowing what is being lost (i.e. via effective taxonomy) cannot be underestimated. The Faviidae are one of the most prominent coral families inhabiting tropical reefs, yet despite their prominence, their taxonomy still remains largely unresolved. Thailand, being within the coral biodiversity hot spot, and its association with both the Indian and Pacific Oceans, makes it an ideal location to unravel the potentially complex taxonomy and systematic relationships within the Faviidae. Using a unique multi-disciplinary approach to taxonomy whereby morphological and genetic techniques are integrated, we unravel the diversity currently represented by the genus *Favia* in Thailand. Multi-character measurements and 3-D Cartesian coordinate analysis were used to delineate species boundaries based on skeletal characters. This morphological approach was extended using sequence analysis of the mtDNA and the complete Internal Transcribed Spacer (ITS) region to detect taxon boundaries in 114 samples of *Favia* from Thailand. In addition, the molecular diversity of symbiotic dinoflagellates associated with *Favia* samples were also examined as a possible additional character state to the taxonomic resolution. Preliminary results support this multi-disciplinary approach as being very robust for scleractinian coral taxonomy.

## 26-36

**From Molecular "markers" To Molecular "drivers": Coral Systematics Using Biomineralization Genes As Determinants Of Skeletal Morphology**

**Herman WIRSHING*[1]**, Andrew BAKER[1]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

Molecular systematics assumes that variation in DNA sequences at one or more genetic loci can serve as useful indicators of evolutionary change. These molecular "markers" serve as proxies for estimating relationships within and between taxonomic groups, and are usually compared with classical systematic relationships that are based on morphological differences among taxa. Often, molecular and morphological datasets do not agree, because one dataset (or both) fails to accurately reflect true phylogenetic relationships. One way of resolving the disagreement between these datasets is to identify and analyze genes directly responsible for generating morphology. For most taxonomic groups this is not currently possible. However, in corals, where taxonomy is currently determined almost exclusively by skeletal morphology, this problem may be tractable, and may also help identify cases of convergent morphological evolution. To test this approach, we used the cDNA sequence of a protein isolated from the organic matrix (a consortium of proteins that forms the scaffolding for biomineralized structures) of *Galaxea fascicularis*, to amplify a 210bp DNA fragment from eight scleractinian species. Phylogenetic reconstruction of the translated amino acid sequences grouped these species according to corallite morphology. Three genera that resemble each other in calyx morphology formed a well-supported clade - *Galaxea*, *Euphyllia* (which contain phaceloid calyces), and *Gyrosmillia* (meandroid calyces). The other two genera exhibit calyx morphologies not shared by the other taxa and formed individual lineages - *Siderastrea* (cerioid calyces) and *Montipora* (plocoid calyces). This novel approach may provide an opportunity to refine our understanding of the genetic underpinnings of conventional morphological taxonomy, and may help resolve some persistent problems in coral systematics.

## 26-37

**Integrative Taxonomy And Phylogeny Of The Siderastreid Scleractinian Corals**

**Francesca BENZONI*[1]**, Fabrizio STEFANI[2], Jaroslaw STOLARSKI[3], Michel PICHON[4], Paolo GALLI[2]

[1]Dept. of Biotechnologies and Biosciences, University of Milan-Bicocca, Milano, Italy, [2]Dept. of Biotechnologies and Biosciences, University of Milan-Bicocca, Milan, Italy, [3]Instytut Paleobiologii PAN, Warszawa, Poland, [4]Ecole Pratique des Hautes Etudes, Perpignan, France

Integrative taxonomy is currently recognised by many as the solution to the "taxonomic crisis". However, the use of a multi-disciplinary approach to the study of species boundaries in Scleractinia has been, so far, limited. Molecular techniques have provided new opportunities to explore taxonomic boundaries and the phylogeny of taxa traditionally identified according to incongruence of macro-morphological characters of the skeleton and have shown that the traditional coral classification is frequently not congruent with the molecular results. However, skeleton morphology remains the most commonly used tool for the identification of coral taxonomy, is the only link between extant corals and the fossil record, and thus indispensable for reconstruction of the complete scleractinian phylogenetic tree.

The family Siderastreidae includes six genera (*Siderastrea* Blainville, 1830, *Psammocora* Dana, 1846, *Coscinaraea* Milne Edwards and Haime, 1848, *Anomastraea* Marenzeller, 1901, *Pseudosiderastrea* Yabe and Sugiyama, 1935, and *Horastrea* Pichon, 1971) grouped together based on frequent presence of synapticulae and the fusion of septa. We re-assessed the taxonomy and phylogeny of the Siderastreidae through a multidisciplinary approach including the morphologic study of the polyp, morphometric analysis of the corallite structures, skeletal microstructures, and the molecular analysis of both a nuclear and a mitochondrial markers. The morpho-molecular study of the Siderastreidae confirmed the partial results previously obtained by other molecular studies indicating that the genera, and some species, currently ascribed to the family belong to different phylogenetic lineages and that commonly used skeletal macro-characters are not necessarily the most informative ones. In particular, the deepest divergence detected separates *Pseudosiderastrea* and *Siderastrea* from the remaining genera, and indicates that the genera *Psammocora* and *Coscinaraea* are not monophyletic. The re-evaluation of the polyp and skeleton characters and of previously disregarded macro and microstructures have proved phylogenetically informative when combined with molecular results.

## 26-39

**Mitochondrial And Nuclear Genes Suggest That Stony Corals Are Monophyletic But Most Families Of Stony Corals Are Not**

**Nancy KNOWLTON*[1]**, Hironobu FUKAMI[2], Allen CHEN[3], Ann BUDD[4]

[1]National Museum of Natural History, Smithsonian Institution, Washington, DC, [2]Seto Marine Biological Laboratory, Kyoto University, Shirahama, Japan, [3]Research Centre for Biodiversity, Academia Sinica, Taipei, Taiwan, [4]Department of Geoscience, University of Iowa, Iowa City, IA

Modern hard corals (Class Hexacorallia; Order Scleractinia) are widely studied because of their fundamental role in reef building and their superb fossil record extending back to the Triassic. Nevertheless, interpretations of their evolutionary relationships have been in flux for over a decade. Recent analyses undermine the legitimacy of traditional suborders, families and genera, and suggest that a non-skeletal sister clade (Order Corallimorpharia) might be imbedded within the stony corals. However, these studies either sampled a relatively limited array of taxa or assembled trees from heterogeneous data sets. Here we provide a more comprehensive analysis of Scleractinia (127 species, 75 genera, 17 families) and various outgroups, based on two mitochondrial genes (cytochrome oxidase I, cytochrome b), with analyses of nuclear genes (beta-tubulin, ribosomal DNA) of a subset of taxa to test unexpected relationships. Eleven of 16 families were found to be polyphyletic. Strikingly, over one third of all families as conventionally defined contain representatives from the highly divergent "robust" and "complex" clades. However, the recent suggestion that corallimorpharians are true corals that have lost their skeletons was not upheld. Relationships were supported not only by mitochondrial and nuclear genes, but also often by morphological characters which had been ignored or never noted previously. The concordance of molecular characters and more carefully examined morphological characters suggests a future of greater taxonomic stability, as well as the potential to trace the evolutionary history of this ecologically important group using fossils.

## 26-40

**Phylogenetics And Morphological Evolution Of Scleractinian Corals.**

**Marcos BARBEITOS*[1,2]**, Sandra ROMANO[3], Howard LASKER[4]

[1]Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS, [2]Biological Sciences, University at Buffalo, Buffalo, [3]Division of Science and Mathematics, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [4]Department of Geology, University at Buffalo, Buffalo, NY

Scleractinian corals are modular organisms of great ecological and economic importance which grow in either solitary or colonial forms. Over recent years, molecular phylogenetic analyses have repeatedly made it clear that Scleractinian taxonomy does not reflect phylogenetic relationships within the order. Pervasive plasticity of skeletal characters and evolutionary convergence make it very difficulty to infer homology when using traditional diagnostic characters. Unlike the current classification schemes, molecular phylogenies suggest the presence of separate lineages in different biogeographic provinces, and have even challenged the monophyly of the order. Perhaps because they are easier to sample, the majority of recent analyses have concentrated on symbiotic reef corals, but half of the extant Scleractinian species are azooxanthellate and are uncommon on coral reefs. We conducted comprehensive phylogenetic reconstructions of the group using partial sequences from a nuclear and a mitochondrial marker (rRNA genes 28S and 12S, respectively). Bayesian and parsimony analyses recovered a monophyletic Scleractinia clade, rejecting the "naked coral hypothesis". Additionally, our analyses recovered well supported clades containing both azooxanthellate taxa that are not normally found in coral reefs and zooxanthellate, reef-dwelling, highly integrated colonial species. The large morphological disparity between these two groups contrasts with the small genetic distances. This pattern can be explained by loss of coloniality via heterochronic processes, which allow for substantial morphological change with minimal genetic reprogramming. Such losses may have been adaptive or exaptive in the context of global change. This hypothesis was corroborated by Bayesian reconstruction of ancestral character states. These results suggest that evolution of coloniality in corals may have been much more dynamic than previously suspected. The link between reef and non-reef coral species points towards the need for more extensive taxonomic sampling of the latter in future phylogenetic reconstructions of the order.

## 26-41

**New Trends in Scleractinian Coral Phylogeny Interpretation: Towards A Solution To Old Taxonomic Wrangles ?**

**Michel PICHON*[1]**, Francesca BENZONI[2], Jaroslav STOLARSKI[3]

[1]Biologie Ecologie tropicale et mediterraneene, Ecole Pratique des Hautes Etudes, Perpignan, France, [2]Biotecnologie e Biocienze, University of Milano-Bicocca, Milano, Italy, [3]Instytut Paleobiologii PAN Warsawa, Warszawa, Poland

The first scleractinian coral species were described by Linnaeus in his «*t*», which saw the birth of the binomial zoological nomenclature. The supra-generic basis for scleractinian classification was however very loose, and it is fair to say that it became better organized thanks to the work of eminent palaeontologists, who took advantage of the long fossil record and the fossilization potential of scleractinian corals. Thus, for over a century, scleractinian coral phylogeny interpretation (and hence classification) was essentially morpho-taxonomic, and exclusively based on skeletal structures. During that time,very few attempts have been made by zoologists to utilize the characters of the living organism. In parallel, a growing awareness of intraspecific variability became widespread and the shortcomings of the traditional purely morpho-taxonomic approach more and more obvious. In the last few decades, new tools were developed so as to improve on a situation deemed less than satisfactory. The usefulness of skeletal microstructures (almost totally forgotten for a while) was re-emphasized, and other avenues were also explored to provide more robust information on species boundaries, in addition to that given by the traditional morpho-taxonomic approach: Physiological and ecophysiological characters were introduced to help discriminating between species, and more recently, molecular genetics. At the same time, characters of skeletal structures colony shape, corallite parameters) were revisited with the help of powerful techniques such as morphometrics, with a large array of statistical data processing methods, and fractal analysis of colony surface characters. There is now a large spectrum of techniques available to the scleractinian coral taxonomist, and if none of the approaches mentioned above can, in isolation, give a satisfactory answer, their simultaneous implementation is, in most instances able to solve taxonomic wrangles inherited from the past situation. Practical examples of the results obtained by such a combined approach are given.

## 26-42

**Microsatellite Markers Reveal Extremely Low *in-Situ* Hybridization Between Sympatric Ecomorphs Of The Coral *favia Fragum***

**David CARLON*[1]**, Catherine LIPPE[2]

[1]Zoology, University of Hawaii, Honlulu, HI, [2]Zoology, University of Hawaii, Honolulu, HI

The origin of biological species rests on the tension between the diversifying effects of reproductive isolation and the homogenizing effects of gene flow. Previous molecular work has shown evidence for significant genetic structure between two sympatric ecomorphs of the coral *Favia fragum* in Panama, but it is unclear if structure results from pre-zygotic or post-zygotic isolation. To address this question, we estimated three components of the mating system for individuals of both ecomorphs living sympatrically in a potential hybrid zone. Adults brood larvae, and genetic information on the identity of parents is stored in larvae that were easily sampled from laboratory cultures. We genotyped parents and broods at 15 new microsatellite markers to determine the fraction of fertilization caused by: i. self fertilization (*s*), ii. outcrossing within ecomorphs (*t*w), and iii. hyrbidization between ecomorphs (*t*h). We could directly observe outcrossing events (*t*w + *t*h) with abundant statistical power by the presence of a non-maternal allele. Outcrossing ranged from 0 – 5%, and since $s = 1 - (tw + th)$, the selfing rate ranged between 95 and 100%. We confirmed that selfing, not ameiotic reproduction, explained similarity between adult and larval genotypes by examining segregation ratios within broods of heterozygous parents. All broods fit the expected segregation ratio under selfing. Lastly, we estimated the hybridization rate (*t*h) by using a multilocus assignment model (INSTRUCT) to determine the fraction of outcrossing events that shared genomes from both ecomorphs. All outcrossed larvae could be assigned to the parental ecomorph population with high Q values, so that *t*h= 0 for all broods. We conclude that genetic differences between ecomorphs are maintained by pre-zygotic isolation, and that high selfing rates and limited larval dispersal can play a large role in the generation of population structure, and the initiation of speciation, in corals with brooding life histories.

## 26-43

**Coral Biodiversity Is Not As It Appears: Cryptic Species, And Morphospecies Flocks in *porites***

**Zac FORSMAN*[1,2]**, Daniel BARSHIS[1], Cynthia HUNTER[1]

[1]University of Hawaii at Manoa, Honolulu, HI, [2]U.S. Fish and Wildlife Pacific Islands Office, Honolulu

The nature of coral biodiversity is obscured by confusing patterns of morphological variation. One of the most extreme examples of the coral 'species problem' is the genus *Porites*. In this study, we examined genetic relationships in *Porites* using two mitochondrial markers and the nuclear ribosomal Internal Transcribed Spacer (ITS) region. The ITS region was congruent with the mitochondrial markers while providing higher levels of polymorphism. The nuclear and mitochondrial data sets revealed that colony-level morphology does not always correspond to genetic differences. The three most derived clades contained both branching and mounding morphospecies that were indistinguishable by genetic markers. *P.astreoides*, *P.rus*, and *P.lichen* contain significant ITS sub-clades, while "*P.lutea*" was found to consist of three cryptic and polyphyletic groups. Corallite-level morphology was generally concordant with the genetic clades. *Synarea* does not warrant designation as a subgenus; it was most closely related to *P.evermanni*, indicating that corallite-level appearance can evolve rapidly. The derived clades warrant further investigation for hybridization, insipient speciation, polymorphism, or phenotypic plasticity. This study demonstrates that appearances can be deceiving in this ecologically important group of reef-building coral.

## 26-44

**One for the Lumpers? Morphological Variants of Caribbean *Porites* (Scleractinia: Poritidae) Demonstrate Low Genetic Variation**

**Sandra ROMANO*[1]**, Matthew LUCAS[2], Tryphena CUFFY[1], Semoya PHILLIPS[1]

[1]Division of Science and Mathematics, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [2]Dept. of Biology, Southeast Missouri State University, Cape Girardeau, MO

Resolution of species boundaries in scleractinian corals is problematic, even using a combination of characters. Yet the ability to recognize species and understand relationships among closely related species is essential for coral reef ecology and conservation. The genus *Porites* is one of only eight cosmopolitan scleractinian genera and is an important component of coral reefs worldwide. In the Caribbean six different species occur sympatrically but studies based on morphological and molecular characters have not clearly resolved relationships within the genus and the taxonomic status of some species is unclear. We are analyzing ten samples of each of the six morphological variants of *Porites* that occur sympatrically in the USVI. Phylogenetic analyses of approximately 1100 bp of DNA sequences from three mitochondrial gene regions (the putative control region and two mitochondrial introns) and one nuclear gene region (the ribosomal internal transcribed spacers) do not support hypotheses suggested by other research. Massive and branching species form two distinct clades approximately 3% different from each other. There are few sequence differences between the two color morphs of the massive species *P. astreoides:* they form a monophyletic clade. There are also few sequence differences between the three branching species *P. divaricata, P. furcata*, and *P. porites*. *P. branneri* (encrusting with a distinct bluish color) is genetically distinct from *P. astreoides*. The relationship of *P. branneri* to the other species remains unresolved. Continuing analyses are being used to more clearly resolve relationships among these taxa and determine whether lack of genetic variability is due to invariant markers or to recent divergence of closely related species.

## 26-45

**Evidence Of Incomplete Lineage Sorting in Caribbean *porites* (Scleractinia, Poritidae) Based On Novel Single-Copy Nuclear Molecular Markers**

**Joel STAKE*[1]**, Joe NEIGEL[2]

[1]Division of Science and Math, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [2]Biology, University of Louisiana at Lafayette, Lafayette, LA

Molecular data have demonstrated the need for taxonomic reevaluation at all levels in the order Scleractinia. However, molecular markers capable of reliably revealing species-level relationships still remain elusive. Understanding the relationships between closely related species is imperative for coral reef conservation and management. The scleractinian coral genus *Porites* has a cosmopolitan distribution and is an important reef-builder worldwide. Species identification in the genus has been problematic making it an ideal system for molecular phylogenetic study. We developed novel single-copy nuclear DNA markers (scnDNA) from a partial genomic library of *Porites compressa*. These markers were analyzed in concatenation for *P. compressa* and all 6 species of *Porites* with distributions in the western Atlantic and Caribbean. Maximum Likelihood analysis and Bayesian Analysis were performed on ~1400 bp total. The phylogenetic analyses were able to differentiate most of the recognized species of *Porites*. *Porites astreoides* was shown to be more closely related to *P. compressa* than to congeners from the Caribbean while *P. colonensis* and *P. branneri* formed separate monophyletic clades. The three ramose species (*P. porites*, *P. furcata*, *P. divaricata*) did not form individual monophyletic clades but were instead found clustered tightly together. The lack of any significant sequence divergence between these species indicates that, at present, they may not represent distinct evolutionary lineages. Incomplete lineage sorting is the most plausible explanation for the pattern observed in our data and is supported by the relatively young fossil record of these three taxa. Our results do not support previous data that have found these branching morphologies to be separate species. Additionally, our data demonstrate that anonymous sequence markers should be a valuable tool for phylogenetic studies of scleractinian corals.

## 26-46

**Geographic Structure and Cryptic Species in Oculina Inferred from Nuclear Gene Sequences**

**Michael HELLBERG*[1]**, Ron EYTAN[2], Marshall HAYES[3], Margaret MILLER[4]

[1]Biological Sciences, Louisiana State University, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, LA, [3]Duke University Marine Lab, Beaufort, NC, [4]NOAA Fisheries, Miami, FL

Colony form is often highly plastic within coral species, leading to taxonomic confusion that cripples efforts to understand the biology of species or to manage their populations. This may be especially troublesome for species found in a variety of habitats. Species of the genus *Oculina* occur along the southeastern coast of the United States and into the Caribbean. Their forms range from small, shallow water colonies that tolerate turbid conditions without bleaching, to deep water azooxanthellate colonies that form reefs extending up to 10 m off the substrate. Our objective was to assess the history of genetic connectivity among nominal species, populations found at different depths, and populations from along ca. 2000 km of their range along the southeastern coast of the US. Although sequence markers are best suited for drawing inferences about population history, mtDNA in anthozoans has proven too slowly evolving for use within species. As an alternative, we developed three nuclear sequence markers from expressed sequence tags (EST's) drawn from a cDNA library. Comparisons with a confamilial species (*Solenastrea bournoni*) shows the three nuclear gene regions evolve at rates ten times faster than mitochondrial COI. Variation within these genes reveals no differentiation between nominal species nor between shallow (1 m) and mid-depth (30 m) populations from the same locale. However, populations did vary geographically, with a pronounced attenuation of variation to the north of Cape Canaveral consistent with a historical range expansion. Most notably, the population from the deep water Oculina Banks (> 80 m) were more distinct than any other sampled, with two of three loci consisting solely of alleles found nowhere else, a degree of differentiation suggesting long term genetic isolation.

## 26-47

**Using The Toolbox On Acroporidae**

**Carden WALLACE*[1]**

[1]Museum of Tropical Queensland, Townsville, Australia

The scleractinian family Acroporidae has maintained a major role in the waxing and waning of coral assemblages and evolution of species diversity, through time and throughout the world, to become a dominant family on modern Indo-Pacific reefs, and its type genus Acropora the most diverse coral genus. New information from molecular studies has prompted neontologists and paleontologists to re-examine membership of this family and re-assess the evolutionary and biogeographic consequences of various life histories and morphologies. So far, we have elevated Isopora (a subgenus of Acropora) to genus, and are considering combining Montipora and Anacropora, and changing the family status of Alveopora, all changes indicated by molecular phylogenies and supported by other evidence. In modern and paleontological distribution studies, it has been found that the widespread Indo-Pacific genus Isopora was briefly present and abundant in the southern Caribbean before becoming extinct there, and that Acropora already exhibited much of its current structural diversity during its build-up on European reefs, before post-Miocene Indo-Pacific diversification. Because Isopora and Acropora have differing reproductive strategies (viviparity versus oviparity respectively), clarification of their taxonomy, modern distribution and paleoecology are indicating the extinction vulnerability incurred by the different strategies under differing environmental scenarios. Dendracis, which occurred in western Indian Ocean, Mediterranean and Caribbean, became extinct by the Miocene, possibly due to a poor potential for morphological variation relative to Acropora, although the almost equally non-diverse Astreopora has survived to the present day. This paper will present an update on the research and researchers involved in the taxonomic renaissance of Acroporidae and the application of the new findings to new issues in coral reef biology.

## 26-48

**Need For A More Integrative Approach To Scleractinian Taxonomy**

**Vassil ZLATARSKI*[1]**

[1]Independent Consultant, Bristol, RI

Different approaches have been used for scleractinian taxonomy. The original taxonomy was typological and based on skeletal parts. Then, the variability of the coralla was recognized at the end of the 19th century. In 1930's very detailed skeletal studies of fossil and extant scleractinians began. After 1960 scuba facilitated *in situ* observations and sampling and helped reveal a global variability that challenged taxonomy. Beginning in the 1980's the discoveries of molecular genetics and life history offered new taxonomic tools. In the last years a taxonomy based on the genetic method found some gross-morphology characters to be homoplasious rather than represent common descent. These molecular data contradict the conventional systematics, but appear to be compatible with detailed paleontological skeletal studies.

Presently, there are four sources of scleractinian taxonomic information: morphology, paleobiology, developmental biology, and molecular genetics. Only the efficient collaboration of specialists using all existing lines of evidence can combine these data into an improved integrative taxonomy.

It is therefore imperative to form an international body of taxonomists of extant and fossil scleractinians, to develop and prioritize goals in global, regional and specific cases, and to coordinate efforts to solve the fundamental and applied taxonomic tasks. These efforts should gain from more complete sampling, field observations and experiments, application of digital tools, usage of cyberinfrastructure, improved collection preservation, and virtual access to collections, along with training of taxonomists to meet the tasks. The present state of the fundamental taxonomy is reflected in the quality of the applied taxonomy and explains the shortage of reliable coral-identification tools necessary for better understanding and preservation of reef diversity.

## 26-49

**Intragenomic Its2 Variation: Low Rates Of Concerted Evolution Are Concordant With Recent Species Radiations in Reef Octocorals**

**Juan SANCHEZ*[1]**, Camila GRANADOS[1], Daniel DORADO[1], Nestor ARDILA[1], Nelson MANRIQUE[1], Luisa DUEÑAS[1], Olga TORRES[1], Martha CARDENAS[1], Santiago HERRERA[1], Claudia AGUDELO[1]

[1]Biological Sciences, Universidad de los Andes, Bogota, Colombia

The internal transcribed spacer 2 is part of the nuclear ribosomal cistron, whose secondary structure has an important function for the ribosome assembling. For a number of years, contrasting results in terms of inter- and intra-specific ITS2 variation have been found in a number of taxa including reef cnidarians. There are different results finding either single or multiple intragenomic variants, even pseudogenes, which have brought a great deal of confusion regarding the evolution and usefulness of ITS2 for phylogenetic reconstruction as well as the generality of the nRNA concerted evolution process. We examined ITS2 copies in a diverse number of Atlantic and Pacific octocorals (Octocorallia: Cnidaria) using Denaturing Gradient Gel Electrophoresis (DGGE) coupled with DNA sequencing, phylogenetic approaches, and prediction of RNA secondary structures. First we found that morphologically diverse taxa exhibited high intragenomic variation. Candidate pseudogenes were seldom found in a few octocorals but most of the multiple intragenomic ITS2 variants were functional according to secondary structure predictions. These low rates of concerted evolution in ITS2, i.e. multiple intragenomic functional ITS2 copies, were concordant with low substitution rates in mitochondrial DNA within multiple-taxa and morphologically diverse octocoral clades. A few intraspecific analyses revealed also that some of the ITS2 copies are shared among populations and might follow gene flow patterns. Moreover, we suggest that low rates of concerted evolution, such as multiple intragenomic ITS2 variants, are concordant with recent species radiations in octocorals, as seen as diverse closely related species with high morphologic diversity but low mitochondrial divergence. What process is driving such rapid radiation and increased phylogenetic diversity is still unknown in reef octocorals.

## 26-50

**Mitochondrial Gene Variation And The Search For An Octocoral Barcode**

**Catherine MCFADDEN*[1]**, Andrew NEVAREZ[2]

[1]Biology, Harvey Mudd College, Claremont, CA, [2]Harvey Mudd College, Claremont, CA

Slow rates of mitochondrial gene evolution have hindered the development of species-specific genetic markers, or DNA barcodes, in the anthozoan cnidarians. Previous studies of various mitochondrial gene regions have concluded that levels of mtDNA variation simply are not sufficient to reliably distinguish closely related species of anthozoans. These results have been extrapolated to predict that the 5' fragment of cytochrome oxidase I (*COI*), proposed for use as a universal species-specific marker for the "Barcode of Life" initiative, will not differentiate all anthozoan species. Levels of sequence variation in this approximately 640 bp gene region have never been explicitly quantified in the anthozoan subclass Octocorallia, however, in part because the universal "Folmer" PCR primers do not amplify octocoral *COI*. Using octocoral-specific PCR primers, we examined intra- and interspecific variation in the 5' *COI* region in a genus of soft corals for which species boundaries have previously been confirmed using allozymes and other genetic markers. Most, but not all, pairs of sister taxa could be differentiated on the basis of unique substitutions in *COI*, but levels of intraspecific variation were often comparable to or greater than the observed interspecific differences. Two other mitochondrial gene regions, the *COI-COII* intergenic spacer and the 5' fragment of the octocoral-specific mitochondrial mutS homolog (*msh1*), had levels of intra- and interspecific variation comparable to the 5' *COI* fragment. A barcode that combined all three of these gene regions (~1500 bp total) had increased species-specificity relative to *COI* alone, but still lacked sufficient variation to distinguish all species pairs unequivocably. We conclude that *COI* is an adequate genus- and clade-specific barcode for octocorals, but even in combination with other equally variable mtDNA regions it lacks sufficient variation to be a reliable species-specific marker.

## 26-51

**Phylogenetic Analysis Of The Caribbean Genera Eunicea And Plexaura (Octocorallia)**

**Carlos PRADA*[1]**, Nikolaos SCHIZAS[2]

[1]Marine Sciences, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico, [2]Marine Sciences, Universitry of Puerto Rico, Lajas, Puerto Rico

Shallow water octocorals are conspicuously found in Caribbean reefs, yet aspects of their basic biology and systematics remain uncertain. Taxonomic work has traditionally relied on morphological features, but often some of these characters are inconclusive or not readily observed, introducing ambiguities in identification keys. Extensive phenotypic plasticity further complicates the correct species identification. *Eunicea* is the most diverse octocoral genus in Caribbean reefs and species of this genus are separated by shape and size of calices and sclerites. These characters are highly plastic, generating non-discrete patterns which are necessary to correctly identify species. Here, a phylogenetic reconstruction of the genera *Plexaura* and *Eunicea* is presented, using mitochondrial and recently developed nuclear markers. The molecular evolution of both genomes is compared and the suitability of these markers to address species boundaries and population level questions is explored. An earlier taxonomic hypothesis regarding the non-monophyletic status of *Eunicea* based on the shape of external clubs is phylogenetically tested. Discrete forms of *Plexaura homomalla* (i.e., kukenthali and homomalla) are examined to determine their taxonomic status. An example is provided where two distinct genetic lineages are present within the conspicuous, well studied *Eunicea flexuosa*.

## 26-52

**Total Evidence Molecular Phylogenetic Analysis Of Octocorallia (Cnidaria: Anthozoa) Yields A Replete Evolutionary Hypothesis And Identifies Potential Species-Level Markers**

**Jaret BILEWITCH*[1]**, Kathryn COATES[2]

[1]Dept. of Geology, University at Buffalo, Buffalo, NY, [2]Dept. of Conservation Services, Bermuda Ministry of the Environment, Flatts, Bermuda

Recent studies seeking to elucidate the species-level systematics of octocorals have been hindered by low variability in the mitochondrial genome. Although many multi-locus datasets are available in GenBank, including some complete sequences of mitochondrial genomes, a comprehensive analysis using several (or all) of them has not been attempted. We sought to consolidate the findings of these studies into a single phylogenetic hypothesis. All existing mitochondrial sequences of octocorals available in GenBank were collated, along with several large nuclear datasets, and the combined alignment was analyzed in a 'total evidence' approach. Application of both parsimonious and model-based phylogenetic criteria yielded results that were largely concordant with the hypotheses originally associated with individual datasets and also allowed comparison to taxa from disparate datasets. The resulting comprehensive phylogeny also summarizes the efforts of researchers to date and indicates several areas where future attempts may be directed. While the focus of many recent studies has been in locating novel one- or two-locus species-level markers, we find that the existing data, when analyzed collectively is ample to address alpha-taxonomic questions, albeit only for species with sufficient numbers of informative characters. Furthermore, our total evidence analysis suggests that several species-level markers may have already been overlooked due to insufficient taxon sampling at the time they were obtained. We advocate that future attempts be analyzed in combination with previous datasets in order to maximize the information content of phylogenetic hypotheses and maintain an inclusive and contemporary synthesis of octocoral systematics.

## 26-53

**Molecular Recognition Of Zooxanthella Clade G in Caribbean Excavating Sponges (Cliona Spp.)**

**Camila GRANADOS*[1]**, Carolina CAMARGO[1], Dairo ESCOBAR[1], Sven ZEA[2], Juan A SÁNCHEZ[1]

[1]Laboratorio de Biología Molecular Marina, BIOMMAR, Departamento de Ciencias Biológicas, Universidad de los Andes, Bogotá, Colombia, [2]Departamento de Biología y Centro de Estudios en Ciencias del Mar - CECIMAR, Universidad Nacional de Colombia, Santa Marta, Colombia

Zooxanthellae (Symbiodinium) are symbiotic dinoflagellates distributed in tropical and subtropical reefs. Eight major clades of zooxanthellae, symbiotic to different organisms such as cnidarians, sponges, and foraminifera, have been found (termed A–H) using molecular techniques. Among them, sponges are one of the least studied for this symbiotic relationship. They are present and abundant in most marine-ecosystems. Besides participating as important bioeroders of the reef framework, some of them engage symbiosis with zooxanthella. Although they are potentially threatened by the same environmental factors affecting reef-building corals they seem to be less affected. In this study, five sponge species were surveyed (Cliona caribbaea, C. tenuis, C. varians, C. aprica, C. laticavicola) in order to characterize the Symbiodinium lineages using molecular markers (SSU-rDNA-18S, ITS2, cp23S-rDNA, and mtDNA) and phylogenetic approaches. Three different sites were sampled in Colombia, which included Southern and Southwestern Caribbean reefs. All specimens collected at all sites contained Symbiodinium clades-A, B, & G determined by the molecular markers. Inferred phylogenies were concordant with all the clades described. Findings of clades-A&B fitted with the general pattern of the province, where clade-B is almost endemic and types such as A4 engage symbiosis with many species. A new finding was the presence of Symbiodinium clade-G. It is found in a wide range of invertebrates but they seem restricted to the Western Pacific. Particularly intriguing, foraminifera that have clade-G in the Indopacific have clade-C in the Eastern Pacific and F or H in the Caribbean. Given that this is the first time clade-G is reported at any Atlantic location, it arises the question on the lineage origin: 1) due to differences in the primordial origin of the symbiosis between sponges and corals or 2) there is a phylogenetic-relic through common ancestors of sponges clades, latter being tested with the host sponge phylogeny.

## 26-54

**Gene Genealogies Reveal Phylogenetic Species Of Clade C Symbiodinium Associating With Corals Of The Great Barrier Reef**

**Dee CARTER*[1]**, Katherine LOW[1]

[1]Molecular and Microbial Biosciences, University of Sydney, Sydney, Australia

The phylogenetic species concept provides a means of characterising species in *Symbiodinium*. The premise behind the phylogenetic species concept is that groups of individuals that are supported on distinct branches on trees derived from different, unlinked gene sequences are not exchanging genetic information and may therefore represent separate species. All phylogenies established for *Symbiodinium* thus far have been based on either nuclear or chloroplast ribosomal DNA. However, the establishment of a comprehensive phylogeny and a consensual nomenclature for *Symbiodinium* requires multiple, unlinked markers from the *Symbiodinium* genome. The aims of this study were to determine whether clade C *Symbiodinium* consists of different phylogenetic speices by 1) developing a suite of molecular markers from *Symbiodinium* obtained from fourteen coral species from One Tree Island reef (southern GBR); and 2) deriving individual and consensual phylogenies from these markers to identify potential phylogenetic species. Phylogenies were constructed from sequences derived from large subunit rDNA, *psbA*, *cob* and actin genes. Genes trees were for the most part congruent, with a high number of strongly supported branches, which we propose represent distinct phylogenetic species of *Symbiodinium*. Many of these phylogenetic species were associated with a particular coral host species, suggesting a stable, intimate host-symbiont relationship that has developed over a long period of time. The distinct genetic differences between the different phylogentic species within *Symbiodinium* are likely to be associated with differences in physiology, ecology and behaviour. This supports the assertion that the coral holobiont is a complex assemblage whose partners cannot be readily substituted, and that coral bleaching may lead to an irreversible loss of coral biodiversity.

## 26-55

**The Biogeography Of *symbiodinium* From *tridacna Maxima* Across The Indo-Pacific**

**Michele WEBER*[1]**, Scott FAY[1], Jere LIPPS[1]

[1]Department of Integrative Biology, University of California Berkeley, Berkeley, CA

Tridacnidae, the giant clams, are one of many groups of host organisms for *Symbiodinium*, a diverse clade of symbiotic dinoflagellates that structurally and energetically support coral reef communities. I collected and sequenced *Symbiodinium* from populations of giant clams in the Red Sea, the Indian Ocean and the Pacific Ocean. Phylogenetic analysis grouped the *Symbiodinium* into two subgeneric clades, A and C. The data suggest that there are significant patterns in symbiont biogeography and biodiversity across the Indo-Pacific. Symbiont populations in *Tridacna maxima* were more diverse in the Pacific Ocean than in the Indian Ocean or in the Red Sea. Most Pacific populations hosted representatives from both Clades A and C and I found multiple subclade level phylotypes. The samples collected in the Red Sea only hosted one phylotype from Clade A and the samples from the Indian Ocean hosted one phylotype of either A or C. According to these data, giant clams are highly specific implying that they select their symbiont populations to optimize the mutualism. This study describes *Symbiodinium* ecology, diversity and biogeography over the complete distribution of one host species.

## 26-56

**Zooxanthellae Diversity Of The Coral Pocillopora in The Pacific**

**Helene MAGALON*[1]**, Jean-François FLOT[2], Emmanuelle BAUDRY[3]

[1]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [2]Département Systématique et Evolution, Université Pierre et Marie Curie/Museum National d'Histoire Naturelle, Paris, France, Metropolitan, [3]Laboratoire Ecologie, Systematique et Evolution, Université Paris Sud, Orsay, France

Coral reefs are threatened by human impacts and global warming, leading to coral bleaching which involves the loss of the photosynthetic algae (zooxanthellae) living in symbiosis with corals. Reef resilience after disturbance depends largely on dispersal and colonisation abilities of corals, and also on the host-symbiont association. We focused on a major species of Polynesian reefs, the coral *Pocillopora meandrina*, whose mode of reproduction, dispersal and zooxanthellae identity were previously unknown.

Using ITS (Internal Transcribed Spacer) sequencing of zooxanthellae inhabiting different *Pocillopora* species (*P. meandrina*, *P. verrucosa*, *P. eydouxi*, *P. ligulata*, *P. molokensis*, *P. damicornis*) collected from different Pacific regions (Hawaii, Japan, French Polynesia and Tongas), we have shown that (1) *Pocillopora* hosts a symbiont type which is a generalist and present across a large geographical area, and (2) *P. damicornis* shows some flexibility in symbiosis, probably permitting its association with more thermotolerant zooxanthellae after a bleaching event and, thus, to better resist temperature rise.

More specifically, the study of *P. meandrina* symbionts using specific microsatellites shows (1) a high level of zooxanthellae diversity in symbiosis with *P. meandrina*, (2) a long-distance dispersal ability of zooxanthellae, and (3) a lack of correlation between host and symbiont population structures. This particular host seems to be able to reassociate with new zooxanthellae strains after a disturbance such as bleaching.

## 26-57

**Diversity of Symbiotic Algae (Zooxanthellae) In Zooxanthellate Corals From Temperate Japan**

**Yi-Ting LIEN*[1]**, Hironobu FUKAMI[1], Chaolun Allen CHEN[2], Yoh YMASHIDA[3]

[1]Kyoto University, Japan, Wakayama, Japan, [2]Acdemia Sinica, Taiwan, Taipei, Taiwan, [3]Kyoto University, Japan, Kyoto, Japan

6 types (A-D, F and G) of zooxanthellae (*Symbiodinium* spp.) have been identified from corals and clade D has been reported to enhance tolerance of corals to environmental change. In temperate zone, degree of the environmental change such as irradiance and temperature is much stronger than that of tropical and subtropical zones. In this study, we focused on the biogeographic diversity of zooxanthellae associated with reef coral communities in temperate waters of Japan to address the issue of environmental adaptation.

43 species from 24 genera in the zooxanthellate scleractinian corals were collected from 4 sites of temperate Japan. Symbiotic algae were isolated from corals and those DNA were extracted. DNA analyses were done using two markers, nuclear small-subunit ribosomal DNA (nssrDNA) and nuclear large-subunit DNA (nlsrDNA). The nssrDNA marker was used for restriction fragment length polymorphism (RFLP) to assay the zooxanthellae clade. The nlsrDNA marker was used to identify subclade within the zooxanthellae clade.

The RFLP analysis showed that *Symbiodinium* clade C was dominant in the corals in temperate zone as well as in tropical and subtropical zones. However there are two exceptions. One is *Alveopora japonica*, which distributes limitedly to the temperate zone and harbored *Symbiodinium* clades C and F simultaneously. Second, the widespread coral *Oulastrea crispata* contained symbionts belonging to clade D. *Symbiodinium* clades D and F might be species-specific symbionts or play a specific role in temperate zone.

Subclade analysis within clade C using nlsrDNA displayed that *Acropora* species in temperate zone harbored subclade C1, whereas some species in tropical zone have been reported to harbore subclade C3 in previous study. Thus, This study suggests that some coral may change symbiont composition to adapt temperate zone. Further research such as seasonal change of symbiont composition is being perused.

## 26-58

**Use of Molecular Tools To Identify Nongeniculate Coralline Algae**

**Maria GOMEZ CABRERA*[1]**, John PANDOLFI[1]

[1]Centre for Marine Studies, The University of Queensland, St Lucia, Australia

Nongeniculate coralline algae (NCA - Corallinaceae, Rhodophyta) are calcified red algae. They appear as pink to red inflexible crusts. These algae play a 'keystone' role in coral reef structure and functioning by binding reef material and enhancing the settlement of coral larvae and other species of invertebrates. NCA can also be indicative of specific habitats and can therefore be an indicator of community structure. Despite their importance in marine environments, especially coral reefs, this group has been relatively overlooked due to taxonomic difficulties. Most NCA species cannot be readily identifiable *in situ* by their external appearance. Samples must be processed in the laboratory to access the micro-structures necessary for their identification. Even where the necessary structures are present, old or damaged specimens cannot be relied upon for identification purposes. Also the key role of reproductive structures in their identification is problematic since reproductive plants are not always present *in situ*.

New molecular tools are emerging that can be used to assist with the identification of modern NCA. These have been used in conjunction with morphological characters to identify NCA and to establish possible phylogenies. DNA from morphologically identified specimens were extracted and several genes (*pbs*A, nSSU, 23S rRNA and COI) amplified and sequenced. Preliminary results suggest that a combination of these genes will give a more accurate relationship at terminal and distal nodes than each of it separately. *pbs*A and COI are more variable therefore provide better resolution at species level. Tests on vegetative plants and damaged specimens were positive. The capacity of identifying NCA using molecular tools will further ecological studies of these plants, including the specific role of individual species on the reef and the impact of anthropogenic influences on them.

## 26-59

**Molecular Phylogeny Of Marine Gobies (Gobioidei: Gobiidae: Gobiinae).**

**Zeehan JAAFAR*[1]**, Rudolf MEIER[1], L.M CHOU[1]

[1]Biological Sciences, National University of Singapore, Singapore, Singapore

The family Gobiidae is a speciose group of some 2000 small teleost fishes commonly known as "gobies". Whilst some are found in the mangroves and freshwater habitats, most occur in marine environs and many are coral reef dwellers. The taxonomy and phylogeny of gobies are problematic due varied forms, behavior, evolution by reduction and specialization. Phylogeny reconstruction of this sub-family thus far, have been restricted to morphological characters and limited taxa sampling. This study aims to elucidate the molecular phylogeny with about 100 representative taxa and four genes; RAG1, cytochrome b, CO1 and 16S. The most parsimonius phylogenetic tree of marine gobies is hereby presented. Rapid colonization of the coral reef ecosystem and specializations, with regards to symbiotic relationships with various coral reef inhabitants, are shown to have independently evolved several times throughout evolutionary history.

## 26-60

**The Biogeography Of Damselfish Skull Evolution: A Major Radiation Throughout The Indo-West Pacific Produces No Unique Skull Shapes**

**W. James COOPER*[1]**

[1]Biology, Syracuse University, Syracuse, NY

Damselfishes (Pomacentridae, Perciformes) occupy all coral reefs and are known to have inhabited these ecosystems for at least 50 million years. The Indo-West Pacific (IWP) is currently home to a large portion of the living damselfish diversity, and contains species from twenty-four of the twenty-nine extant genera. Phylogeographic evidence indicates that much of this diversity, including sixteen genera and approximately half of all pomacentrid species, belongs to a single branch of the damselfish tree that diverged shortly before the closing of the Tethys seaway 12-18 million years ago. A strong majority of these species can only be found on coral reefs, and this lineage represents a major radiation of coral reef fishes within this region. Although this clade constitutes a large component of the damselfish diversity, the results of morphometric analyses indicate that it does not contain any species with unique cranial shapes, and the results of permutation tests revealed that the morphological diversity of the skulls of these fishes is significantly less than that of damselfishes from the other branches of the pomacentrid radiation. The damselfish skull shapes that are not represented among these closely related IWP genera belong to fishes that inhabit rocky reefs in other parts of the world. Many of these species live in temperate waters, and several are considerably larger than their tropical relatives. If only species from predominantly coral reef genera are compared, then there is no significant difference in skull shape diversity between fishes from the strictly IWP genera and damselfishes from other clades. The damselfish radiation can be characterized as containing numerous examples of morphological and trophic convergence, such that a major expansion among the coral reefs of the IWP has produced no unique examples of skull anatomy.

## 26-61

**Planktivory in Genicanthus Angelfishes (F. Pomacanthidae): Reversal Of A Functional Innovation During Transition Between Feeding Strategies.**

**Nicolai KONOW*[1]**, Peter WAINWRIGHT[2]

[1]Department of Biology, Hofstra University, Hempstead, NY, [2]Section of Evolution & Ecology, University of California, Davis, CA

Marine angelfishes of the family Pomacanthidae all have a novel intramandibular joint in the lower jaw, resulting in a unique gape-closure mechanism which is functionally linked with trophic shifts into biting dislodgement of robust and sturdily attached reef-building invertebrates. Never the less, several angelfish taxa are capable of functional reversal to suction-feeding – the basal piscine feeding mode – and engage in planktivory. The fact that these taxa retain the capability of detaching prey from the substratum using a powerful bite suggests that their jaw mechanics may govern considerable functional versatility. This hypothesis was tested by comparing feeding apparatus motion during biting and suction feeding in the angelfish *Genicanthus melanospilos* with the feeding apparatus motions in an obligate biting sister-taxon *Centropyge (Xiphypops) bispinosus*. We found comparable biting motions in these taxa, lending functional support to their phylogenetic sister-status. Meanwhile, differences between biting and suction-feeding in *Genicanthus* exceeded previous measures of vertebrate feeding behavioural modulation. Intramandibular joint flexion was diminished during suction feeding and shifts in timing of the jaw-closure stages between feeding modes were key differentiating variables, suggesting that intramandibular joints actually are disadvantageous for other than biting feeding activity. Trophic reversal to planktivory commonly occur among coral reef fishes, e.g. in wrasses, serranids, butterflyfishes and damselfishes, but has not previously been shown to involve extensive modulation of feeding apparatus motion. Reduction of intramandibular flexion in *Genicanthus* during suction-feeding therefore provides an important example of the close links between structural innovations and associated behavioural changes that in turn may affect evolutionary diversification. Intramandibular joints may in fact couple their bearers into biting strategies, thus constraining diversification across alternative trophic strategies. Herein, the evolutionary role of these novel joints differs from the roles of previously quantified functional innovations, e.g. in the labroid feeding apparatus, which have prompted species-radiations by increasing functional versatility.

## 26-62

**Comparison Of Larval Fish Richness Between A Coral Reef Zone And Open Waters in Gorgona Island (Colombia), Eastern Tropical Pacific.**

**José GARCÍA*[1]**, Luz Ángela LÓPEZ DE MESA[1,2], Alan GIRALDO[1]

[1]Biología, Universidad del Valle, Cali, Colombia, [2]Marine Biology, Universidad del Valle, Cali, Colombia

Monthly ichthyoplankton samples were collected in Gorgona Island (Colombia), western tropical Pacific, during September 2005 and August 2006 in a coral reef station (CRS) and an open water station (OWS). CRS was located in La Azufrada coral reef, while PWS was located in open waters (5 km away from shore) near La Azufrada. Samples were collected using a 30 cm diameter plankton net with 250 μm mesh equipped with a flowmeter. Oblique tows were made at different depths, varying according to the site (<50 m). Enviromental parameters were monthly measured for each station.

Ichthioplankton composition and distribution was estimated through space and time. Family diversity results were correlated with enviromental parameters for each station.

19 families were identified (Cotidae, Labridae, Lutjanidae, Muraenidae, UN (unidentified), Trichiuridae, Congridae, Carangidae, Ophiididae, Gobiesocidae, Paralychthidae, Myctophidae, Haemulidae, Serranidae, Pomacentridae, Gerreidae, Scianidae, Engraulidae, Gobiidae) in 353 larvae. Only 8 families presented abundances greater than 10 individuals. Gobiidae presented the greatest abundance (128) and occurrence (8 months). There was no significant difference in family richness (CRS=15, OWS=13) and abundance (CRS=165, OWS=188) between stations. Differences in family compositions were found between months and between stations. Carangidae, Cotidae, Labridae, Ophidiidade and Trichiuridae were exclusive for CRS, while Congridae, Gobiesocidae, Muraenidae and Lutjanidae were exclusive for OWS.

Increase of fish larval abundance was observed on November and June in OWS, and on December in CRS. On November and June fish larvae were found only in OWS. These results were related to reproductive behavior of observed families and to abiotic factors of the zones.

## 26-63

**Life-History Traits Of Rare Coral Reef Fishes Of The South Pacific Region.**

**KULBICKI MICHEL*[1]**, **VIGLIOLA LAURENT*[2]**, WANTIEZ LAURENT[3], MOUTHAM GERARD[4], GALZIN RENE[5]

[1]Marine Biology, IRD, Perpignan, France, [2]IRD, Plouzane, France, [3]Marine Biology, UNC, Noumea, New Caledonia, [4]Marine Biology, IRD, Noumea, New Caledonia, [5]Tropical marine biology, EPHE, Perpignan, France

Rare species are thought to play a significant role in the delivery of several ecosystem services, in particular resilience to perturbations. However, very little is known on the life history characteristics of these species, especially for coral reef fishes. Here, we characterized diet, size and geographic distribution of rare coral reef fish species of the South Pacific from the analysis of a large data set collected by underwater visual censuses and containing nearly 500 000 fish records along a geographical gradient going from New Caledonia to French Polynesia. Species were considered rare when recorded less than once every 1000 fish records. Results revealed that rare species tended to have smaller geographic distribution than common species. Rare species geographic distribution tended to increase with island isolation and oceanic influence but decreased with island size. Rare species also displayed larger average sizes than common species. Carnivorous and piscivorous species were more frequent amongst rare than amongst common species. The proportion of rare species was not linked to gamma diversity and only weakly correlated to alpha diversity. Large scale factors (island size, island isolation, latitude, and distance to the center of biodiversity) had little influence on the proportion of rare species. These findings suggest that perturbations affecting rare species would affect rare functional groups some of which may be essential to the functioning of reef fish assemblages.

## 26-64

**Ecological Determinants Of Variable Body-Size Distributions in Atlantic Reef Fishes**

**Osmar LUIZ JR.* [1]**, Sergio FLOETER[2]

[1]Dept. of Zoology, Universidade Estadual de Campinas, Campinas, Brazil, [2]Lab. of Marine Macroecology and Biogeography, Universidade Federal de Santa Catarina, Florianópolis, Brazil

The frequency of animal body-size distributions generally is right-skewed in continental assemblages, meaning that there are more small-bodied than large-bodied species. Several theories were developed to explain this pattern: (1) fractal geometry of habitat structure offering more niches for smaller species; (2) an energetic optimum body size where fitness is maximized; (3) higher rates of speciation of small-sized species and greater extinction of large species. At the local scale, assemblages have more variable distribution of body-sizes, retaining the right skewness or becoming normal log-distributed. Testing the factors that potentially correlate with this variability may generate insights on what determines the right skewed body-size distributions. We analyzed the body size distributions of 1,200 species of fishes distributed on 29 reef localities in the Atlantic over a broad latitudinal range (40°N to 30°S). The skewness of each body-size distribution was plotted against gradients of variables namely: sea surface temperature (SST), latitude, distance from the mainland, fish and coral species richness. Contrary to expectations that the variability of local assemblages is driven mainly by Bergmann's rule, skewness of body-size distributions was not significantly correlated with latitude or SST. Instead, it was positively correlated with coral and fish richness. Coral reefs have great habitat complexity and this probably provides additional niches for small species, which could be explained by the hypothesis 1. The correlation of skewness with fish diversity suggests that small species dominate richer assemblages. The species/genus ratio is higher for small-sized than bigger genera only at highly diverse coral reefs, thus hypothesis 3 was supported in part when associated with hypothesis 1.

## 26-65

**Structure of reef fish assemblages on coral and rocky habitats of the tropical eastern Pacific: are coral reef fish assemblages really so diverse and distinctive?**

Adriana ALZATE-VALLEJO[1], **Fernando A. ZAPATA*[1]**

[1]Department of Biology, Universidad del Valle, Cali, Colombia

Traditionally, reef fishes have been considered as circumtropical assemblages clearly linked to coral reefs. However, reef fish assemblages also occur on rocky reefs around the world and notably on temperate coasts. Previous comparisons indicate that tropical (coral) reef fish assemblages support at least one order of magnitude more species, which tend to attain smaller body sizes, have a smaller proportion of viviparous species, and more planktivores and herbivores than temperate (rocky) reef fish assemblages. Such differences have been attributed partly to fundamental differences in habitat characteristics, particularly the nature of hard substrates. To examine whether coral and rocky reef fish assemblages have a distinctive structure, we performed a comparative study at a single locality in the Tropical Eastern Pacific (TEP), effectively removing latitudinal and regional confounding effects inherent in previous comparisons. Data were collected through standardized visual censuses within coral (N = 53) and rocky habitats (N = 42) at Gorgona Island, Colombia. Analysis of similarity and non-metric multidimensional scaling among censuses based on both species composition and abundance showed two distinct clusters corresponding to each habitat. Of the 93 species observed in either habitat 47.3% were common to both habitats, while 15.1% and 37.6% were exclusive of coral and rocky reefs, respectively. Contrary to expectation, the coral reef fish community was significantly less species rich (S=58) and less diverse (Shannon H'=1.82) than the rocky one (S=79, H'=2.63). Ten of 15 species compared attained smaller sizes on coral reefs. However, the abundance distribution, trophic structure and frequency of reproductive modes were similar between habitats. Although TEP coral reef fish assemblages are less diverse, they exhibit a distinctive assemblage structure in spite of the greater availability of rocky habitats and thus a greater opportunity for the evolution of a closer habitat association with them.

## 26-66

**Species-Area Relationship in Damselfish Assemblages On Small Patch Reefs in A Shallow Shore Zone Of Ishigaki Island, Okinawa, Japan**

**AKIHISA HATTORI*[1]**, TAKURO SHIBUNO[2]

[1]FACULTY OF EDUCATION, SHIGA UNIVERSITY, OTSU, Japan, [2]ISHIGAKI TROPICAL STATION, SEIKAI NATIONAL FISHERIES RESEARCH INSTITUTE, ISHIGAKI, Japan

In assessment of habitat quality for resident reef fishes, patch reef based species-area relationship must be useful, because the area of a patch reef is crucial in receiving stochastic recruitment and settlement of the fishes. Species-area relationship (SPAR) of damselfishes was examined on 84 patch reefs in a small spatial scale (45.4 m2-0.05 m2) at a very shallow back reef (<2 m deep), Ishigaki Island, Okinawa, Japan. Detailed maps (1/2500), which were made using an enlarged high resolution aerial photograph, were used for data collection. Coral coverage and area of inter-specific territories of herbivorous damselfishes (*Stegastes*) were also measured. Random placement simulations will be conducted to evaluate the effects of random settlement on SPAR in the very small spatial scale. Although a significant log-log liner relationship was found, we used semi log SPAR because of small species richness (S=24) and higher coefficient of determination: S = 4.994 + 4.675 × log10 (REEF AREA), $R^2$ = 0.6804. The territorial herbivores were abundant in large reefs, while they were not found in small reefs. The influence of territorial herbivores on SPAR will be discussed. As coral coverage was relatively low in this study site (0.319 on average, range = 1-0), survival rates of recruits after random settlement might have been lower on large reefs probably due to the interspecific interactions. Considering multicollinearity, multiple regression analysis reveals the most accountable regression: S = 3.64 + 3.37 × log10 (REEF AREA) + 4.45 × CORAL COVERAGE +4.60 × log10 (REEF AREA) × CORAL COVERAGE, $R^2$ = 0.7552. As habitat patch abundance is incorporated, this methodology can be more useful than ordinary line census techniques for the local assessment of habitat quality especially in shallow coral reef shore zones.

# Poster Session

## 1.1

**Fringing-Reef Geomorphology and Facies controlled by hurricanes at Punta Maroma, Mexico.**

**Sócrates IBARRA-FERNÁNDEZ*[1]**, Paul BLANCHON[2]

[1]Oceanographic Research Station of Progreso, Secretary of the Navy, Merida, Mexico, [2]Inst. of Marine Sciences & Limnology, National Autonomous University of Mexico, Cancun, Mexico

Geological investigation of modern reef tracts using drill-cores has invariably assumed that coral communities seen on the surface should also be encountered in facies from the reef interior. Implicit in this fair-weather view of reef development is that storms merely interrupt community succession and leave little trace in the reef's geological record.

Here we challenge that notion using satellite imagery and a transect of 12 closely-spaced cores from a fringing reef off Punta Maroma in the northeast Yucatan Peninsula. We find that the distinct community depth zones across the crest and proximal reef-front are underlain by a uniform facies type consisting of a medium-cobble coral gravel with sparse in-place colonies of Acropora palmata. The only variable is the degree of encrustation by Homotrema rubrum which increases slightly at the crest. Satellite images show that the reef-crest is located a uniform 300 m distance from a mid-shelf slope break at 10 m below msl.

These findings support a hurricane control on reef development. Decimetre-sized storm waves crossing the shelf are tripped by the mid-shelf slope break and spill over shallow reef-front communities destroying in-place coral thickets and producing a layer of cobble gravel that culminates in a submerged ridge deposited at mean sea-level. Between storms, the ridge and rubble sheet are re-colonized by similar coral communities with a similar depth zonation, thereby completing the cycle.

## 1.10

**Distribution Of Clionid Sponges in The Florida Keys, 2001-2005**

**Michael CALLAHAN*[1]**

[1]FWC/Florida Fish and Wildlife Research Institute, St. Petersburg, FL

Clionid sponges can be aggressive coral bioeroders and effective spatial competitors. In 2001, the Coral Reef Evaluation and Monitoring Program (CREMP) began monitoring the abundance and area covered by three clionid sponges (*Cliona delitrix*, *C. lampa*, and *C. caribbaea*) throughout the Florida Keys National Marine Sanctuary (FKNMS) and the Dry Tortugas. Three 1-meter wide belt transects, centered on the existing CREMP video transects, were used to delineate the clionid survey area for an individual station. For each clionid colony within the 1-meter wide belt transect, the surface area (m2) and stony-coral species affected was recorded. Surface area was measured using a 40 cm2 quadrat frame divided into 5 cm2 grids. Results are reported for 109 CREMP stations including offshore shallow (39), offshore deep (34), and patch reef (36) stations. For all 109 CREMP stations surveyed, mean clionid area (cm2/m2) decreased significantly from 7.9 cm2/m2in 2001 to 4.9 cm2/m2in 2002 (Wilcoxon rank sum p= 0.04). However, mean clionid area steadily increased between 2002 (4.9 cm2/m2) and 2005 (6.5 cm2/m2). High clionid area (~20 cm2/m2) was recorded consistently only at Lower Keys patch reef stations during all four years. The back-country patch reef stations had high mean clionid area, but with high variability between years. Of the three clionid species, *C. delitrix* was the most common species, accounting for approximately 80% of the recorded observations. Among the recorded stony coral species, *Montastraea annularis*, *Montastraea cavernosa*, and *Siderastrea siderea* were the most frequently and extensively invaded by clionid colonies. However, it is important to note that the majority of clionid colonies occurred in substrata not associated with a live coral colony.

## 1.11

**Sediment transport pathways on a fringing reef based on taphonomic alteration of larger benthic foraminifera *Baculogypsina sphaerulata***

**Murray FORD*[1]**, Paul KENCH[1]

[1]School of Geography, Geology and Environmental Science, The University of Auckland, Auckland, New Zealand

Determining sediment transport pathways on coral reefs is essential in understanding the delivery of sediment to shorelines considered increasingly vulnerable to the affects of sea-level rise. Traditional approaches involve the use of tracer grains; grains of sediment identifiable by a user applied characteristic or by geological/biological origin. Foraminifera have been used successfully as sediment tracers in the past by following a source to sink methodology where both the habitat and deposition zones of the target species are determined. Such approaches generally take a snapshot in time and interpret pathways based on this. Essentially a black box this methodology offers little detail in terms of the time scale of processes between source and sink. The key objective of this study was to determine whether the observed patterns of taphonomic alteration of foraminiferal tests can be used as a proxy for the degree of transportation. A series of tumbling barrel experiments were used to simulate abrasion as a result of transportation on the tests of larger benthic foraminifera *Baculogypsina sphaerulata*. Image processing and analysis techniques were used to determine shape change through time. Tests exhibit a predictable non-linear trajectory of shape change based on exposure to abrading forces. Tumbling barrel results were then compared to observed patterns of alteration of tests from surfical samples to determine the sediment transport pathways on Coconut Reef, Great Barrier Reef. This poster presents the approach undertaken using *B.sphaerulata* tests and the implication of this on the delivery of sediment to the shoreline adjacent to Coconut Reef.

## 1.12

**A Comparison of Rates and Styles of Bioerosion With Varying Sedimentation: Holocene Reefs in the Western Dominican Republic versus Modern Reefs off St. Croix, USVI**

**Andrew ESTEP*[1]**, Timmons ERICKSON[1], Dennis HUBBARD[1]

[1]Geology, Oberlin College, Oberlin, OH

While the importance of bioerosion in reef building has been generally accepted, we are just beginning to appreciate the potential of bioerosion patterns as possible paleo-ecological indicators. A systematic study of the nature and intensity of infaunal bioerosion was conducted on two modern reefs off St. Croix and two fossil Holocene reefs exposed in the western Dominican Republic.

Samples of dead *Montastraea* spp. were collected at 10-ft depth intervals along three transects on St. Croix (max = 80 ft). In the Dominican Republic, fossil *Siderastrea* spp. *Montastraea* spp. colonies were recovered at regular intervals along a time surface buried rapidly by storm debris. These colonies were presumed to have been dead at the time of burial based on surface taphonomic characteristics. The age and elevation of each coral were used to assign paleo-depth for comparisons with modern corals. Bioeroded samples were slabbed and scanned at high resolution. Bioerosion galleries were traced and color-coded using Adobe Photoshop. Area measurements of each type of gallery were tabulated within the bored coral rim using ImageJ, and were reported as a percent within the bioeroded rim (i.e., not the entire colony).

Significant differences were identified in both the extent and type of bioerosion within the open and exposed reefs off St. Croix and the more protected reefs within Bahia Enriquillo. Total bioerosion off St. Croix ranged consistently between 10 and 20% or less, and was dominated by sponges that left large galleries or complexes of smaller ones. In the DR reefs, bioerosion was much greater (20-60%), and was dominated by molluscs (mostly *Lithophaga*) and large sponges. Worms were minor players (<2%) at both sites. The greater bioerosion and the importance of large molluscs in the Bahia Enriquillo reefs are consistent with an interpretation of higher sedimentation and nutrient levels in these reefs.

## 1.13

**Depth-Related Patterns of Infaunal Bioerosion in Two Modern and Two Fossil Caaribbean Reefs: US Virgin Islands and the Dominican Republic**

**Timmons ERICKSON*[1]**, Andrew ESTEP[1], Dennis HUBBARD[1]

[1]Geology, Oberlin College, Oberlin, OH

Reef-accretion studies often focus on coral growth and underestimate the importance of bioerosion. Recent findings suggest that not only is bioerosion an important part of the accretion equation, but that bioerosion and sediment export might strongly impact depth-related patterns of reef building. However, studies of depth-related bioerosion within individual reefs are generally lacking. Boring was quantified along a depth gradient in two modern reefs (St. Croix: d = 3-10m; 3-27m) and two Holocene reefs (Dominican Republic: d = 5-22m). In over 40 slabbed samples, galleries were traced and categorized. Total area for each major bioeroder group (molluscs, various sponges, worms) was measured within the outer bioeroded rim of the corals using NIH ImageJ.

The St. Croix reefs are exposed to higher energy and lower sedimentation than those in the DR. This is reflected in a difference in the infaunal community at the two sites (*Lithophaga* sp. in the DR versus sponges on St. Croix). Worm burrows are of minor importance. The intensity of infaunal bioerosion on St. Croix is largely bimodal, with maximum rates occurring near 6m (20-30%) and dropping abruptly to 5-15% beyond. However, boring generally increases within the offshore samples from ~5% (10m) to ~15% (27m). In the fossil DR reefs, total bioerosion is likewise bimodal, with rates of 40-60% in samples from paleodepths of 5-8m. Between 11 and 22m, total bioerosion ranged from 20 to 30 percent. If sponges are considered alone, a pattern similar to what was seen on St. Croix emerged.

This study provides only a snapshot of the final product. Similar studies addressing rates of bioerosion by both grazers and infaunal borers will be needed to complete the picture. Nevertheless, this study does show that higher rates of bioerosion correlate with increased levels of nutrient availability either between sites or along a depth gradient.

## 1.14

**The Role Of Constituent Durability On The Sediment Budget Of A Fringing Reef, Lizard Island, Great Barrier Reef**

**Murray FORD*[1]**

[1]School of Geography, Geology and Environmental Science, The University of Auckland, Auckland, New Zealand

Tropical landforms associated with coral reefs such as reef islands and coastal plains are often made entirely of carbonate sediments derived from surrounding reefs. Consequently, sediment supply has a direct control on the development of such landforms. Sediment is produced through the mechanical and biological erosion of the reef framework and reef dwellers. The exchange between gross reef productivity and the production of sediment is poorly understood. This is considered a 'black box' where the inputs and outputs are well understood, but little is known of the internal workings of the system. Furthermore, there is a dearth of knowledge regarding the fate of sediments produced on reefs. This has significant implications for landforms adjacent to reefs. The objective of this study is to enhance the understanding of the role durability plays in the determining the composition of reef flat sediments and the implications of this on sediment budgets and the availability of sediment for land-building processes. This objective is addressed utilising both a detailed field investigation and through rigorous laboratory experiments. Tumbling barrels were used to determine the durability of six common constituents of sediment from a fringing reef on Lizard Island, Great Barrier Reef. Each constituent was tested in tumbling barrels and the coefficient of durability determined. The results of these experiments show the durability of common sediment constituents vary on several orders of magnitude. The implications of this investigation are discussed within the context of the sediment budget and the availability of sediment for landform building processes.

## 1.15

**Response of soft-bottom macrobenthic coral reef communities to hurricane disturbance (Reunion Island, Western Indian Ocean)**

**Dorothée TADDEI*[1]**, Lionel BIGOT[1], Heloïse ROUZE[2], Patrick FROUIN[1]

[1]Biology, ECOMAR Lab, University of Reunion Island, Saint Denis cedex 9, Reunion, [2]University of Bretagne, Plouzané, France, Metropolitan

The impact of hurricane GAMEDE on soft-bottom macrofauna was evaluated in the three main fringing reefs (St Gilles / La Saline, Etang Salé and St Pierre) of Reunion Island (Western Indian Ocean). This baseline study of the macrobenthos will be used as part of a global survey of the main soft-bottom areas recorded at Reunion Island. Sediment (grain-size, total organic load and chlorophyll load) and community (diversity and density) variables were studied during a warm season before and after the passage of the hurricane GAMEDE in 2006. Communities of each fringing reef are poorly diversified (H' = 2.23) characterized by abundant Actiniarian (*Edwardsia* spp.) with more than 60 % of total abundance for some stations. Macrobenthic abundance did not vary significantly after the hurricane disturbance despite slight changes occurred in the most hydrodynamically exposed stations. Inversely community composition was affected by a decreasing of diversity. The environmental factors could not explain the macrofauna spatial variability as they showed different patterns of variability. The study finally suggests that: 1) the fringing reef ecosystem is resistant despite subject to disturbance (hurricane); 2) this stability is related to low diversity with species well adapted to strong hydrodynamism; 3) a slight impact of the hurricane can be show on the most exposed environments.

## 1.16

**Late Quaternary Deposits On The Southern Belize Shelf: How Does The Mixed Carbonate-Siliciclastic Succession Record Pleistocene Sea-Level Variation?**

**Eberhard GISCHLER*[1]**, Robert GINSBURG[2], Sachandra PRASAD[2]

[1]Geosciences/Geography, Johann Wolfgang Goethe University, Frankfurt am Main, Germany, [2]RSMAS-MGG, University of Miami, Miami, FL

The shelf of Belize (Central America) is a classic example of mixed carbonate-siliciclastic system, which receives carbonate from the reefs and siliciclastics from the hinterland. Six cores from the shelf of Belize are composed of coral grainstone and boundstone, mollusk-foraminiferal wackestones and packstones, a variety of marls and clays, dolomite, and rare quartz and shell-rich layers. The cores are between 67.7-105.8 m long and have a total thickness of 529.5 m. In contrast to cores taken in the fore reef of the Belize Barrier Reef close-by, which apparently recorded glacio-eustatic sea-level variation since marine isotope stage 11 by more or less regular fluctuations in carbonate content and composition (Droxler et al. 2003), our Belize shelf core exhibits no clear successional patterns or rhythms. Limestone sections, interpreted as being deposited during highstands, and marls, clays and sands, considered as lowstand deposits, alternate in a very irregular way. Thick limestone deposits predominate the upper core sections down to 40-50 m below present sea-level. This section can be subdivided in a Holocene and late Pleistocene part, based on preservation. Interestingly, no siliciclastics occur between Holocene and Pleistocene limestones. Below these carbonate sections, brownish, reddish, gray and black marls and clays occur, which reach thicknesses of 20-40 m. Underlying the siliciclastic deposits, mollusk-foram packstones and wackestones, and fine-grained dolomite marls predominate. No traces of subaerial exposure were found in the cores. The interpretation of the shelf successions in the light of late Quaternary climate and sea-level fluctuations will strongly depend on radiometric and biostratigraphic dating, which is currently underway. A limited number of aragonitic corals are being dated by the U/Th-method and calcareous nanoplankton in fine-grained limestone, marls and clays is investigated for biostratigraphy. Results will be available by the time of the ICRS 2008 and will be presented together with the sedimentological data.

## 1.17

**Carysfort Reef, Key Largo, Florida Keys Is Melting**

**Phillip DUSTAN*[1]**

[1]Department of Biology, College of Charleston, Charleston, SC

The latest reports on the state of the world's coral reefs are tragic. At least one quarter of known reefs are in seriously degraded and over half are seriously threatened. Photographs, taken from the same vantage point from 1975 to 2004, illustrate the rapid degradation of coral reefs that has occurred throughout the Florida Keys and Caribbean Sea. Carysfort Reef, once the largest, most diverse and luxuriant reef in the Florida Keys, has lost over 92% of its living coral cover. The factors responsible for this degradation include an accumulation of simultaneous, synergistic, nested stresses operating at local to global scales (fishing, anchor/grounding damage, watershed effluents from urban, agriculture, and industry; global warming and ocean acidification). While this complex milieu makes it extremely difficult to determine the contribution of each stressor, the impact has been catastrophic.

In 1975 the Acropora palmate zone consisted of large colonies oriented into the prevailing seas, typical throughout the Caribbean. The high degree of three dimensional complexity provided habitat for a wide variety of reef fishes and invertebrates. By 1985, some of the A. palmata colonies had suffered physical damage from boat groundings and storms. Large fragments were strewn about and decreased urchin grazing allowed for increased growth of macroalgal turf communities. In 1995, the reef structure continued to degrade, coral cover was below 5%, and scleractinain corals ceased providing any significant contribution to reef framework. By 2004, bioerosion had dramatically reduced the reef's three-dimensionality and softly rounded the remaining rubble fragments. Dead skeletons of the once dominant Elkhorn coral appear to be melting as they are rapidly converted to carbonate sand. Observations based on the remnants of cement bore-hole fillings suggest that rates of bioerosion match or exceed rates of past skeletal growth, but in the opposite direction.

## 1.18

**The Effect Of Marine Protection On Carbonate Sediment Production in St. Croix, Usvi**

**Alex BURPEE*[1]**, Lisa GREER[1], Robert HUMSTON[2], Dennis HUBBARD[3]

[1]Geology, Washington and Lee University, Lexington, VA, [2]Biology, Virginia Military Instiute, Lexington, VA, [3]Geology, Oberlin College, Oberlin, OH

Previous research has shown that marine preserves contain greater densities of predators, parrotfish, and live coral than unprotected reefs, as well as decreased densities of algae. These biological differences associated with reef protection affect carbonate sediment production on a reef by altering the relative densities of grazers present (parrotfish and *Diadema antillarum*), as well as the balance of coral and algal cover. However, it is not generally understood how altering the two grazer populations might affect sediment production by bioerosion. In St. Croix, a protected site at Buck Island (BI) and an unprotected site at Tague Bay (TB) were used as study areas to explore the effect of coral reef management on the reef carbonate budget. The sites sit on opposite sides of a channel and are separated by only 5 km. Duplicate 10-minute predator and grazer counts were compiled along two 10 m transects at 7.5 m, 4.5 m, and 2 m depths for each of the 3 locations at both BI and TB. The primary bioeroders included 7 species of parrotfish, and *Diadema antillarum*. Survey data show statistically significant differences in grazer densities between the two sites (2,286 parrotfish and 400 *Diadema* at BI versus 1,507 parrotfish and 3,123 *Diadema* at TB). Although the grazer populations are very different, initial analyses based on previous estimates of sediment production by individual fish and urchins show that the difference in sediment production caused by these grazers is not as different. Efforts are ongoing to determine how present-day sediment production rates at the two sites compare to those associated with the reefs prior to their degradation by fishing, disease, hurricane stress, and nutrification. Hopefully these will allow us to compare patterns of carbonate cycling in pre- and post-decline reefs to fossil reefs.

## 1.19

**A Possible Epibiont Signature for White Band Disease and/or Bleaching in Acropora palmata, Buck Island National Monument, St. Croix, USVI**

**Anne LAGOMARCINO*[1]**, Dennis HUBBARD[1]

[1]Geology, Oberlin College, Oberlin, OH

The role of poster-child for recent reef decline is shared by White Band Disease and bleaching. Monitoring has documented the catastrophic decline of *Acropora palmata* and numerous other species, but is an ineffective way to understand change in the context of longer-term community turnover. With *A. palmata*, both stressors share one important characteristic that separates them from the common and presumably "natural" cause of death. Storm action reduces colonies to rubble that either recruits asexually or dies and is bound into the substrate. In contrast, disease and bleaching leave the colony standing and subject to increased grazing and encrustation. Over 150 colonies of standing, dead colonies of *A. palmata* were collected from two sites off Buck Island, where White Band Disease was first described. At the same sites, samples were recovered from 1-2 meter deep pits that were dominated by broken, toppled and encrusted branches. As a pilot study, a subset of 15 "standing-dead" and 15 "pit" samples were chosen randomly from the larger group at one site. Each was impregnated with epoxy, slabbed and cut into large-format thin sections. The relative importance and order of ebibionts were quantified along ten randomly chosen transects on each slide. Cluster analysis and Bray-Curtis ordination revealed two clusters that separate standing-dead and pit samples. Within these clusters, thick and conformable coralline algae, vermetid gastropods and worm tubes were statistically more abundant on the standing dead colonies ($\alpha = 0.05$), while *Carpenteria utricularis*, *Biarritzina carpenteriaeformis* and high-relief morphs of *Homotrema rubrum* were more common within the pits. While this is only a subset and we still have to examine our reef cores in the intervals where *A. palmata* apparently had difficulty in the past, the differences described here involve easily distinguished organisms that have a high potential for preservation in cores and Quaternary outcrops.

## 1.2

**Results of Scleractinian and Reef Investigation Conducted 1983-1984 in Southeastern Mexico**

**Vassil ZLATARSKI*[1]**

[1]Independent Consultant, Bristol, RI

From 1983 to1984, the Center for Advanced Studies and Research in Mérida, Yucatán, Mexico (CINVESTAV-Unidad Mérida) conducted an extensive study of scleractinians in southeastern Mexico. The results were not published. The aim of this work is to preserve the unique information of two dozen years ago regarding species richness, community data and the scleractinian role in building different reef types and to make it available for better reef understanding and preservation.

The area of investigation included waters all around the peninsula of Yucatán, from Cayos Arcas to the border of Belize. Scleractinians were the object of day and night scuba diving, from the coast to a depth of 60 m on the shelf edge, in transects with 141 sites and 168 stations. 4, 579 coralla were collected and identified. 630 color pictures were taken, from which 231 were selected for an atlas. In 1985, CINVESTAV donated 801 coralla to the Smithsonian Institution in Washington, D.C., and these remain well preserved. With the exception of three azooxanthellate species identified by Dr. S. Cairns, the rest were identified by the author. The species presence and their participation in reef formation were given for each site and station. In total 42 species and one hybrid of 27 scleractinian genera were determined and four reef types were established.

In 1983-84, the severe negative impact of oil exploitation was evident in Cayos Arcas. Poorly conducted tourism and fishing damaged the reefs in Cozumel, Punta Brava and Isla Mujeres. Scleractinian health did not show significant anomalies. No epizootic phenomena were established. Recruits frequented non-damaged locations.

The results offer a quarter-century baseline for prognosis and recommendations concerning reefs in southeastern Mexico.

## 1.20

**Grain Size And Sedimentary Constituents As Indicators Of Changing Environments And Energy Levels in Smugglers' Cove, St. Croix, U.s.v.i.**

**Matthew KLINMAN*[1]**, Sarah CHAMLEE[2], Selina TIRTAJANA[3], Donald BARBER[1], Donald POTTER[2], Karla HUBBARD[4], Dennis HUBBARD[4]

[1]Geology, Bryn Mawr College, Bryn Mawr, PA, [2]Geology, University of the South, Sewanee, TN, [3]Earth & Environmental Science, Wesleyan University, Middletown, CT, [4]Geology, Oberlin College, Oberlin, OH

Twelve 1.5-3.0m vibrocores (diameter = 7.6 cm) were taken along two shore-perpendicular transects in Smuggler's Cove, St. Croix (US Virgin Islands) to understand the development of the lagoon and possible changes in major environments (primarily open and bioturbated sand versus grassbeds with little or no burrowing) over time. Surface samples were also taken along a third transect to provide a more systematic view of onshore-offshore patterns of grain size, organic content and sedimentary constituents as a result of both position in the lagoon and lagoon-bottom character. Grain-size analyses were completed on the surface samples and at 20-cm intervals throughout all the cores. Thin sections of the sand fraction were used to characterize sedimentary constituents. Terrigenous content in both the sand and mud fractions were determined using a Magnetic Susceptibility Meter, a $CO_2$ Coulometer combined with loss-on-ignition analysis, and digestion using HCl and Hydrogen Peroxide. Additional work was done analyzing diatom species composition down-core. The depth of a hard antecedent surface in the deepest cores indicates that deposition in the lagoon began between 7,000 and 6,000 years ago when rising sea-level initially flooded the surface. Assuming a constant rate of sedimentation, the lagoon deposits accumulated at rates of 0.4 – 0.6 m/ky. In the sand fraction, terrigenous input is typically confined to areas very close to the beach; terrestrially derived mud has a broader impact. Antecedent topography plays an important role in both flooding history and the relative impact of the developing reef. Changes in both constituent types and grain size within the carbonate fraction appear to reflect highly variable conditions, but show a general reduction in wave energy and some shifting of environments as Tague reef developed. Elevated levels of total carbon in all the surface samples may reflect increased runoff from recent upland development.

## 1.21

**Preservation Potential Of Lagoon Faunas And The Role Of Deep Bioturbation in Shell Bed Formation**

**Caitlin TEMS*[1]**, Ashley BURKETT[2], Karla HUBBARD[3]

[1]Geology, Colorado College, Colorado Springs, CO, [2]Geology, Muskingum College, New Concord, OH, [3]Geology, Oberlin College, Oberlin, OH

Twelve 1.5-3.0m vibrocores (diameter = 7.6 cm) were taken along two shore-perpendicular transects in Smuggler's Cove, St. Croix (USVI) to address the preservation potential of lagoon environments and to understand patterns and processes of shell bed formation. Molluscs were sampled from three common lagoon environments: seagrass beds, open carbonate sand, and areas affected by burrowing callianassid shrimp. Mollusc samples near the surface were used to establish the community structure of each environment, and all shells were further characterized by taphonomic condition. Previous work has established that lagoon environments can be recognized by the taphonomic condition of the molluscan community without regard to taxonomic composition.

Results from the cores indicate that shell beds were not as common a feature in the subsurface of the lagoon as has been previously assumed. Most cores had very few shell beds greater than the thickness of any single shell. This was true in both areas with and without obvious burrowing activity. However, the bottom of nearly every core that reached the hard antecedent subsurface (pre-Holocene?) exhibited a shelly lag generally in the range of 20 cm thick. This lag was always associated with the hard pavement, which varied in depth across the lagoon. The uppermost 70cm of core is similar to the present surface environment both taxonomically and taphonomically; bivalves are better preserved than gastropods. The faunal assemblage near the core bases did not reflect the present surface assemblage nearly as well, and all shells were generally better preserved regardless of type. The published depth estimates for callianassid burrowing may be low if these lags are the result of shrimp activities. On the other hand, if lags are not the result of bioturbation, they may reflect more rapid burial of shells during earlier phases of lagoon development.

## 1.22

**Holocene Reef Accretion Along the North Side of Bahia Enriquillo (Western Dominican Republic): Unique Insights Into Patterns of Reef Development in Response to Paleoceanography and Sea-Level Rise**

**Dennis HUBBARD*[1]**, Wilson RAMIREZ[2], David CUEVAS[3]

[1]Geology, Oberlin College, Oberlin, OH, [2]Geology, University of Puerto Rico-Mayaguez, Mayaguez, Puerto Rico, [3]Marine Science, University of Puerto Rico-Mayaguez, Mayaguez, Puerto Rico

Well-exposed Holocene reef outcrops along the northern side of the Enriquillo Valley record continuous reef accretion between 9,000 and 5-6,000 CalBP, when the bay closed. All the zones on Caribbean reefs today are well represented. Despite high sedimentation (>2-3 mm/yr) that nearly matched the reduced rates of coral growth (~1-3mm/yr), over 25 species of coral were present on the reef, and coral abundance averaged 50-75%. The importance of sediment-tolerant corals (especially *Montastraea* spp. and *Siderastrea* spp.) supports the premise of elevated sediment stress, as does the importance of conical and columnar colonies resulting from the inhibition of lateral growth. The high rates of bioerosion (especially in conical colonies that provide cryptic space) and the dominance of *Lithophaga* and other molluscs likewise argue for a significant input of mud and the nutrients that adsorb onto the surfaces of finer grains. A storm-debris layer up to a meter thick, and dominated by what has been described as *Madracis myriaster* was deposited across the massive-coral zone ca 8,000 years ago, and provides a time-line that defines reef morphology. Preliminary taphonomic studies along this surface indicate that as little as half of the coral along any time-contemporaneous surface was alive at the same time. Thus, measurements of coral abundance in outcrop probably overestimate live-coral cover when compared to modern monitoring studies. Direct observations within the outcrops and radiometric dating along several vertical transects confirm that the most continuous section located in Cañada Honda reflects transgression until ca. 7,000 CalBP when sea level slowed, followed by regression as shallower portions of the reef dominated by *Acropora cervicornis* began to build out over the older and deeper forereef. Continuous outcrop exposure provides marked advantages over cores, and does not support a sudden and rapid rise of sea level proposed for ca. 8,000 CalBP.

## 1.23

**Historical And Present Status Of The Pearl Oyster, Pinctada Margaritifera, in The Northwestern Hawaiian Islands**

**Elizabeth KEENAN*[1,2]**, Russell BRAINARD[3], Lawrence BASCH[4]

[1]NOAA, NOS, Papahanaumokuakea Marine National Monument, Honolulu, HI, [2]Research Corperation of the University of Hawaii, Honolulu, [3]NOAA, PIFSC, Coral Reef Ecosystem Division, Honolulu, HI, [4]University of Hawaii Manoa,Pacific Islands Cooperative Ecosystem Studies Unit, Honolulu, HI

Populations of the black-lipped pearl oyster, *Pinctada margaritifera*, at Pearl and Hermes Atoll in the Northwestern Hawaiian Islands (NWHI) were first reported in 1928 and heavily harvested over the next 2 years. Approximately 150,000 pearl oysters were either exported or killed during the exploitation. An expedition in 1930 to assess post-harvest population status determined the population to be severely depleted. Limited surveys in 1994 and 2000 found only a few pearl oysters and led to the conclusion that the population remained depleted. From 2003 to 2006 quantitative observations of *Pinctada margaritifera* were collected, including the location, size, depth, habitat, and orientation of individual pearl oysters on the reef. The surveys in 2003 discovered a higher abundance of pearl oysters in shallow waters than after the late 1920's harvest, though few oysters were found at deeper depths. Further studies in 2006 included a depth-stratified distribution survey to determine whether the 2003 depth distribution was accurate or if the results were an artifact of survey method. The depth-stratified study confirmed the 2003 finding of a predominantly shallow water distribution for pearl oysters at Pearl and Hermes Atoll. These results, along with density estimates, strongly suggest that there has been no significant population increase or recovery of pearl oysters since harvest occurred there over 75 years ago. This implies limitations on population growth due to Allee effects operating on fertilization and early life history ecology. The research conducted in 2004 through 2006 also included surveys at four other reefs in the NWHI: Kure Atoll, Midway Atoll, Maro Reef, and French Frigate Shoals. Pearl oysters were found to be rare at the other NWHI locations surveyed; indicating an apparent absence of minimum viable populations outside of Pearl and Hermes Atoll, within the northern Hawaiian Archipelago.

## 1.24

**Enigmatic Coral Rock Pillars -Another Look Into Reef Dynamics**

**Helmut SCHUHMACHER*[1]**, Roland KRONE[2], Peter VAN TREECK[1]

[1]Dept of Hydrobiology, Universitaet Duisburg-Essen, Essen, Germany, [2]Marine animal ecology, Alfred-Wegener-Institute for polar and marine research, Bremerhaven, Germany

Stone capped calcareous pillars, rising 10-70 cm above the surrounding reef surface are to be found at Aqaba (Jordan) and on several other fringing reefs of the Northern Red Sea from intertidal down to 3 m depth. Terrigenous (non-calcareous) cobbles and boulders are fixed on top of coral limestone. It is assumed that the stones were once introduced by fishermen or by exceptional floods and came to rest in depressions of the reef. Afterwards the surrounding reef limestone was eroded so that only the substrate underlying the granite stones has been left as singular towers. 14C-dating of a column sample from Aqaba provided an age of 560-345 years. Several interpretations are possible: the respective reef part did not grow since then, or younger layers were removed by bioerosion – during which time? Some suggestions are provided based on erosion data of sea urchins (*Diadema setosum*) and fish, gathered at that site. More (subtidal and intertidal) examples of partial reef decline are presented to stir discussion about circumstances and modes of bioerosional reef shaping.

## 1.25

**Ancient Reefs And The "Legacy Cycle": A New Pedagogical Approach To Teaching Earth Science, With Emphasis On Climate Change And Sea Level Rise Awareness**

**Katherine ELLINS*[1]**, Lida TENEVA[2]

[1]Institute for Geophysics, University of Texas - Austin, Austin, TX, [2]Earth and Environmental Sciences, Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY

Effective communication of recent findings to the public, especially on issues pertaining to global climate change, is vitally important in order to prepare citizens to make informed decisions that affect human well-being and the future of our planet. We have designed a new pedagogical approach, Legacy Cycle,that uses computer technology to formulate a series of inquiry activities around a set of three driving questions. Students mimic the work of scientists by generating ideas around a given challenge, listening to multiple perspectives from experts on the topic, researching a set of sub-questions and revising their original ideas, testing their mettle with labs and quizzes, and finally composing a project or paper that answers the original challenge. Each challenge builds on the previous challenge(s); students start with more concrete, basic knowledge and eventually apply it to novel situations. In our Legacy Cycle, the first challenge asks students to identify what the presence of certain corals (*Montastrea annularis, Acropora palmata,* and *Acropora cervicornis*) in coral cores indicates about the marine environment of the coral at the time of growth and sea level. Sub-questions involve learning about modern coral reef environments and investigating the ancient El Capitan reef complex (Permian) in the Guadeloupe Mountains of Texas to understand how this typical rimmed carbonate platform formed, at a time of great biodiversity, and just prior to the Permo-Triassic extinction. The second challenge asks students to examine and evaluate the quality of paleosealevel data from Barbados, Tahiti, Papua New Guinea and other records. The third challenge requires that students gain a better understanding of current climate change and present and future influences causing sea level to rise and fall, in particular.

## 1.26

**Coral Morphology as an Indicator of Sedimentation Rate in Two Exposed Holocene Reefs: Western Dominican Republic**

**Allicia DAVIS*[1]**, Dennis HUBBARD[2], Alexandra STEIN[3]

[1]Geological Sciences, Indiana University, Bloomington, IN, [2]Geology, Oberlin College, Oberlin, OH, [3]Monterey Bay Aquarium, Monterey, CA

Coral-community structure was examined in two subaerially exposed Holocene reefs in the western Dominican Republic. Four coral facies (branching, mixed, massive, platy) were identified based on species abundance and diversity. At both sites, coral-growth rates were slower (1-3 mm/yr) than for similar species at the same water depths on modern reefs. Corals were also classified by shape along over 20 vertical transects. Colony shape is controlled by a) the intensity of sediment stress and b) coral species. Within a single species, colonies change from hemispherical to conical to columnar as increasing sedimentation progressively discourages lateral colony extension. In the Cañada Honda reef, colonies of *Montastaea faveolata* are predominantly columnar, compared to a more conical shape for nearby colonies of *Siderastrea* spp. The reef at Las Clevellinas was closer to shore and is characterized by interfingering alluvial sediments and nearshore reefs under greater sediment stress. Accordingly, colonies of more-tolerant *Siderastrea* shifted to a columnar morphology, and less-resistant *Montastaea* spp. all but disappeared. These patterns collectively support the presumption of high levels of sediment stress in these outcrops, despite the occurrence of over 25 species of coral and an overall abundance rivaling or exceeding what has been reported for unstressed modern Caribbean reefs. On both reefs, fluctuating sedimentation results in fluted colony margins, as the colony base is overcome by rapid sediment and later grows outward in times of lower sedimentation (termed "pancakes", owing to their stacked morphology). Within colonies exhibiting this morphology, patterns appear to be rhythmic on a scale of 8-15 years, and may reflect cyclic rainfall under the influence of larger climate patterns (e.g., ENSO). Equally important, because these corals appear to be growing at or near their ability to avoid burial, they provide a unique opportunity to quantitatively characterize sedimentation on these reefs, both spatially and temporally.

## 1.27

**120 Years Record Of Delta-18ow Deconvolving From Porites Coral Delta-18o And Sr/ca At San Benedicto Island in The Mexican Transition Zone in The Northeastern Pacific.**

**Julio VILLAESCUSA*[1]**, Jose CARRIQUIRY[1]

[1]IIO-Environmental Geochemistry, Universidad Autonoma de Baja California, Ensenada, Mexico

The oxygen isotopic composition of seawater (delta-18Ow) was reconstructed from delta18O and Sr/Ca records from a coral Porites sp. from Island San Benedicto, Revillagigedo Archipelago in the Tropical - Subtropical Transitional zone in the Mexican Pacific (PTM), for the last 120 years. This region is located in the north edge of the eastern Pacific warm pool and is one of the areas less studied of the major coastal currents of the world, despite the tropical Mexican Pacific is recognized as a key region that modulates the climate of an important part of Mexico and North America. The delta-18Ow variation reconstructed responds directly to the changes in the regional sea surface salinity (SSS) and consequent with the hydrologic balance (Evaporation – Precipitation or E-P). The delta-18Ow shows a freshening trend during the last four decades, coherent with the trend analyses of salinity or precipitation (e.g., Boyer et al. 2005, GRL 32, L01604, doi:10.1029/2004GL021791). The delta-18Ow from the San Benedicto coral varies with the long term changes in the average position of the Intertropical Convergence Zone (ITCZ) in the northeastern Pacific. The negative correlation between both signs implies that the northern displacement of ITCZ (~14ºN) produces an enhancement of rainfall in San Benedicto region (19Nº). The correlation between delta-18Ow and the changes in the ITZC position, as well as the long term changes in delta-18Ow show low frequency variability, are in phase with the interdecadal changes in the intensity of the ENSO events. The periods from 1878 to 1906 and from 1932 to 1967, a more positive delta-18Ow signal suggests a lower rainfall than average and is consistent with periods of low variability in the ENSO activity. In contrast, a more negative delta-18Ow, that implicate periods of rainfall higher than average that occurs from 1906 to 1932 and of 1967 until the end of record, and are coincident with periods of strong ENSO activity.

## 1.3

**Environmental Effects On Back-Reef Sponge Distribution in The Florida Keys (Usa)**

**Jeremy WEISZ*[1]**, Mark BUTLER IV[1]

[1]Dept. of Biological Sciences, Old Dominion University, Norfolk, VA

Sponges are an abundant and conspicuous feature of back-reef hard-bottom environments in the Florida Keys (USA), where they often dominate the sessile animal biomass, provide shelter to other animals, and significantly alter planktonic communities and biogeochemical cycles through their filtering activities. Although predation and competition influence sponge community structure on coral reefs, these interactions cannot explain the distribution of sponges found in Florida's back-reef environments. Environmental conditions in these habitats are influenced by water management strategies in the freshwater marshes of the Everglades, climatic conditions (e.g., temperature, rainfall, wind), and coastal oceanography. As a consequence, salinity, nutrients, and plankton concentrations all vary dramatically. We therefore examined the implications of water quality on back-reef sponge community structure in two ways. First, in laboratory experiments we tested the tolerance of five prominent sponge species to salinities ranging from 15 psu to 45 psu during summer and winter temperatures. We then compared data on sponge distributions at 32 sites throughout the Florida Keys with water quality data from a water quality monitoring network (SERC) using canonical correspondence analysis (CCA). The mesocosm experiments showed that the golfball sponge, *Cinachyra* sp., tolerated the full range of salinities, whereas the other four species died at salinities above and below 35 psu at summer temperatures, and most died at salinities < 30 psu at winter temperatures. The CCA showed that some species, such as *Ircinia variablis* and *Cinachyra* sp., are "weedy" species, able to grow in most habitats, whereas others, such as *Spongia graminea* and *Spongia barbara*, are less tolerant of variable salinities and nutrient concentrations. These analyses suggest that local and global environmental changes will significantly impact the species distribution of sponges, with potentially drastic impacts on reef and other nearshore benthic communities in the Florida Keys.

## 1.4

**Classifying Coralline Rubble Beaches in The British Virgin Islands**

**Shannon GORE*[1]**, J. A. G. COOPER[2]

[1]Conservation & Fisheries, Government of the British Virgin Islands, Cruz Bay, Virgin Islands (U.S.), [2]School of Environmental Sciences, University of Ulster, Coleraine, United Kingdom

More than 100 beaches in the British Virgin Islands (BVI) are composed of coarse coral reef rubble (coralline rubble). Descriptions of similar beaches elsewhere in the Caribbean and Pacific focus on their deposition during storm or tsunami events in which coralline rubble is transported onshore to create ridges, and over time, ridge complexes. Observations in the BVI indicate that coralline rubble beaches occur in a variety of settings and vary in morphology and composition. In this paper a preliminary classification scheme is presented based on the attributes of 50 coralline rubble beaches in the BVI.

Methods involved mapping the distribution of coralline rubble beaches throughout the BVI and as describing the following six factors that potentially influence the morphology of these beaches: 1) Clast size of coral debris (smaller Porites ssp. vs. larger Diplora ssp. and A palmata); 2) Orientation of the beach to offshore reef types (fringing, patch, barrier); 3) Offshore bathymetry (steep beachface vs. carbonate platform); 4) Prevailing wave approach direction (onshore vs. longshore); 5) Amount of accommodation space available (behind and adjacent to the beach)); 6) type of barrier (single, prograded, overwash, etc). Multivariate statistics were then used to classify each beach and determine the importance of each of the variables on coralline rubble beach form.

## 1.5

**Results Of Long-Term Bioersion Study, Belize Patch Reefs**

**Halard LESCINSKY*[1]**, Maxwell HILL[1], Ann HOEDT[1]

[1]Life and Earth Sciences, Otterbein College, Westerville, OH

Bioerosion rates of branching corals were tracked for up to 8 years on patch reefs in central Belize using natural and experimental substrates. Bleaching induced mortality in 1998 provided the start of a natural experiment in which *Acropora cervicornis* and *Agaricia tenuifolia* skeletons were collected at 1-2 year intervals for 8 years. In addition, experimental substrates (conch shells) deployed along a depth gradient (1-15m) were retrieved at 1, 3, and 5 year intervals. Macroboring bioerosion rates were initially highly linear (8%/yr), and inversely related to depth. After 3 years macroboring bioerosion slowed and all substrates tended towards a maximum bioerosion intensity of approximately 35%. This threshold value may reflect the maximum gallery density for *Cliona* or the collapse and disappearance of more highly bored substrates. Over the same intervals, substrates were widely encrusted by coralline algae and there was little loss of corallite surface topography suggesting that scraping bioerosion was negligible on branching corals and rubble. These results highlight the importance of boring over grazing for some reef habitats, and for some types of substrates. While previous studies, primarily in the Pacific, have proposed that grazing bioerosion is generally an order of magnitude or more greater than macroboring, this is probably not the case for branching corals and carbonate rubble, two of the most rapidly produced substrates on the reef. It is also possible that Caribbean bioerosion differs significantly from Pacific bioerosion because of the loss of grazing *Diadema*, and the absence of the deepest excavating parrotfish.

## 1.6

**Reef Sedimentation Patterns, Southwestern Shelf of Puerto Rico**

**Raquel HERNANDEZ*[1]**, Clark SHERMAN[1], Ernesto WEIL[1]

[1]University of Puerto Rico at Mayaguez, Lajas, Puerto Rico

Effects of terrigenous sedimentation are considered a serious threat to Puerto Rico's coral reefs. This study assesses: 1) the composition of sediments accumulating at reef sites; 2) the spatial extent to which terrigenous materials are reaching the reefs off of La Parguera's coast; 3) the spatial variability of sediment composition, size and sedimentation rates at La Parguera; and 4) the temporal variability of sediment composition, size and sedimentation rates at La Parguera. Sediment traps were deployed at 9 sites from inner shelf to shelf edge. Mineralogy was determined by X-Ray diffraction. Bulk carbon composition was determined by carbon coulometry, specifying: relative weight percent calcium carbonate (in situ production), relative weight percent organic material, and relative weight percent other material. Environmental factors influencing sedimentation are addressed, such as precipitation, wind speed, and passage of tropical storms.

X-ray diffraction analyses indicate that sediments consist primarily of magnesian calcite and aragonite, both produced *in situ*, as well as smaller quantities of clay minerals and quartz, i.e. terrigenous origin. Analyses of total sediment weight (April 2006 - April 2007) show a similar temporal pattern at all sites where June, July and August have the highest sedimentation rates. Carbon composition analyses indicate a consistently higher percentage of terrigenous material in the fine fraction (<63µm) and show a decrease in percent terrigenous sedimentation with distance offshore.

Some preliminary conclusions that may be drawn are: 1) Terrigenous sediments are reaching all sites. However, the primary source of sediments settling at the reef sites is the *in situ* production of calcium carbonate by organisms. 2) At a given site, the relative percentage of terrigenous material is fairly constant regardless of sedimentation rate, suggesting that observed changes in sedimentation rates are due to resuspension of existing material rather than an influx of new terrigenous material.

## 1.7

**Microboring And Surface Taphonomy Of Fossil Reefs, Enriquillo Valley, Dominican Republic**

**Benjamin TITUS*[1]**, Halard LESCINSKY[1]

[1]Department of Life and Earth Sciences, Otterbein College, Westerville, OH

Paleoecologists have several metrics for distinguishing ecological information from post-mortem history (taphonomy), but it has been difficult to calibrate these with metrics used in ecological studies. Here we use microboring patterns to calibrate taphograde in the Holocene reefs of the Enriquillo Valley, Dominican Republic. Pioneer microborers become established on newly exposed coral substrates by two weeks, and are then substantially replaced by other species within 3 months. Thus post-mortem exposure can be closely estimated using microboring abundance, depth, and type. Surface microboring also determines how "pristine" a fossil looks and hence its taphonomic grade. A correlation between the two measures was examined along two 125m transects on an exposed reef at Cañada Honda. Each coral was assigned a taphograde on a 1 to 6 scale (1 is pristine) and examples of each taphograde were then randomly selected and returned to the lab for analysis. Coral samples were cut, impregnated with epoxy-resin, etched, and examined under the S.E.M. for microborers. Microboring intensity was quantified at .5mm intervals perpendicular to the coral surface using Image analysis software. Taphograde assignments and microboring intensity were closely related. Grade 1 corals had no microboring indicating post mortem exposure of <2 weeks, and grade 2 corals had only surficial microboring composed of the convolute tubes of pioneer microborers. Grade 3 corals had surficial microboring to 85%, with a decrease to <50% 1mm from the surface and <25% by 2mm. Microboring fell to a background rate of 5% by 7mm from the surface. Higher grade corals (4,5 and 6) had more deeply penetrating microborers. By using microboring to calibrate taphograde, we can now identify corals in the field that were likely buried alive, providing a tool to recreate live coral cover in the fossil record.

## 1.8

**Real Time Coral Stress Observations Before, During, And After Beach Nourishment Dredging Offshore Southeast Florida, Usa.**

**Lou FISHER*[1]**, Ken BANKS[2], Dave GILLIAM[3], Richard E. DODGE[3], David STOUT[2], Bernardo VARGAS-ANGEL[4]

[1]Environmental Protection Department, Broward County, Florida, USA, Plantation, FL, [2]Environmental Protection Department, Broward County, Florida, Plantation, FL, [3]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [4]Coral Reef Ecology Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

Beach renourishment in Southeast Florida is commonly accomplished by dredging sand deposits from between offshore coral reefs and moving the sand to shore. Broward County, Florida, USA constructed 10.9 km of beach from May, 2005 through February, 2006 utilizing a hopper-dredge and placing 1.9 million cubic yards of sand on the beach. Dredging causes suspension of sediments that may result in stressful conditions for sessile reef organisms, including smothering or reducing photosynthesis. To monitor a real-time response of stony corals during dredging, a stress index was developed for three coral species (*Montastrea cavernosa*, *Solenastrea bournoni*, and *Siderastrea siderea*). Scoring involved healthy = 0 (no mucus sheets, structurally sound); moderately stressed = 1 (moderate polyp swelling, increased mucus); markedly stressed = 2 (coloration changes, bleaching, advanced mucus, tissue thinning); and severely stressed = 3 (severe swelling and thinning, extensive color changes-fully bleached). The method was applied to six colonies each at 34 sites (26 treatment and 8 control sites) weekly for 13 weeks pre-dredging, 38 weeks during dredging, and 8 weeks post-dredging. There were 4-6 sites surrounding 5 sand-borrow (dredging) areas. Average values above 1.5 at 50% of assessment sites surrounding a sand-borrow area would trigger the cessation of dredging until weekly assessment fell below threshold. Stress values mostly remained below 0.5 through the 14$^{th}$ week of dredging. The influence of three hurricanes in the region from week 15 through week 25 (August-September 2005) helped to elevate the observed average stress values above 1.0. Post-event stress remained between 0.5 and 1.0 for eight weeks, indicating a long recovery to pre-dredging levels. Results indicated coral stress index observation was an effective tool in detecting and adaptively managing coral stress during a dredging event adjacent to sensitive marine habitat.

## 1.9

**Late Jurassic Coral Reefs From Outcrops Of The Western Caucasus-Crimea: Analogues For The Eastern Black Sea**

**Li GUO*[1]**, Stephen J. VINCENT[1], Samuel P. RICE[1], Vladimir LAVRISHCHEV[2]

[1]CASP, Cambridge, United Kingdom, [2]Kavkazgeols'emka, Yessentuki, Russian Federation

Recent seismic reflection data from the northwestern Shatskiy Ridge, Eastern Black Sea, image a number of possible Late Jurassic reef-facies occurrences up to 1-2 km thick and 10-20 km wide. Excellent onshore exposures of Late Jurassic reefs in the Russian Western Caucasus and Crimea provide reservoir analogues for these offshore targets.

Late Jurassic reefs in the Western Caucasus and Crimea are mainly coral-dominated, although siliceous sponge-microbial and microbial types also occur. The coral reefs developed throughout the Oxfordian-Tithonian succession, and display small lense-like, mound and massive morphologies. The corals are hermatypic scleractinians that are dominated by phaceloid, meandroid and dendroid growth forms. The coral reefs formed at shallow-water platform margins or in slightly restricted deeper-water mid shelf settings. The development of these reefs was controlled mainly by local variations in water depth, light and the availability of nutrients. In addition, isolated coral reefs occur very close to and even directly within areas of siliciclastic sedimentation in eastern Crimea. The coral communities are characterised by their reduced diversity, and in this case, the main factors controlling reef growth were the distribution and accumulation of terrigenous sediment on the shelf and/or associated nutrient availability.

The studied coral reefs exhibit a complex pattern of porosity development reflecting independent diagenetic histories mainly involving near-surface and deep-burial dissolution. Porosity is common and consists of both primary and secondary types.

## 2.28

**Coralline Algae in Messinian (Upper Miocene) Mediterranean Reefs**

**Juan C. BRAGA*[1]**, Alessandro VESCOGNI[2], Francesca BOSELLINI[3], Julio AGUIRRE[1]

[1]Estratigrafía y Paleontologia, Universidad de Granada, Granada, Spain, [2]Scienze della Terra, Universita di Modena e Reggio Emilia, Modena, Italy, [3]Scienze della Terra, Universita di Modena e Reggio Emilia, Modeba, Italy

The last reefs built by zooxanthellate corals in the Mediterranean region thrived during the Messinian (7.2 to 5.3 Ma, Late Miocene). *Porites* is almost the only reef-building coral and only a few colonies of *Siderastrea* and *Tarbellastraea* have been recorded. Coralline red algae are secondary reef builders, together with encrusting foraminifers and microbial micritic crusts. The study of coralline algae from the Messinian reefs of the Salento Peninsula (southern Italy) and of the Sorbas and Almería basins (southeastern Spain) reveals coralline assemblages that are substantially different from their coeval low-latitude counterparts. In all studied sites, these coralline assemblages show palaeodepth-related distribution. Shallow-water corallines mainly occur as plants encrusting coral colonies and their assemblages are dominated by *Neogoniolithon, Spongites*, and *Lithophyllum* species. Deeper-water corallines occur as rhodoliths (algal nodules) and crusts on bioclasts dominated by *Lithothamnion* and *Phymatolithon*, with minor *Sporolithon* and *Mesophyllum*. Although the most common species, *N. brassica-florida* and a few other components, have been reported from tropical reefs, the Messinian coralline assemblages in the Mediterranean lack the main building corallines in Upper Miocene reefs in tropical latitudes—namely thick *Hydrolithon* species. Moreover, most of the recorded species lived or are still living in the Mediterranean Sea and the Atlantic coast of Europe. This species composition probably reflects the isolation of the Mediterranean Basin from the Indo-Pacific area since the Middle Miocene and the general cooling of the Mediterranean region throughout the Miocene.

## 2.29

**Lower Miocene Submerged Reefs On The Koko Seamount**

David A. CLAGUE[1], **Juan C. BRAGA*[2]**, Jody M. WEBSTER[3], Davide BASSI[4], Willen RENEMA[5]

[1]Monterey Bay Aquarium Research Institute, Moss Landing, CA, [2]Estratigrafía y Paleontologia, Universidad de Granada, Granada, Spain, [3]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, [4]Scienze della Terra, Universita di Ferrara, Ferrara, Italy, [5]Nationaal Natuurhistorisch Museum, Leiden, Netherlands

Koko Seamount is in the southern part of the Emperor seamounts near the bend of the Hawaiian-Emperor chain, in the northern Pacific basin. Radiometric (40Ar/39Ar) ages of shield and postshield volcanism in the seamount range from 52.6 to 50.4 Ma (Early Eocene) (Sharp & Clague, 2006). Dredged carbonate samples from the top of the seamount reveal the occurrence of Lower Miocene coral reefs and associated deposits. *Porites* and several faviid genera encrusted by coralline algae (*Hydrolithon?*) represent the shallowest facies recorded. Packstones of *Amphistegina* with minor coralline algae probably formed at intermediate depths according to depth distribution of modern analogs. Packstones to floatstones with lepidocyclines, bryozoans, and coralline red algae nodules (mainly made up of *Lithothamnion* and *Sporolithon*) accumulated in the deepest settings of the carbonate platform that developed on the volcanic building. The recorded lepidocyclinids indicate an Early Miocene age for the carbonate deposits. The carbonate platform on the seamount now at about 500 m depth was drowned and remained submerged since that age.

Sharp, W.D. & Clague, D.A. 50-Ma initiation of Hawaiian-Emperor bend records major change in Pacific plate motion. Science, 313, 1281-1284

## 2.30

**Pattern of fossil coral communities from Ryukyu Island, Japan and Palau Islands during Holocene sea-level change**

**Chuki HONGO*[1]**, Hajime KAYANNE[1]

[1]Department of Earth and Planetary Science, The University of Tokyo, Tokyo, Japan

Information of dynamics of coral communities following abrupt sea-level rise in Holocene is necessary to predict coral population responses to future sea-level rise. It is critical to understand on what time scale coral populations respond and whether communities and populations change in their formation to correspond to sea-level rise. Sedimentological and ecological analyses of boring cores from fringing reefs in Ishigaki Island, Ryukyu Islands and from a barrier reef in Palau Island have delineated different responses of fossil coral communities to the sea-level rise at their initial stage of reef development. Initiation timing of Holocene reef growth in Ishigaki and Palau Islands corresponded with each other around 8000 cal. years BP, however, coral communities were different between the two reefs. Holocene coral reefs in Ishigaki Islands were mainly composed shallow water coral communities (e.g. *Acropora digitifera*, *A. hyacinthus*, *Goniastrea retiformis*, and *Montastrea curta*) between around 8000 cal. years BP and 4800 cal. years BP at a mean growth rate of 6.1 m/ 1000 years, whereas Holocene coral communities of Palau Islands changed from *Porites* spp. in turbidity environment to arborescent coral communities (e.g. *Acropora formosa* and *A. nobilis*) after around 8000 cal. years BP until 7200 cal. years BP, and then uppermost coral reef of the islands consisted of shallow water coral communities (e.g. *Acropora digitifera*, *A. robusta*, and *A. danai*). It assumed that the difference in pattern of communities and populations depended on the initial wave condition related to wave directions and the type of initial coral population. It is clear that coral communities of the islands could survive the past sea-level rise, and also, it is essential to research on communities, population dynamics and environmental conditions in present coral reefs for projections of sea level rise in the future.

## 2.31

**Shallow Seismic Profiling Survey On Holocene Coral Reefs Near The Present-Day Northern Limit Of Coral Reef Formation in The Northwestern Pacific**

**Kohsaku ARAI*[1]**, Takahiko INOUE[1], Hiroki MATSUDA[2], Hideaki MACHIYAMA[3], Keiichi SASAKI[4], Yasufumi IRYU[5], Kaoru SUGIHARA[6], Kazuhiko FUJITA[7], Masakazu NARA[8]

[1]Geology and Geoinformation, Geological Survey of Japan, AIST, Tsukuba, Japan, [2]Department of Earth Science, Kumamoto University, Kumamoto, Japan, [3]Kochi Institute for Core Sample Research, JAMSTEC, Kochi, Japan, [4]Department of Cultural Properties & Heritage, Kanazawa Gakuin Unversity, Kanazawa, Japan, [5]Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, Sendai, Japan, [6]Department of Earth System Science, Fukuoka University, Fukuoka, Japan, [7]Department of Physics and Earth Sciences, University of the Ryukyus, Nishihara, Japan, [8]Center for Marine Environmental Studies, Ehime University, Ehime, Japan

Shallow seismic profiling survey, bathymetric mapping and ROV (remote operating vehicle) submersible observations were carried out to the east of northern Amami-o-shima Island (28°24' N, 129°38'E). The survey area is located in a northern part of the Ryukyu Island Arc and close to the present-day northern limit of coral reef formation in the northwestern Pacific. This survey aims to delineate spatial distribution of modern coral reefs at a marginal region for a reef province and to unravel the factors controlling initiation of coral reefs during the last deglaciation.

High-resolution seismic data were collected using AA300 Boomer Plate with 8 channels digital streamer cable. The survey lines in a direction for WNW to ESE ranged in length from 2 to 2.5 km, where water depth was 10 – 60 m. The interval of the lines was 100 m. Bathymetric surveys were conducted using a SeaBat 8101 multibeam echosounder along the seismic survey lines.

The ROV video images and bathymetric map indicate that the eastern part of the survey area is characterized by presence of irregular-shaped mounds of modern coral reefs. In contrast, the flat seafloor, consisting mainly of coarse-grained, extends in the western area. Distinct, randomly undulated reflector which may represent erosional surface formed in the last glacial period is recognized throughout the survey area. The Holocene stratified sediment overlies this reflector; their thickness decrease eastward. The grooves which may correspond to eroded valleys formed during the last glacial period are found in the western margin of the eastern part of the survey area where the irregularly-shaped mounds occur. These results indicate that the coarse-grained sediment transported from Amami-o-shima Island has been trapped into grooves and that limited transportation of sediments into the eastern part may have allowed coral reef formation in this area during the last deglaciation.

## 2.32

**Pleistocene Reefs Of The Egyptian Red Sea**

**Lorraine CASAZZA*[1]**

[1]Dept. of Integrative Biology and UC Museum of Paleontology, University of California, Berkeley, Berkeley, CA

Rifting of the Red Sea basin has resulted in eight emerged reef terraces along the Egyptian coastline representing three cycles of reef growth during the middle to late Pleistocene: Oxygen Isotope Stages 5 (75 - 127 ka BP), 7 (170 - 230 ka BP), and 9 (300 - 330 ka BP). This study compares three of those reef terraces: terraces I and III, representing two distinct periods of reef growth during Oxygen Isotope Stage 5 and Terrace V, representing Stage 7, in order to determine if and how these fringing reefs have responded to environmental change over the last 230,000 years. Three locations along the Egyptian Red Sea coast were chosen for 1) the presence of all three terraces and 2) good outcrop access at the mouths of wadis (dry riverbeds). For each terrace in each location coral species were photographed and/or collected for identification every 1 m along a 120 m line transect. An experimental method was also attempted for comparison. This involved photographing 1m2 quadrats every 5 m along the same 120 m transect, and percent coverage of total outcrop sampled calculated for each coral species. Visible specimen of bivalves, echinoids and gastropods were collected for each quadrat, and loose reef sediment was collected where it was found for identification of reef foraminifera. Coral species composition and diversity for each terrace was combined with presence /absence data for bivalve, gastropod and echinoid species to create a characterization of each terrace community. Differences between the reef communities of Stage 7 and Stage 5 may be due to a complete recolonization after hypersaline conditions in the Red Sea during low sea level, or a result of differences in local paleoenvironment during the two time periods.

## 3.33

**Coral Growth Of Porites Astreoides Correlates Negatively With Temperature Along The Coast Of Venezuela**

**Marco CAPUTO*[1]**, Carolina BASTIDAS[1], Elia GARCÍA[1], Sebastian RODRÍGUEZ[1]

[1]Laboratorio de Comunidades Marinas y Ecotoxicología, University Simon Bolivar, Caracas, Venezuela

Coral growth correlates positively with sea temperature in most cases and it relates to the coral species and the environmental conditions in a complex way. In this study we measured the growth of *Porites astreoides* as the maximum lineal extension of carbonate accretion, using computer tomography to reveal the pattern of density bands. A nested design was used to assess the variability of coral growth at scale of meters, kilometers and hundred of kilometers, the largest scale corresponding to localities at the Morrocoy National Park, and the islands of La Blanquilla and Cubagua. These localities differed up to 6.1 C° in their monthly mean Sea Surface Temperature (10 years of record), among other environmental conditions. We found a yearly growth of 5.85 ± 1.92 mm, 3.65 ± 1.32 mm and 2.84 ± 1.27 mm for the colonies of Cubagua, La Blanquilla and Morrocoy, respectively. Surprisingly, these rates of growth correlated negatively with the mean SST of those localities. We also found significant differences in the rate of growth of *Porites astreoides* at the scale of meters, but not at the intermediate scale of kilometers. The effect of temperature on coral growth as found in this study, indicates that at some localities an elevation in SST in the future could negatively affect coral lineal extension.

## 3.34

**Rising $Co_2$ Disproportionately Affects Extension Versus Mass Deposition in Reef Corals**

**Nancy MUEHLLEHNER*[1]**, Peter EDMUNDS[1]

[1]Biology, California State University, Northridge, Northridge, CA

The production of mineral skeletons by scleractinian corals is one of the primary sources of topographical complexity on tropical coral reefs. Although ocean acidification is known to decrease calcification in corals, the effects have been measured almost exclusively in terms of the mass deposition of aragonite. Interestingly, it remains virtually unknown how this translates into morphological consequences in a taxon well known for phenotypic plasticity. This study used manipulative experiments to test the hypothesis that increasing pCO2 has unequal effects on different components of growth that contribute to colony size and morphology. First, increased levels of CO2 (700 vs. 350 µatm) were tested for effects on the mass deposition (µg mm-2 day-1) and linear extension (µm day-1) of *Acropora hyacinthus* and *A. pulchra* in French Polynesia. The experiments were completed using microcosms exposed to light levels of ~650 µmol m-2 s-1, ambient temperature (28˚C) and a pH treatment of 7.8 or 8.2. Overall, mass deposition and linear extension were significantly reduced by high pCO2 in both species. For *A. pulchra*, high CO2 reduced mass deposition by 26%, from 4.9 ± 0.1 to 3.7 ± 0.2 µg mm-2 d-1, and linear extension by 44%, from 245 ± 15 µm d-1 to 137 ± 11 µm d-1 (all mean ± se). In *A. hyacinthus*, the disproportional effects of high CO2 on mass deposition and extension were accentuated, with mass deposition reduced 25%, from 3.0 ± 0.7 to 2.2 ± 0.5 µg mm-2 d-1, and linear extension by 146%, from 3.0 ± 5.0 µm d-1 to -1.38 ± 2 µm d-1 (all mean ± se). Importantly, in both cases, high $CO_2$ had a significantly greater effect on linear extension than on mass deposition, with extension reduced 2-6 fold more than mass deposition.

## 3.35

**Carbonate production on coral reefs – the influence of terrestrial runoff on encrusting communities and coral recruits**

**Jennie MALLELA*[1]**

[1]Life Sciences, University of the West Indies, Trinidad, Trinidad and Tobago

Land based runoff (e.g. sediment and nutrients) is now recognised as a serious threat to coral reef development in the Caribbean. This study assessed whether reefal carbonate production by encrusting organisms (crustose coralline algae, bryozoans and foraminifera) and coral recruits was influenced by terrestrial runoff (e.g. fluvial inputs). Experimental substrates were deployed at ten marine sites along a gradient of terrestrial disturbance in Jamaica (n=4) and Tobago (n=6). Artificial substrates were deployed in order to mimic cryptic and exposed reef substrates (downwards-facing versus upwards-facing). Initial findings indicate that encruster carbonate production (g m-2 y-1) was significantly higher at less terrestrially impacted sites, characterised by high wave energy, than that observed at sites subjected to high levels of terrestrial runoff and low wave energy. Cryptically orientated tiles were also found to support a greater diversity of encrusting organisms. Comparisons in Jamaica with earlier (1970s) studies indicate that encruster cover on the reefs has reduced. Findings from this study have implications for both current and future rates and styles of reefal framework production.

## 3.36

**Mineral phase of COCs and fibers in coral skeletons**

**Kohki SOWA*[1]**, Tsuyoshi WATANABE[1], Satoko MOTAI[1], Yusuke SETO[1], Takaya NAGAI[1]

[1]Hokkaido university, Sapporo, Japan

It should be useful to get mineral phase information corresponding to coral skeletal textures from micro- to nano-meter scale (microstructure and nano-texture are used as terms, respectively). To confirm mineral phase differences in coral skeletons, we conducted mineral phase identification in microstructures and nano-textures on coral, *Porites lobata*.,by X-ray diffraction analysis with synchrotron radiation (SR-XRD) and transmission electron microscope (TEM) respectively. Coral microstructures consist of center of calcifications (COCs) and fibers. COCs occupy small volume percentage (~3%) against the total volume of coral skeletons. The size of COC is <30 $\mu$ m in diameter in the samples. This study could obtain the information of mineral phase in COCs and fibers independently by SR-XRD because the X-ray beam was collimated to 15 or 40 $\mu$ m in diameter. To assess the detection limit of strontianite in aragonite by SR-XRD, we prepared several standard mixtures of strontianite and aragonite. These results indicate that the limit of detection of strontianite in standard mixtures is ~1%. All diffraction peaks of COCs and fibers can be explained as aragonite, and no significant difference of cell parameters can be observed. All TEM observations also showed aragonite in coral nano-textures. The mineral phase other than aragonite could not detect in coral microstructures and nano-textures in this study.

## 3.37

**Growth and Population Dynamics Model of the Solitary Sunset Cup Coral *Leptopsammia pruvoti* (Scleractinia, Dendrophylliidae) in the Mediterranean Sea**

**Stefano GOFFREDO*[1]**, Erik CAROSELLI[1], Guido MATTIOLI[2], Elettra PIGNOTTI[3], Francesco ZACCANTI[1]

[1]Department of Evolutionary and Experimental Biology, University of Bologna, Bologna, Italy, [2]Operative Unit of Radiology and Diagnostics by Images, Hospital of Porretta Terme, Local Health Enterprise of Bologna, Porretta Terme, Italy, [3]Taskforce for Statistical Analysis, Marine & Freshwater Science Group Association, Bologna, Italy

Demographic parameters reveal relationships between organisms and their environment, and contribute to the assessment of habitat stability. Scattered information is available on the population dynamics of corals, especially for temperate species. In this study we describe growth and population turnover in *Leptopsammia pruvoti*, a dominant species in shaded habitats (sea caves and crevices) of the Mediterranean Sea, by applying age-structured demographic models. Age was determined by counting the number of annual growth bands in corallite skeletons by means of computerized tomography technology. Populations located at the extremes of the sampled latitudinal range, 890 km apart, showed similar patterns of growth and population dynamics. Linear growth rates (corallite's oral disc length, width, and oral-aboral height) decreased with age according to power functions. Age explained 83-95% of growth rates variance. Turnover time ranged from 7 to 10 years, with a maximum longevity of more than 40 years. This is nearly two times the turnover time and maximum life span recorded for another dendrophylliid solitary coral in the Mediterranean Sea, *Balanophyllia europaea*, and seven times compared to *Balanophyllia elegans* of the western coast of North America. The similarity of growth and demographic patterns of *Leptopsammia pruvoti* among distant sites may be related to the stability of the species' habitat.

## 3.38

**Coral Resiliency To Changing $Pco_2$ in Florida Bay**

**Remy OKAZAKI*[1]**, Peter SWART[1], Chris LANGDON[1], Frank MILLERO[1]

[1]University of Miami - RSMAS, Miami, FL

Despite evidence showing increased pCO2 decreases coral calcification, coral growth appears to be unaffected in Florida Bay, where pCO2 varies seasonally by over 400 ppm. These changing conditions make Florida Bay an ideal environment in which to study coral responses to different pCO2 levels. In-situ calcification rates of the dominant coral species, *Solenastrea* sp. and *Siderastrea* sp., are measured bi-monthly. Furthermore, other variables affecting coral growth are monitored, including temperature, saturation state, and light. Superimposed on this natural variability, coral growth is measured under artificially lowered pH conditions. These measurements will evaluate corals' responses to a range of physiochemical conditions and whether they have adapted to changing pCO2.

## 3.39

**Physiological Effects Of Co2-Mediated Ocean Acidification On Reef-Associated Corals**

**Noah BEN-ADERET*[1,2]**, Maoz FINE[1]

[1]Mina & Everard Goodman Dept. of Life Sciences, Bar-Ilan University, Ramat Gan, Israel, [2]Inter-University Institute for Marine Science, Eilat, Israel

Calcifying organisms rely on carefully balanced levels of calcite and aragonite for skeletal construction; decreases in ambient pH disrupt these processes. Lower pH has been shown to increase photosynthetic rates in plants and algae, however it is detrimental to calcification and growth. This fact raises the questions: How would corals respond to low pH conditions? Do the benefits to photosynthesis outweigh the detriments to calcification and growth?

I examined four species of reef-building corals found along the Israeli coast of the Red Sea in the northern Gulf of Aqaba. Fragments of *Stylophora pistillata*, *Pocillopora damicornis* and two *Acropora spp.* were grown in 3 differing pH levels (7.0, 7.3, and 7.6), with one ambient control (8.2) in water tables fed from a raw water source pH system. Changes in pH were achieved by bubbling pure $CO_2$ into seawater in holding tanks to achieve the desired pH. Fragments were maintained in the system for up to six months. Due to the somewhat problematic nature of chlorophyll fluorescence measurements in detecting the effect of low pH on photosynthesis, Membrane Inlet Mass Spectrometry (MIMS) coupled with Fast Repetition Rate Fluorometry (FRRF) were used to quantify the effects of low pH on both photosynthesis and respiration

Gross photosynthesis of corals at the lower pH (7.3) was significantly higher than that of those in ambient pH (8.2). This may be explained by increases seen in oxygen production by algal cells in lower pH. We also measured higher respiration rates (dark and light) in the lower pH treatment; this was attributed mainly to host metabolism.

While the fragments survived the lower pH, demonstrated increased primary production and even recorded some growth, calcification was reduced. Overall, data indicated definite stress to the organisms at lower pH, additional work is needed to the significance of acidic stress on corals.

## 3.40

**Coral Accretion in The Harsh Conditions Of The Western Coast Of Mexico**

**Luis E. CALDERON-AGUILERA*[1]**, Héctor REYES-BONILLA[2], José CARRRIQUIRY[3]

[1]Ecology, CICESE, Ensenada, Mexico, [2]Biología Marina, UABCS, La Paz, Mexico, [3]Geoquimica Ambiental, IIO - UABC, Ensenada, Mexico

The aim of this work was to assess comparatively the carbonate potential production along a latitudinal gradient in the western coast of México, an area that has been subjected to severe natural perturbations in the last decade. In the study region, coral reefs are small, very shallow (less than 10 m in depth), and with low relief (<3 m). They grow under harsh conditions, because waters are relatively cold and very acidic, and the continental shelf is very narrow. For this study we visited three locations between the lower Gulf of California and Oaxaca (23.5° to 15.5° N) for a series of years, estimated coral cover using 25 m long line transects, and calculated growth rate of the four most abundant species *Pocillopora damicornis*, *P. verrucosa*, *Porites panamensis* and *Pavona gigantea.*, with alizarin stain and radiographs. Finally, we took data from coral carbonate density of these species from the literature, and with the three parameters we estimated gross carbonate deposition per square meter. Our calculations indicate that potential production of carbonates at Cabo Pulmo reef, Gulf of California (23°50'N) has descended from 20 to 4 kg $CaCO_3/m^2$/year between 1987 and 2004; in La Entrega, Oaxaca (15°42'N) production decreased almost to half in less than a decade (from 28 to 15 kg $CaCO_3/m^2$/year from 1997 to 2003), and has remained about 20 kg $CaCO_3/m^2$/year in Tenacatita, Jalisco (19°16'N from 2000 to 2003). Considering the decrease in reef gross growth rate, the fact that bioerosion in the eastern Pacific is intense due to the high primary production in the water column, and the expected reduction of coral skeletal density in the near future triggered by ocean acidification, it can be expected that global warming will irreversibly affect the ability of scleractinian corals to produce reefs in the Mexican Pacific.

## 3.41

**Effect Of Seawater Saturation State On Early Skeletal Development in Two Atlantic Corals (*porites Astreoides* And *favia Fragum*)**

**Samantha DE PUTRON*[1]**, Anne COHEN[2], Daniel MCCORKLE[2]

[1]Bermuda Institute of Ocean Sciences, St Georges, Bermuda, [2]Woods Hole Oceanographic Institution, Woods Hole, MA

Planulae of the common brooding Caribbean species *Favia fragum* and *Porites astreoides* were settled on pre-conditioned clay tiles and reared in non-through flow aquaria in which variable seawater saturation state (Ω) was achieved by HCL addition and bubbling with laboratory air, yielding Ωaragonite = 3.71 (unmodified), 2.4, 1.04, and 0.22. Microscopic analysis and photographic software were used to quantify cross sectional area of corallites accreted by the primary polyps under different conditions. Skeletal development of *F. fragum* and *P. astreoides* exhibited marked differences in their responses. A systematic reduction in septal and basal plate development of *F. fragum* corallites was evident with decreasing Ωseawater. Using cross sectional skeletal area as a proxy for calcification indicated a 16% and 50% decline relative to the control at Ω=2.4 and 1 respectively. Remarkably, early skeletal development by *P. astreoides* recruits exhibited little measurable response to changes from Ω = 3.7 to Ω = 1. Under the most strongly under-saturated conditions (Ω = 0.2) no skeletal development had occurred after 7 days. Based on data from *F. fragum*, Cohen et al., (2007) proposed that the corals expend a fixed amount of energy on proton pumping to raise Ωcalcifying fluid and as Ωseawater becomes unfavorable for calcification, the inability to channel more energy into proton pumping limits the increase in Ωcalcifying fluid and reduces calcification. If this is true for *F. fragum*, then contrasting data from *P. astreoides* suggests there may be significant differences amongst species in the ability to divert energy into proton pumping for calcification and therefore, in their responses to changes in seawater saturation state. Compromised skeletal growth immediately after settlement will likely reduce recruitment success through reduced competitive ability. A species specific response to decreased Ω implies differential future recruitment success that could lead to shifts in adult species composition.

## 3.42

**Skeletal Calcium Carbonate Phase Polymorphism in Two Temperate Scleractinians**

Stefano GOFFREDO[1], **Erik CAROSELLI*[1]**, Francesco ZACCANTI[1], Giuseppe FALINI[2]

[1]Department of Evolutionary and Experimental Biology, University of Bologna, Bologna, Italy, [2]Department of Chemistry, University of Bologna, Bologna, Italy

In 1975 evidence of magnesium-calcite in the first skeletal parts deposited after coral settlement, and up to 46% magnesium-calcite in the aragonitic skeleton of adult *Porites* was found. In 1976, it was stated that magnesium-calcite was a contamination deposited by microborers, rather than biomineralized by the corals. Since then, further investigations are rare. This study investigates the calcium carbonate polymorphism in two Mediterranean solitary scleractinians, *Balanophyllia europaea* and *Leptopsammia pruvoti*. Specimens were collected on the Italian coasts along a latitudinal gradient and dated using computerized tomography-based growth bands analysis. Powder x-ray diffraction (XRD) was performed on three corallite sections (base, intermediate, apex), to identify and quantify calcium carbonate phases. Scanning electronic microscopy (SEM) was performed on corallite sections, and the presence of magnesium was detected. XRD analyses on both species' corallites showed up to 12% magnesium-calcite content. *B. europaea* XRD data analyses showed a decreasing magnesium-calcite content from young (4-5%) to old individuals (2-3%) and from corallite base (6-16%) to apex (0-1%), while in *L. pruvoti* it was age-independent. Decreasing magnesium-calcite content as mean annual sea surface temperature increases was found, similarly to some mussel shells. SEM images of *B. europaea* did not show evidences of microborers contamination, and showed skeletal morphological differences: corallite basis was composed of regularly disposed open chambers, with a high magnesium content; corallite apex was compact with no detectable magnesium content, confirming XRD findings on phase distribution. These preliminary data indicate that: both species' corallites have a significant content of magnesium-calcite; in *B. europaea* magnesium-calcite deposition is a polyp-controlled age-dependent phenomenon. The presence of a mixture of aragonite and magnesium-calcite in *B. europaea* corallite base may provide a better mechanical resistance to water movement and wave action, as composite materials are more elastic than pure ones.

## 3.43

**Hiatuses in Holocene reef growth at Kodakara Island in the Ryukyus, Japan: links to global climate variability**

**Nozomu HAMANAKA*[1]**, Hironobu KAN[2], Yusuke YOKOYAMA[3], Takehiro OKAMOTO[2], Yosuke NAKASHIMA[4], Toshio KAWANA[5]

[1]Department of Earth System Science, Graduate School of Natural Science and Technology, Okayama University, Okayama, Japan, [2]Faculty of Education, Okayama University, Okayama, Japan, [3]Department of Earth and Planetary Sciences, School of Science, University of Tokyo, Tokyo, Japan, [4]Ariake National College of Technology, Omuta, Japan, [5]Faculty of Education, University of the Ryukyus, Nishihara, Japan

Continuous reef growth controlled by sea level change during the Holocene is typically studied by reef coring. Recently, however, variability of the Holocene global climate and change in ocean-atmospheric conditions on centennial to millennial scales have been discussed with reference to geographic synchrony. However, the relationship between climate variability and coral reef growth after the middle Holocene is still poorly understood.

We present evidence for the existence of hiatuses associated with coral reef growth and their timing in relation to global climate variability during the middle to the late Holocene in the northwest Pacific using high-resolution geologic data from excavations at Kodakara Island, located in the passage of the Kuroshio current. The excavations cut into the raised coral reef terraces show the real anatomy of reefs with both lateral and vertical accretion through the reef flats to the reef edges.

We recognized that the middle Holocene reef is stratigraphically divided into three units by sharp boundaries. The radiocarbon dates indicate these units formed at about: 7.2-5.9, 5.8-4.5, and 4.0-2.7 cal kyr BP respectively. These timings approximately correspond to the strengthened periods of the Kuroshio current, which were superimposed on relatively weakened events. This trend correlates with the East Asian monsoon and the North Atlantic climate change during the Holocene. Our results indicate the existence of hiatuses in reef growth that may have been controlled by global climate variability.

## 3.44

**Calcification Rates Of The Endemic Coral Mussismilia Braziliensis Declined Associated With Ocean Warming**

**Marilia OLIVEIRA*[1]**, Zelinda LEAO[1], Ruy KIKUCHI[1]

[1]Federal University of Bahia - Brazil, Salvador, Brazil

Impacts in the reef ecosystems caused by variations in the environmental parameters, due to anthropogenic activities and climate changes, imprint information in the calcareous skeleton of massive corals. From living colonies of the massive coral *Mussismilia braziliensis*, the major reef-building coral in the Abrolhos region (Eastern Brazil), eleven cores were taken, in November 2003, in order to evaluate the coral growth characteristics, based on the skeleton linear extension, density bands and calcification rate, applying computerized tomography techniques. Sea surface temperature and wind speed data were obtained from the Abrolhos Meteorological Station, in the Abrolhos Radio Lighthouse. Time series span from 04/15/1973 to 12/31/2003. From these data annual and seasonal mean were calculated based on monthly means. Annual anomalies were normalized based on 30 years climatological mean (1974 to 2003) and in the related standard deviation of each series. Three years running mean were applied to each time series. The mean annual linear extension of *M. braziliensis* was of 0.8±0.05 $cm.y^{-1}$. The calcification rate was direct controlled by water temperature in the Abrolhos region. The average calcification rate of corals between 1924 and 2003, was of 1.37±0,23 $g.cm^{-2}.year^{-1}$ and between 1979 and 2003 was of 1.24±0,17 $g.cm^{-2}.year^{-1}$, showing a clear decline in the last 25 years. This indicates a strong influence of El Niño events in the Abrolhos reefs. This reduction of the mean annual rate of the coral calcification of Abrolhos reefs, of 10% in the last 25 years, is an indication that global climate changes are occurring in the South Atlantic Ocean and are causing a reduction in the amount of calcium carbonate that is precipitated in the Abrolhos reef environment.

## 3.45

**Physiological Vs. Environmental Factors Triggering Skeletal Mineralogy And Geochemistry in Scleractinian Corals**

**Jaroslaw STOLARSKI*[1]**, Anders MEIBOM[2]

[1]Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland, [2]Muséum National d'Histoire Naturelle, Paris, Paris, France

Environmental influence on biomineralization processes of scleractinian corals is widely acknowledged, and it is interpreted from the various skeletal geochemical and isotopic proxies. However, it is still a matter of debate whether those skeletal geochemical signatures reflect mainly polyp's physiological response to the changed environment (biologically controlled calcification) or represent direct migration of the ions from the ambient seawater to the mineralization sites (physicochemical model of calcification). By analogy with chemical $CaCO_3$ precipitation, it has been proposed that the Mg/Ca ratio of seawater may also directly control the mineralogy of hypercalcifying organisms such as corals, favoring those with aragonitic mineralogy in seas with high Mg/Ca ratio or those with calcite mineralogy in seas with low Mg/Ca ratio. The Mg/Ca ratio of seawater changed dramatically through the scleractianian evolutionary history and was probably the lowest during the Cretaceous. Exactly from the same period (ca. 70 milions years ago) we have evidence that some solitary scleractinian corals produced pristine calcite skeleton. However, from the same sediments and other Late Cretaceous sediments we have also abundant examples of clearly aragonitic scleractinians. It seems therefore that the Mg/Ca ratio of seawater does not control the scleractinian skeleton mineralogy directly, however, it may influence biomineralization physiology of some groups of corals.

## 3.46

**Computational Modelling Of Calcification in Zooxanthellate Scleractinian Corals**

Jiangjun CUI[1], Marten POSTMA[1], **Jaap KAANDORP*[1]**, Denis ALLEMAND[2]

[1]Section Computational Science, University of Amsterdam, Amsterdam, Netherlands, [2]Centre scientifique de Monaco, Monaco, Monaco

Zooxanthellate scleractinian corals take up large amounts of $CO_2$ and $Ca^{2+}$ during the formation of the calcareous skeleton. This process requires active transport of ions through several layers of tissue, which consumes high amounts of energy. The main source of energy comes from symbiotic algae, the Zooxanthellae, which live in the corals' cells and produce nutrients through photosynthesis. Both calcification and photosynthesis require inorganic carbon. The carbon from photosynthesis in the form of sugars is released during respiration in mitochondria, producing $CO_2$ and ATP that is further used in the calcification process to form $CaCO_3$.

To study the complex interplay between the different physiological processes and environmental conditions, we have developed a multi-compartmental model. The compartments represent the different layers in the coral tissue. The production, consumption and fluxes between layers of the relevant compounds are described by a set of coupled transport equations. To develop realistic models we have used detailed experimental data where available.

The light dependent $CO_2$ assimilation during photosynthesis was approximated by an experimental curve for C3 plant cells. Respiration in the layers with mitochondria was modelled by a $CO_2$ and ATP production term. The transport processes in each layer for $Ca^{2+}$, $H^+$ and $HCO_3^-$ was modelled by diffusion, channels and transporters. The action of carbonic anhydrase was modelled explicitly. The precipitation rate in the extracellular calcifying fluid was modelled by a rate equation adopted from a model for deep-sea coral calcification.

The numerical modelling allows us to extract the most important factors that determine calcification rate. More specifically, it allows us to validate various mechanisms proposed for light-enhanced calcification. Furthermore the model can predict how calcification rate dependents on several other environmental factors e.g. $pCO_2$, pH, $Ca^{2+}$ and temperature.

## 3.47

**Temporal Variations in Coral Growth And Microskeletal Development in Nearshore Terrigenoclastic-Dominated Reef Environments.**

**Ronan ROCHE*[1]**, Ken JOHNSON[2], Christopher PERRY[1], Scott SMITHERS[3]

[1]Manchester Metropolitan University, Manchester, United Kingdom, [2]Natural History Museum, London, United Kingdom, [3]James Cook University, Townsville, Australia

Recent published data from the central Great Barrier Reef lagoon suggests that sediment loading has increased five to ten fold, total nitrogen discharge has increased by a factor of four, and nitrate and total phosphorus by a factor of ten since the period of European settlement and subsequent land clearance (since ~ 1850 AD)[1]. Whilst such inputs have intuitively been regarded as exerting a negative affect on nearshore coral communities, recent studies have shown high live coral cover on many of these reefs and stratigraphic data suggests that these reefs have been growing steadily over the late Holocene period with relatively stable community structures. This raises interesting questions about whether these coral communities have been able to produce reefs in areas of high terrigenous sediment accumulation because of high calcification rates?

The objective of this study is therefore to quantify temporal and spatial variations in coral growth and microskeletal characteristics within coral reefs that are, and which have been through their growth history, strongly influenced by terrigenoclastic sediment inputs. Specifically the research is utilising coral samples obtained from reef cores recovered from a range of nearshore sites along the central and northern sections of the Great Barrier Reef (GBR) shelf at Magnetic Island, Paluma Shoals, Lugger Bay and King Reef. Evidence for changes in coral community structure, calcification rates and skeletal microarchitectural development over time are being obtained using novel (and non-destructive) Computerised Tomography (CT) scanner and X-ray diffraction (XRD) approaches, as well as existing Scanning Electron Microscopy (SEM) techniques. The detailed examination of coral skeletal characteristics in this study will shed light on the long-term development of turbid-zone, nearshore coral reefs and inform the on-going debate over the effects of the land-use changes on coral health in the central GBR region.

1) McCulloch M., Fallon S., Wyndham T., Hendy E., Lough J. & Barnes D. (2003) Coral record of increased sediment flux to the inner Great Barrier Reef since European settlement. Nature 421, 727-730.

## 3.48

**A geochemical model for coral reef formation based on organic and inorganic carbon productions of reef communities**

**TAKASHI NAKAMURA*[1]**, TORU NAKAMORI[1]

[1]Institute of Geology and Paleontology, Graduate school of Science, Tohoku University, Sendai, Japan

The conspicuous growth of a reef crest and the resulting differentiation of reef topography into a moat (shallow lagoon), crest and slope have long attracted the interest of scientists studying coral reefs. A geochemical model is here proposed for reef formation, taking into account diffusion-limited and light-enhanced calcification. First, to obtain data on net photosynthesis and calcification rates in the field, a typical coral communities were cultured in situ on a reef. Using these data, equations including parameters for calcification were then developed and applied in computer simulations to model the development over time of reef profiles and the diffusion of carbon species. The reef topography simulated by the model was in general agreement with reef topography observed in nature.

The process of reef growth as shown by the modeling was as follows. Increases in the shore-to-offshore gradients of the concentrations of carbonate species result from calcification by reef biota, giving a lower rate of growth on near-shore parts of the reef than on those further offshore. As a result, original topography is diversified into moat and reef crest for the first time. Reef growth on the reef crest is more rapid than in the inshore moat area, because more light is available at the crest. Reef growth on the near-shore side of the reef is further inhibited by damming of carbon-rich seawater on the seaward side of the reef by the reef crest. Over time, the topographic expression of the reef crest and moat becomes progressively more clearly defined by these geochemical processes.

## 3.49

**Style Of Reef Accretion At Poleward Front in The Late Holocene, in The Northern Ryukyu Islands, Japan**

**Hironobu KAN*[1]**, Yosuke NAKASHIMA[2], Nobuyuki HORI[3], Tatsuo NAKAI[4], Yusuke YOKOYAMA[5], Nozomu HAMANAKA[6], Takehiro OKAMOTO[1], Tomoya OHASHI[1]

[1]Faculty of Education, Okayama University, Okayama, Japan, [2]Ariake National College of Technology, Omuta, Japan, [3]Department of Geography, Nara University, Nara, Japan, [4]Geography and Environmental Studies, Kokushikan University, Tokyo, Japan, [5]Department of Earth and Planetary Science, The University of Tokyo, Tokyo, Japan, [6]Department of Earth System Science, Okayama University, Okayama, Japan

Typical acroporid reefs with distinct wave-resistant structure gradually disappear around 30 degrees north latitude in the northwestern Pacific. The Holocene development of two high-latitude reefs in the northern Ryukyu Islands was studied by core drilling and exposure of a cutting excavated across a modern reef.

Misaki Reef at northwestern Mage Island (30°45'40"N) developed from 6,650 to 4,500 cal yBP with an accumulation rate between 1.2 and 2.3 m/ka to form a 2.5 to 4.0 m-thick reef structure. Shojiura Reef at northeastern Tane Island (30°42'N) developed from 3,500 to 2,300 cal yBP with an accumulation rate between 1.2 and 2.3 m/ka to form a 2.8 m-thick reef structure.

Major reef development at these sites ceased within less than 2,000 years. The timing of reef development at Misaki Reef is coincidental with the Holocene maximum, whereas Shojiura Reef developed after Misaki Reef formation stopped. This phase shift shows that reef growth at high latitude is a site-specific phenomenon; similar reef development did not occur at nearby areas at the same timing, resulting in patchy distribution of reefs around the two islands.

The characteristic features of high-latitude reef development is delayed onset of growth after sea level rise, slow accumulation rate and short duration of reef formation, forming thin reef structures. The site-specific reef development indicates the uncertainty of reef response to environmental factors that have increased at the poleward front in the northern Ryukyu Islands during the late Holocene.

## 3.50

**In Situ Measurements Of Calcification Rates And Calcification/dissolution Thresholds in Coral Reef Communities Of South Florida And The U.s. Virgin Islands**

**Kimberly YATES*[1]**, Chris DUFORE[1], Nathan SMILEY[1]

[1]U.S. Geological Survey, St. Petersburg, FL

Rates of community calcification were measured, in situ, in representative habitat types of coral reef ecosystems in Florida Bay, Biscayne National Park, and the U.S. Virgin Islands using a large benthic incubation chamber called the Submersible Habitat for Analyzing Reef Quality (SHARQ). Carbonate system parameters including total alkalinity, pH, and total carbon dioxide were measured every four hours during 24-hour incubation periods, and calcification rates were calculated using the alkalinity anomaly method. Habitat types included patch reef, seagrass, hard bottom, and mud substrate. Diurnal trends in calcification rates were observed for all substrate types with calcification occurring primarily during day-light hours and dissolution of carbonate sediments observed during dark hours. Average rates of calcification during 24-hour incubation periods were 0.47 and 1.18 g $CaCO_3$ $m^{-2}$ for patch reefs and hard bottom communities, respectively. Seagrass and mud bottom communities showed equivalent rates of net carbonate sediment dissolution of -0.22 g $CaCO_3$ $m^{-2}$. Linear correlations were calculated for each substrate type. Carbonate ion and $pCO_2$ thresholds were estimated as the concentration of $CO_3^{2-}$ and $pCO_2$ at which rates of calcification and dissolution were equivalent. The average $pCO_2$ threshold for all substrate types was 585 µatm, and the average $CO_3^{2-}$ threshold was 203 µmol $kg^{-1}$. Threshold values vary considerably among substrate types, and on similar substrate types during different time periods. Atmospheric $pCO_2$ is predicted to reach 700 µatm by the year 2100, surpassing the average $pCO_2$ threshold for these substrate types, and indicating that a significant amount of sediment in coral reef ecosystems may be lost due to carbonate sediment dissolution.

## 4.51

**Status Of Genus Acropora in Indian Reefs And Its Role As An Indicator Of Reef Health**

**Sumitro SEN*[1]**, Satyanarayana CHOWDULA[2]

[1]Pondicherry University, Kolkata, India, [2]Zoological Survey of India, Kolkata, India

Acropora is the largest genus in order scleractinia and the major contributor to much of the reefs in the world. There are very few contributors to the systematic status of this genus because of its elastic phenotypic character, sensitive nature and depth varied distribution. National and International explorations carried out in all the major reef regions in India with the efforts of Zoological Survey of India over a decade yielded interesting results. Qualitative studies carried out yielded about 61 valid Acropora species out of more than 120 species listed in the world. 40 valid species are added during the study. The quantitative studies clearly show that the diverse and extensive reefs of India are under relentless attack by diverse anthropogenic threats especially, because of the heavy dependence on its resources by its stake holders and also more alarmingly due to quasi-natural threats like coral bleaching, tsunami etc. The threats were listed in all the sites on the basis of their potentiality in that region. Statistical analysis made with the data collected from all the major reef regions keeping Acropora as a keystone species yielded interesting results. Extensive Acropora beds in north India reefs which are acclaimed as the ones which probably seeded the western reefs by renowned Acropora Biologists were totally wiped out due to sedimentation and tectonic activity. Oceanic Atoll reefs of Lakshadweep were affected primarily due to bleaching. Andaman reefs are affected recently due to Tsunami. Findings of the study are useful to draw accurate management strategies for the conservation of Indian reefs. Present diversity status of Acropora and its role in pointing out at the potentiality of the recorded threats including site specific threats is clearly discussed in this paper with a much needed checklist review of this genus.

## 4.52

**The Potential Of The Soft Coral Sinularia Polydactyla And The Scleractinian Coral Leptastrea Purpurea As Bio-Monitoring Organisms: A Case Study**

**Peter SCHUPP*[1]**, Paulina WELCH[2], Chie TAKASE[1], Gary DENTON[2]

[1]UOG Marine Laboratory, University of Guam, Mangilao, Guam, [2]WERI, University of Guam, Mangilao, Guam

The objective of this study was to evaluate the soft coral *Sinularia polydactyla* and the scleractinian coral *Leptastrea purpurea* as bio-monitoring organisms for the distribution and abundance of recalcitrant contaminants in tropical reef waters. Marine invertebrates such as sponges, hard and soft corals are common inhabitants of barrier reef lagoons throughout the world and show great potential as bio-monitoring organisms for aquatic contaminants. The remarkable capacity of soft corals to accumulate polychlorinated biphenyls (PCBs) has recently been demonstrated, making them attractive candidates as bio-monitoring organisms. To evaluate PCB uptake and depuration kinetics in *Sinularia*, we transplanted colonies from a clean site to one known to be affected by PCBs and vise versa. In addition we investigated the effect of spawning by comparing PCB levels in pre- and post-spawn females, intra-colonial differences between the top and the bottom of colonies and the effect of size/age. Results will be discussed in detailed.

In another case study we examined the potential of *L. purpurea* larvae as test organisms for toxicity of antifouling agents (e.g. Irgarol®1051) and herbicides (e.g. Roundup® Ready). Acute toxicity to larvae and minimum concentration of each chemical required to adversely effect larval settlement was determined. Settlement bioassays ran for 24 h and employed either treatment of larvae or substrate with the test chemicals. The 24-h LC50 values for Roundup, POEA (surfactant) and glyphosate (active ingredient) were 9.6 mg/L, 1.5 mg/L and 9.3 mg/L respectively. Irgarol®1051 reduced settlement in both treatments at 100 mg/L, but was ineffective at lower concentrations. The minimum experimental concentrations of Roundup, POEA and glyphosate that significantly reduced larval settlement were 1 mg a.i./L, 10 mg/L and 3.6 mg/L respectively. The significance of the findings is discussed with respect to levels of Irgarol®1051 and Roundup® encountered in aquatic environments elsewhere in the world.

## 4.53

**Biogeographic Pattern And Impact Of Climate Change On Coral Communities in Taiwan**

**Sheng-wen HORNG*[1]**, Chang-feng DAI[1]

[1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan

Coral reefs are found in all waters around Taiwan except in the sandy areas on the west coast. Approximately 300 scleractinian species are found in Taiwan and its offshore islets. We explored the factors influencing or controlling Taiwan's coral assemblages, with extensive underwater survey. The sampled transects represented variation in sea surface temperature (SST), substrate composition, and geography. Species data from 16 sites and 129 species were analysed by canonical redundancy analyses. The three quantitative variables of SST, substrate composition (percentages) and geographic coordinates were used as explanatory variables in the canonical analyses. The first canonical axis divided the sites into reefal communities and non-reefal communities. The second axis revealed a separation of sites by coral-dominance and algae-dominance. Variation partitioning showed that geographic gradients accounting for 18% of species variation was the most important factor, while sea surface temperature and substrate composition explained 11% and 10% of species variation, respectively. The results show that the distribution pattern of scleractinian corals in Taiwan is controlled mostly by environmental factors reflecting a latitudinal gradient. Using the same set of scleractinian distribution data and data from previous studies, we modeled the spatial relationship of corals with Genetic Algorithm for Rule-set Prediction (GARP), and used it to predict the influences of climate change on coral communities in Taiwan. Under the impact of climate change and projected rise in SST, the spatial distribution of corals is likely to expand toward northern Taiwan, and the species richness in these areas would increase up to 2025. However, the spatial distribution of corals would contract with species richness in most areas decreasing dramatically beyond 2055, resulting in the loss of coral community heterogeneity. Unbalanced changes of coral communities can also be envisaged from the model predictions.

## 4.54

**Deep Reef Radiocarbon Records From The Straits Of Florida**

**Brad ROSENHEIM*[1]**, Thiago CORREA[2], Peter SWART[2], Gregor EBERLI[2], Mark GRASMUECK[2]

[1]Earth and Environmental Sciences, Tulane University, New Orleans, LA, [2]MGG, RSMAS, University of Miami, Miami, FL

The deep reefs of the Straits of Florida contain a significant habitat at depths seldom explored. A submersible exploration of the reefs in 2007 uncovered evidence of coral die-off with many parts of the reefs consisting of both standing dead corals and dead coral rubble. The discovery raised questions about the life cycles of these coral reefs. Are episodes of reef death part of a natural cycle or caused by environmental factors? Is this a common state in which these reefs are found? What are the environmental stressors that can cause such die-off? Timing the death of these corals can yield significant information toward these questions, complimentary to the environmental data recorded in their skeletons. We present radiocarbon ages of these coral skeletons, both standing-dead and living, to compare the age of dissolved inorganic carbon being incorporated into the skeletons at the time of death/collection. This information can yield clues about timing, as well as information about water chemistry when coupled with independent methods of dating. With other environmental proxy information archived in their skeletons, radiocarbon records will constitute an important first step in characterizing the living environment and life cycles of these coral reefs.

## 4.55

**Deep-Sea Corals From The Straits Of Florida As Proxy Indicators Of Bottom Conditions in The Florida Straits**

**Angela ROSENBERG*[1]**, Peter SWART[1], Gregor EBERLI[1], Mark GRASMUECK[1], Thiago CORREA[1]

[1]MGG, University of Miami, Miami, FL

Recent studies have shown the presence of large accumulations of non-zooxanthellate corals growing in mounds (up to 120 meters in height) scattered across the Straits of Florida at depths of up to 800 m. The surfaces of these mounds are covered in live corals, but the corals in the mounds themselves can be several 1000s of years old. Hence combined with appropriate dating, these mounds offer the opportunity to obtain a glimpse into variations in environmental conditions over this time period. This study reports high-resolution geochemical analyses (□18O, □[1]□C, Sr/Ca, Ba/Ca, and Mg/Ca) of the coral *Lophelia pertusa* growing in these environments and interprets these data in terms of changes of salinity and temperature. These data have been obtained by using a New Wave micromill to excise material from longitudinal sections of previously live specimens of *L.pertusa*. This material was then processed for stable carbon and oxygen isotopes (Finnigan Delta-Plus) and for minor elements (Inductively Coupled Plasma Optical Emission Spectrometer; Varian Vista-Pro). The Sr/Ca ratio of these corals can be interpreted as indicating principally a temperature driven signal, while the □18O reflects both temperature and □18Ow (□[18]O of the water). These parameters can in turn be related to variations in the strength of the near bottom current pattern.

## 4.56

**Opposed Trend Of Skeletal Carbon Isotopic Ratios Found in Two Different Coral Species Collected From The Same Site: Genus-Dependent Responses**

**Michiyo SHIMAMURA*[1]**, Kiseong HYEONG[1], Tsuyoshi WATANABE[2], Tomohisa IRINO[2], Chan-Min YOO[3], Woong-Seo KIM[1]

[1]Korea Ocean Research and Development Insitute, Ansan, Korea, Republic of, [2]Hokkaido University, Sapporo, Japan, [3]Korea Ocean Research and Development Insitute, Ansan, Japan

In order to better understand the controlling factor of δ13Cc, two different coral species, *Porites sp.* and *Platygyra ryukyuensis*, were collected at the exactly same site from Ishigaki Island, Japan, and analyzed for δ13Cc and δ18Oc. In an effort to develop paleo-environmetal proxy in mid-latitude region north of 30°N, *Platygyra*, one genus of faviidae corals that dominate in mid-latitude region, were analyzed for the study together with *Porites,* the most common and faithful coral proxy known up to now. The results were compared with observed environmental variables.

As expected, both coral's $\delta^{18}$Oc showed variations well matching observed SST. On the other hand, $\delta^{13}$Cc variations were opposite to each other between *Porites* and *Platygyra*. *Porites* δ13Cc shows a clear seasonal fluctuation matching that of solar radiation, high in summer and low in winter. In contrast, δ13Cc of *Platygyra* was low in summer and high in winter with weaker seasonality. Both colonies had been exposed to same environmental conditions during growth period, so these opposed trends should be attributed to factors other than environments, such as kinetic isotope effect depending on calcification rate or species-dependent responses against same environmental condition. Skeletal density, extension rate and calcification rate were estimated and compared with isotope variations for both species. However, no clear relationships were found between these factors and $\delta^{13}$Cc.

These results suggest following possibilities: 1) Different symbiotic relationship between coral and zoothantellae and 2) Coral diet variation depending on genus (or species). Probably, these are key factors that controls spatial distribution of each coral species.

## 4.57

**Preliminary assessment of the impact of solid waste on reef flat gastropod community in Talim Bay, Batangas, Philippines**

**Alexander ALOY*[1]**, Benjamin VALLEJO JR[1]

[1]Environmental Science and Meteorology, University of the Philippines, Quezon City, Philippines

Stratified quadrat surveys were conducted randomly over four plots on an intertidal reef flat and beach in Talim Bay in Batangas, Philippines for gastropods, other macro-invertebrates, solid wastes and organic debris. In this area some beaches are regularly cleaned by beachfront leaseholders. Epifaunal data were recorded as absolute quadrat density and while relative spatial cover was recorded for organic and inorganic debris and garbage. We developed rapid methods in measuring ambient abiotic parameters in the intertidal substrate like the oxic layer of the sand (i.e. 10 cm from surface) and slope using a mechanical angle finder level. The plots were selected based on the degree of disturbance due to the presence of solid waste material deposited in the upper areas (e.g. "swash zone") of the reef flat. We postulate that the presence of garbage (e.g. mostly composed of plastic sachets, plastics and bottles) affects the spatial distribution and feeding ecology of macrofauna, thus negatively decreasing gastropod community diversity. A total of five species of intertidal snails were present. A simple ordination procedure (PCA) was used to explore the diversity patterns of macrofauna over various quadrats and sampling areas. A species of Nassarius was the most commonly occurring species even in the most garbage-impacted reef flats. Other gastropods include Polinices, Oliva and Heliacus while other macrofauna were soldier crabs and Arcaster typicus all of which were associated with "regularly-cleaned" intertidal zones. A canonical correspondence analysis resulted into a general pattern of inverse corrrelation between garbage-debris cover with the oxic layer properties of the sand.

## 4.58

**150 Years of Coral Growth Rates and Water Quality on the Mesoamerican Reef**

**Jessica CARILLI*[1]**, Richard NORRIS[1], Konrad HUGHEN[2], Nancy PROUTY[3]

[1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, [2]Woods Hole Oceanographic Institution, Woods Hole, MA, [3]Pacific Science Center, United States Geological Survey, Santa Cruz, CA

We report coral growth rate data derived from 96 cores of *Montastrea faveolata* from the Mesoamerican reef spanning the last 150 years. X-rays reveal a severe slowing or hiatus in growth rate, or partial mortality event in every core in 1998. This growth anomaly is coincident with severe bleaching related to El Niño warming. Previous El Niño events did not produce such severe bleaching events, and no growth anomalies are seen prior to 1998. In late 1998, Hurricane Mitch passed over Honduras, causing massive flooding, freshwater plumes and sedimentation onto the reef. Mitch undoubtedly affected the Mesoamerican corals, as runoff plumes are detected in satellite images at all of our sites. However, the presence of anomalous growth rates during 1998 in corals from Florida and Mexico underscores the severity of this worldwide bleaching event.

Based upon preliminary master chronologies, growth parameters decrease over the length of the record at the sites closest to the largest sources of terrestrial runoff. At sites farther from runoff sources, growth increases. This may indicate that the corals at the more sediment-laden sites have reached a threshold in terms of a response to runoff, and that further increases over time have reduced growth rates. In contrast, increasing growth rates at sites further from the mainland implies that poor overall reef health at these more distal sites may not be due to runoff, but instead climate change, disease, overfishing, or other impacts. Coral geochemical records of water quality support this interpretation; Ba/Ca shows an increase in terrestrial runoff over the 20$^{th}$ century, and a lower overall amount of terrrestrial material at the offshore sites. In addition, coral oxygen isotope records indicate increasing freshwater runoff at the landward sites.

## 4.59

**Maracajau Reefs (In Northeastern Brazil) -An Ecosystem Under Severe Thermal Stress**

Elga MAYAL[1], Sigrid NEWMANN-LEITAO[2], **Elga MAYAL*[1]**

[1]Zoology, UFPE, Recife, Brazil, [2]Oceonography, UFPE, Recife, Brazil

All reefs in which corals grow or grew in Northeastern Brazil have a base of sandstone or sometimes another rock type cropping out of the sea floor. Where corals occur, there is also a great profusion of algae which usually grow on the seaward side of the reef, where the wave action is strong (Laborel,1965). Reefs, thus, are excellent sentinels of the quality of their environment. Proper monitoring of reefs can identify changes in water quality or impacts from land-based activities. Reefs are good environment quality indicators because even the slightest change in hydrology and many anthropogenic impacts may result in community structure changes.

This research provides baseline information on the hydrological conditions and on the coral and plankton communities at the Maracajaú reef ecosystem. Studies were performed from February to June 2000, covering the transition from dry to rainy season. In this area, there is an offshore coral reef formation, where corals were observed in loco and water samples were collected to obtain hydrological and plankton data. Six Scleratinians species were identified. Stable isotope analysis on the carbonate fraction of Favia gravida fragments showed that these corals are under severe thermal stress. Chlorophyll-a varied from 1.1mg m-³ to 9.3mg m-³, with higher values during the rainy season. Average zooplankton wet weight biomass were 117.0mg m-³(microzooplankton) and 15.7mg m-³(mesozooplankton). 136 Phytoplankton and 61 zooplankton taxa were identified. Seasonal forcing determined the micro- and mesozooplankton community structure, rather than the coastal offshore gradient.

Our results will help to assess anthropogenic disturbances and assist decision-making processes by helping local resource managers to understand the implications of actions associated with particular coral communities. These connections will help in developing management plans for coral reefs and other coastal and marine resources in Brazil.

## 4.60

**Seawater Isotopic Composition Variation in Abrolhos Reef Complex, Brazil**

**Ricardo DOMINGUES*[1]**, Alexandre COSTA[2], Ruy KIKUCHI[3]

[1]Instituto de Geociências, Universidade Federal da Bahia, Salvador, Brazil, [2]Instituto de Física, Universidade Federal da Bahia, Salvador, Brazil, [3]Geophysics and Geology Research Center, Universidade Federal da Bahia, Salvador, Brazil

Coral skeletons provide powerful tools for investigating past environmental conditions of their growth sites, especially information about sea surface temperature (SST). The precise understanding of d18O and d13C in coral skeletons demand that their behavior in seawater is well known as well. The aim of this study was to evaluate isotopic composition of sea water along one year in Abrolhos Reef Complex and contribute to set the basis for the use of stable isotope proxies for temperature in the South Atlantic. From December 2005 to September 2006, water samples were taken in Abrolhos Archipelago twice a month during low tide and high tide. These samples were analyzed in a Delta Plus mass spectrometer, following instructions of the International Atomic Energy Agency (IAEA Guidelines/ Manual for Operation of an Isotope Hydrology Laboratory). Sea water content of d18O varies from 1.5‰ (SMOW) in summer (February) to 1.0‰ (SMOW) in winter-spring (September). This seasonal trend in the sea water isotopic composition for the Abrolhos region may be due to the precipitation/evaporation balance, since the low values of d18O occurred in the rainy season, thus leaving the water lighter. A similar variability occurs with d13C. During fall and winter, its values vary from about 0 to -1.5‰ while during the summer, its value varies from 0.5 to 1.0‰.

## 4.61

**Montastrea cavernosa thermal stress bioindicator in the South Atlantic**

**Elga MAYAL*[1]**, Mara FISNER[2], Alcides SIAL[3], Valderez FERREIRA[3], Isabelle SOARES[1]

[1]UFPE, Recife, Brazil, [2]Oceonography, UFPE, Recife, Brazil, [3]Geology, UFPE, Recife, Brazil

We work with species collected from the Atol das Rocas in 1999, and from Tamandaré, south region of Pernambuco, in 2002 and 2003. Some analysis of stable isotopes C and O were done, being as follows: 41 analyses in the Atol das Rocas in 7 specimens; 11 analyses in Tamandaré in 2002 in 2 specimens, and 57 analyses in 2003 in 4 specimens. Both places are units of preservation These 109 analyses have shown that in all these years of collection, with the exception of one specimen in 2003, the temperature registered was higher than 30ºC. The estimated temperatures with values equal or above 30ºC are considered as anomalous in this study.

The samples were collected with SCUBA and apnea dives. The samples were washed with tap water and after immersed in a container with hydrogen peroxide 15% during 24 hours. Next, the samples were sliced; micro drilled and collected powders. The powder reacted overnight with orthophosphoric acid and was placed in a high vacuum extraction line. The gas was analyzed in a dual inlet, triple collector mass spectrometer. The C and O isotope ratios are reported on the PDB scale and the temperature was estimated assuming isotope equilibrium, between aragonite and seawater, for each sample, using the Horibe and Oba(1972) equation and d18O‰PDB, and paleosalinity using Craig&Gordon (1965) equation.

The isotopic analysis obtained for specimens in Atol das Rocas for the year 1999, presented variations of d13C -0.412 to -1.836‰PDB ; d 18O -4.162 to -4.611 ‰PDB.

The analysis obtained for specimens in Tamandaré for the year 2002, presented variations of d13C -3.269 to 2.647‰PDB ; d18O -4.122 to -4.506.‰PDB. In 2003, the isotopic analysis obtained presented variations of d13C -0.363 to -1.617 ‰PDB ; d18O -3.216 to -3.813 ‰PDB.

## 4.62

**Sr/Ca and Mg/Ca Use As Temperature Proxy In A Southwestern Atlantic Endemic Coral**

**Maria Cristina SANTEDICOLA*[1]**, Priscila GONÇALVES[1], Carlos MENDONÇA-FILHO[2], Ruy KIKUCHI[1]

[1]Geophysics and Geology Research Center, Universidade Federal da Bahia, Salvador, Brazil, [2]Institute of Geosciences, Universidade Federal da Bahia, s, Brazil

The aim of this study is to validate use of Sr/Ca and Mg/Ca ratios in skeletons of Mussismilia braziliensis as geochemical indicators of sea surface temperature (SST) in the Abrolhos reef complex, Eastern Brazil. Upon completion of a 17-sample pilot study to customize the methodology, 393 samples of coral skeleton were cut at every 2mm were cut along the maximum grownth axis of 4 different cores drilled in 2003. Samples were ground, and organic matter eliminated with H2O2. Twenty milligrams of each sample were decomposed by gradually adding 10 mL of HNO3 0,5M, and analyzed with an ICP-OES. The ranges obtained were 203-2260 ppm for Mg and 4553-8194 ppm for Sr. Geochemical ratio averages of 244 samples were compared to average SST nighttime temperature data acquired by the satellite AVHRR Pathfinder Version 5.0 since 1985, considering yearly, half-yearly and quarterly time intervals. A progressive reduction of Sr/Ca ratios at CAB-2 since 1948 may be translated as SST increase. However, a fine adjustment of Sr/Ca and Mg/Ca to temperature variation was not yet possible. We tried a yearly, half-yearly and quarterly resolution comparison between elemental rates and temperature. The best adjustment between SST and Sr/Ca-Mg/Ca was obtained with half-yearly averaged temperature and elemental rates. In addition to comparing pairs of contemporaneous geochemical and temperature data series, a lag of one unit of time was applied in order to investigate possible delayed effects of sea surface temperature over the physiology governing the incorporation of Sr/Ca and Mg/Ca by the coralline skeletons. The application of such lag did not provide significant changes in data plotting for the yearly time interval, but showed an increase in the relationship of temperature and Sr/Ca- Mg/Ca in half-yearly time interval.

## 4.63

**Coral Morphology As An Indicator of Sedimentation Rate; Cañada Honda, Dominican Republic**

**Allicia DAVIS*[1]**, Dennis HUBBARD[2]

[1]Dept. of Geological Sciences, Indiana University, Bloomington, IN, [2]Geology Dept., Oberlin College, Oberlin, OH

Coral distribution, abundance, and morphology were measured in a subaerially exposed Holocene coral reef in Cañada Honda, which is located in the western Dominican Republic. Four coral facies (branching, mixed, and two distinct massive-coral beds) have been identified. The lowermost massive-coral facies is focused on for this study. The facies is divided into two beds, by a probable storm layer. Six vertical transects were done throughout the two beds with sampling occurring at 20-cm intervals. Twenty corals at each transect were described in terms of morphology, degree of bioerosion, and vertical position within a facies. Samples of typical corals were collected for lab analyses.

The lower bed of the facies, M1, is distinguished by the prominence of *Montastrea* spp., while *Siderastrea* spp. dominates M2, the higher bed. Differences in colony morphology also distinguish the facies: M1 has more corals with 'pancake' morphologies (i.e. draping of successive layers) while M2 shows a more diverse range of shapes, including domes, inverted cones, and 'pancakes.' All shapes can be associated with multiple coral species, but *Montastrea* spp. strongly tends toward the 'pancake' morphology.

The excellent exposure at Cañada Honda allows for the correlation of growth form with sedimentation rate and degree of bioerosion. Overall, conical forms tend to be more bioeroded, regardless of species or facies. Therefore, they either grew faster or encountered slower sedimentation, resulting in colonies with longer exposure times and more bioerosion. High and variable sedimentation rates lead to periodic swamping of pancake-shaped colonies, which then overgrew the sediment as deposition slowed. Rapid burial led to less bioerosion. Annual growth bands revealed in X-radiographs can be used to quantify this relationship. Comparison of coral growth-rates in various forms may allow for the assignation of absolute values to terms such as "fast" or "slow" with respect to sedimentation in fossil reefs.

## 4.64

**Reconstruction Of Climatic Variability Induced By The Pna Pattern in The Southern Gulf Of Mexico: Geochemical Evidences From Coral Growth Bands**

**Constanza RICAURTE*[1]**, Jose CARRIQUIRY[1], Julio VILLAESCUSA[1], Guillermo HORTA[2]

[1]Instituto de Investigaciones Oceanologicas, Universidad Autonoma de Baja California, Ensenada, Mexico, [2]Facultad de Estudios Superiores Iztacala, Universidad Autónoma de México, Mexico D.F., Mexico

The climatic conditions of the Gulf of Mexico region are strongly influenced by large-scale extra-tropical variability in the atmospheric circulation of, well-known as Pattern Pacific/North american (PNA) (Slowey and Crowley, 1995). Although coral records have been extensively used to study tropical climatic events as El Niño and the South Oscillation, little has been made to understand the influence of extra-tropical phenomena like PNA on the tropical regions, such as the southern Gulf of Mexico. In this work we show that the rate of skeletal growth and the calcification rate of the coral Montastraea faveolata, collected from the Veracruz Reef System, in Mexico, is influenced by the effects of the PNA, which in turn affects sea surface temperature (which was reconstructed from Sr/Ca and Mg/Ca ratios). The rate of skeletal growth (cm year-1) of the coral Montastrea faveolata increases during the positive phase of the PNA pattern (in winter), characterized by negative anomalies in SST, while the rate of calcification (gr cm-2 year-1) increased during the negative phase of the PNA pattern (in summer) which is characterized by positive anomalies of SST. This means that the corals' annual growth respond to longer-term (decadal?), extreme variability of SST. The close relationship between the coral growth rate and calcification rate with PNA variability, suggest that corals are not only responding to SST changes, but to broader climatic conditions resulting from atmospheric climate patterns developing in the region. These results also indicate that it is possible to reconstruct the historical variability of the PNA in time-scales that exceed those available from instrumental records.

## 4.65

**Enso Variability Recorded in The Growth Rate Of Southwestern-South Atlantic Corals**

**Danielly GODIVA*[1]**, Heitor EVANGELISTA[2], Abdelfettah SIFEDDINE[3], Zelinda LEÃO[4], Nivaor RIGOZO[5], Barbara SEGAL[6], Tércio AMBRIZZI[7], Milton KAMPEL[8], Ruy KIKUCHI[4]

[1]Geoquímica Ambiental, Universidade Federal Fluminense, Rio de Janeiro, Brazil, [2]Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil, [3]Institut de Recherche pour le Développement, Paris, France, [4]Universidade Federal da Bahia, Salvador, Brazil, [5]FAETEC, São José dos Campos, Brazil, [6]Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil, [7]Universidade de São Paulo, São Paulo, Brazil, [8]Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil

The knowledge of the effects produced by El Niño Southern Oscillation (ENSO) to marine communities from the Southwestern-South Atlantic (SWSA) is restricted to observations from recent years. To extend these observations back in time, we conducted a study of coral skeleton from the Abrolhos Coral Reef Bank (ACRB), Brazil, and compared them to meteorological and oceanographic parameters in order to better understand the impact of ENSO during past decades. Here, we present an evidence of potential El Niño impacts in the SWSA inferred from the sclerochronology of the massive coral *Favia leptophylla*. The application of spectral analysis (wavelet decomposition and the iterative regression) to coral growth length and to meteorological-oceanographic parameters (air temperature, sea surface temperature and precipitation) as well as to the Southern Oscillation Index (SOI) and solar irradiation indicated a major significant inverse relationship between SOI and coral growth length in the 4–8 years frequency band. We propose that coral growth rate in the SWSA could be affected by El Niño Southern Oscillation (ENSO) events through an ''atmospheric bridge''. Although more work is needed to better define the relationship between coral growth rate and the SOI, we found that during El Niño years, southerly cold fronts do not reach the ACRB, reducing the water turbidity and favoring coral growth.

## 4.66

**Sclerochronology And Geochemistry Of Brazilian Corals To Reconstruct Southwestern-South Atlantic Climate Variability**

**Danielly GODIVA*[1]**, Heitor EVANGELISTA[2], Abdelfettah SIFEDDINE[3], Bruno TURCQ[3], Thierry CORRÈGE[4], Nivaor RIGOZO[5], Ruy KIKUCHI[6], Zelinda LEÃO[6], Milton KAMPEL[7], Renato CAMPELLO[8]

[1]Geoquímica Ambiental, Universidade Federal Fluminense, Rio de Janeiro, Brazil, [2]Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil, [3]Institut de Recherche pour le Développement, Paris, France, [4]Université Bordeaux 1, Talence, France, [5]FAETEC, São José dos Campos, Brazil, [6]Universidade Federal da Bahia, Salvador, Brazil, [7]Instituto Nacional de Pesquisas Espaciais, São José dos Campos, Brazil, [8]Geoquímica Ambiental, Universidade Federal Fluminense, Niterói, Brazil

It has been shown that interannual variations of environmental parameters (e.g. sea surface temperature (SST), salinity, P/E balance and sediment supply) are recorded in the high and low density growth bands of coral skeleton. Here, we investigate the potential of *Siderastrea stellata* and *Favia leptophylla*, Southwestern-South Atlantic (SWSA) zooxanthellate corals, as archives of physical and biological changes in the marine environment, induced by oceanic-atmospheric processes. The coral samples were obtained from different Brazilian coastal sites exposed to different environmental and anthropogenic forcing factors. The SST and salinity will be studied through the geochemical composition (stable oxygen, Sr, Ba, Mg, Ca) of coral skeletons. Preliminary sclerochronology studies from X-ray radiographs on corals from Buzios (22º 44' S 41º 88' W - 22º 75' S 41º 53' W) and Abrolhos (17º 52' S 39º 14' W - 18º 01' S 38º 66' W) showed a different growth pattern between the two sites. The Abrolhos corals growth present a linear decrease for the past 35 years whereas the Buzios corals seem to have a more stable growth rate despite the fact that they grow in shallower waters and are sometimes exposed during low tides. The Morlet wavelet decomposition and the iterative regression applied to SWSA coral growth band length and to climatic parameters (SST, air temperature, precipitation, Southern Oscillation Index and solar irradiation) indicate growth cyclicities around 2-3 years, 4-7 years, and a decadal component that seem to correlate with the physical parameters. A more precise sclerochronology study using a digital X-ray apparatus will be conducted, as well as geochemical analyses on specific transects.

## 4.67

**Using Nearshore Macrobenthos As Environmental Indicators Adjacent To A Major Navigational Inlet: Port Everglades Inlet, Florida**

**Jessica CRAFT*[1]**

[1]Marine Science & Biological Research, Coastal Planning & Engineering, Boca Raton, FL

The reefs off Broward County, Florida, lie near the northernmost limits of tropical coral reefs, are non-accreting, and have long been affected by human influences including land-based sources of pollution. Port Everglades may be a source of many anthropogenic contaminants, including freshwater and nutrients, which are discharged in a plume that sweeps over the coastal reef. The results of two nearshore reef studies were used here to determine if the inlet effluent plume produces a water quality gradient and associated biological gradient, and if any biological indicators of water quality can be determined.

Water quality variables, including nutrients, specific conductivity and chlorophyll levels, were analyzed. Results indicate a low-salinity wedge being discharged from the inlet at low tide, which is significantly correlated with increased levels of chlorophyll. Nutrients, including nitrates and nitrites, phosphorus, and TKN, also show peak levels occurring around the mouth of the inlet.

Macrobenthos cover at 33 sites from two separate studies was also assessed from Port Everglades inlet south to the Broward County line. Although preliminary results of the first study indicate that coral cover in the nearshore appears to be dependent on substrate variability, macroalgae cover was shown to significantly increase with proximity to Port Everglades inlet. No significant trends were determined from sponge abundance. These results suggest that Port Everglades may be a source of coastal pollution and freshwater discharge, causing localized increases in algal abundance which may be detrimental to the benthic ecology of the surrounding nearshore reef.

## 4.68

**Evidences Of Magdalena River As A Sporadic Stress Factor To Coral Reefs in Tayrona National Park (Colombia)**

**Iliana CHOLLETT-ORDAZ*[1,2]**, Alberto RODRÍGUEZ-RAMÍREZ[3], Eduardo KLEIN[2]

[1]Marine Spatial Ecology Lab. University of Exeter, Exeter, United Kingdom, [2]Instituto de Tecnología y Ciencias Marinas. Universidad Simón Bolívar, Caracas, Venezuela, [3]Instituto de Investigaciones Marinas y Costeras, Santa Marta, Colombia

In disturbance ecology, scale matters. "Coral reefs are affected by disturbances operating at different scales in space and time", is a standard sentence that can be found in almost every coral reef ecology book. However, sometimes transient events act at overlooked and surprising scales.

Coral reef degradation in Tayrona National Park, Colombia, has been related to the influence of continental waters from local - Ciénaga Grande de Santa Marta, a coastal estuarine lagoon, Gaira and Manzanares Rivers- and regional sources -Magdalena river- and the gradual increases of siltation, turbidity and nutrient loads. A neural networks analysis of 10 years of SeaWiFS satellite derived chlorophyll maps, revealed that the eastern Colombia Caribbean Sea experiences a very predictable annual pattern in ocean colour, only interrupted in 8 scenes (0.003% of the total) during two transient events in 1999 and 2000. In these two brief periods, Magdalena River's plume experienced a change in its westerly direction, tipping to the north and then to the east, reaching Tayrona. During the events, estimated surface chlorophyll concentration raised 16.07 $mg/m^3$ above the 10 year climatological mean ($0.99\pm1.88$ $mg/m^3$). These mesoscale perturbations, in synergy with a bleaching event in 1998 and the impact of hurricane Lenny in 1999, concurred with the largest annual reduction of coral cover in Bahia de Chengue, Tayrona: -3.6 and -5.1% during 1998/1999 and 1999/2000, related to an average absolute annual change of 1.7□1.2% in 12 years of monitoring.

The evidenced occasional but strong impact of the Magdalena River over Tayrona National Park might act as a stress factor for its coral reefs. Such mesoscale sporadic events may trigger large changes in coral cover, and must be included to the big picture assessments of Tayrona ecosystems.

## 4.69

**Application Of The Sedcon Index On Patch Reefs in Biscayne National Park, Florida**

**Alexa RAMIREZ*[1]**, Camille DANIELS[1], Pamela HALLOCK[1]

[1]College of Marine Science, University of South Florida, St Petersburg, FL

A simple index has been developed to assess the integrity of a reef system using sediment composition. The Sediment Constituent (SEDCON) Index is based upon the long-established methods of sedimentological facies interpretation using grain constituents, along with observations that phase shift in benthic communities is reflected in sediment composition. Shells of symbiont-bearing foraminifers, along with physically eroded, identifiable zooxanthellate coral fragments, characterize reef sediments in oligotrophic waters conducive to reef accretion. In contrast, higher proportions of shells of smaller, heterotrophic foraminifera, unidentifiable carbonate grains, and calcareous algae fragments tend to increase with increasing nutrient flux or other changes in water quality.

Biscayne National Park (BNP), Florida, contains over 4000 reefs in a relatively small area in relatively close proximity to a major urban area. Thus, BNP is an ideal location to test the SEDCON Index. Sediment samples were hand-collected by divers at 32 patch reefs in BNP in May 2007. Several environmental parameters also were measured at each site sampled. The sediment samples were individually assessed microscopically by identifying and counting the constituents in a 300-grain subsample. SEDCON Index values were calculated from the resulting data.

Interpolation maps were created for the SEDCON Index values for the sampled patch reefs, as well as for temperature, salinity, pH, and dissolved oxygen data. Spatial correlations were carried out between interpolation maps. Significant correlations were found between the SEDCON Index values and temperature and salinity, which implicate the influence of Biscayne Bay water on the patch reefs. Identifying the aspects of bay water responsible for the observed spatial patterns could be an important step in mitigating the loss of coral cover in BNP and elsewhere along the Florida reef tract.

## 4.70

**A Comparison Of Chemical Records in Montastraea Faveolata And Siderastrea Siderea As Examined By Laser Ablation Icp-Ms: A Look At Methodology For Caribbean Coral For Seasonal And Storm Events**

**Alan KOENIG*[1]**, Jessica CARILLI[2], Noreen BUSTER[3]

[1]Mineral Resources Team Denver, US Geological Survey, Denver, CO, [2]Scripps Institution of Oceanography, La Jolla, CA, [3]FISC Coastal and Watershed Science Team, US Geological Survey, St. Petersburg, FL

The importance of understanding past and recent climate and environmental patterns is no more evident than now. The utility of corals to decipher paleoclimate records such as temperature, salinity and ocean chemical patterns has been demonstrated. Most trace-element studies of coral have utilized bulk-sampling techniques such as microdrilling or Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) for small framework coral such as *Porites*. The large framework of *M. faveolata* leads to sampling problems with LA-ICP-MS. Detailed LA-ICP-MS analyses and SEM imaging of ablation tracks in *M. faveolata* indicate that inadvertent sampling of multiple or discontinuous skeletal elements can lead to false interpretations (Buster and Koenig, in prep.). Cores of *M. faveolata* and *S. siderea* were collected within a 20-meter radius at Frank's Caye in southern Belize. A comparison of LA-ICP-MS of identical time periods in these cores indicate that the smaller framework of *S. siderea* provides a clearer seasonal signal in metals without the noise introduced by sampling problems as in *M. faveolata*. We will compare data from different resolutions within *M. faveolata* utilizing bulk methods at monthly and yearly intervals and LA-ICP-MS at various spatial resolutions. Bulk annual samples in *M. faveolata* show spikes that correlate with known hurricane events, although not all events are resolved. Monthly drilled samples resolve seasonal cycles in Ba/Ca, with increasing variance toward the present indicating increasing runoff associated with land use change, however known hurricane events are still not all resolved. LA-ICP-MS provides higher resolution measurements of metals, and may help determine whether known events have not previously been resolved due to smoothing by low-resolution sampling, or if the signal is not being recorded.

## 4.71

**Heavy Metal Contents in Growth Bands Of Porites Corals: Record Of Anthropogenic And Human Developments From The Jordanian Gulf Of Aqaba**

**Saber AL-ROUSAN*[1]**, Rashid AL-SHLOUL[2], Fuad AL-HORANI[1], Ahmad ABU-HILAL[2]

[1]Marine Science Station, P.O.Box 195, The University of Jordan and Yarmouk University, Aqaba, Jordan, [2]Department of Earth and Environmental Science, Yarmouk University, Irbid, Jordan

In order to assess pollutants and impact of environmental changes in the coastal region of the Jordanian Gulf of Aqaba, concentrations of six metals were traced through variations in five years growth bands sections of recent *Porties* coral skeleton. X-radiography showed annual growth band patterns extending back to the year 1925. Baseline metal concentrations in *Porites* corals were established using 35 years-long metal record from late Holocene coral (deposited in pristine environment) and coral from reef that is least exposed to pollution in the marine reserve in the Gulf of Aqaba. The skeleton samples of the collected corals were acid digested and analyzed for their Cd, Cu, Fe, Mn, Pb and Zn content using Flame Atomic Absorption Spectrophotometer (FAAS). All metal profiles (except Fe and Zn) recorded the same metal signature from recent coral (1925-2005) in which low steady baseline levels were displayed in growth bands older than 1965, similar to those obtained from fossil and unpolluted corals. Most metals showed dramatic increase (ranging from 17 to 300 %) in growth band sections younger than 1965 suggesting an extensive contamination of the coastal area since the mid sixties. This date represents the beginning of a period that witnessed increasing coastal activities, constructions and urbanization. This has produced a significant reduction in coral skeletal extension rates. Results from this study strongly suggest that *Porites* corals have a high tendency to accumulate heavy metals in their skeletons and therefore can serve as proxy tools to monitor and record environmental pollution (bioindicators) in the Gulf of Aqaba.

## 4.72

**Study Of Heavy Metal Accumulation in Scleractinian Corls Of Viti Levu, Fiji Islands**

Sofia SHAH[1], **Edward LOVELL*[2]**

[1]Chemistry/Marine Science, University of the South Pacific, Suva, Fiji, [2]Marine Science, USP, SUVA, Fiji

The concentration of heavy metals (Copper, Lead, Zinc, Cadmium and Iron), together with the partitioning of the metals in the skeleton, tissue and zooxanthallae have been studied in three different coral families. The variation of metals in *Acropora formosa, Pocillopora damicornis* and *Porites spp* was also looked into. Heavy metal accumulation rates were studied for *Acropora formosa* and *Pocillopora damicornis* for a period of five days. Study sites included Suva and Nukubuco reefs, Coral Coast and Dravuni.

High concentrations of metals were determined for the zooxanthallae, than the tissue and the skeleton, suggesting that the zooxanthallae is responsible for the metal uptake in corals. This was the case for nearly all the corals studied. There is variation in the uptake of metals, suggesting that *Porities spp* seem to accumulate lower concentration of the metals than *Acropora* or *Pocillopora*. Corals from Dravuni had lower metal concentrations than that from the Coral Coast or the southern reefs, hence represents an excellent reference site.

Dose response curves show that as the nominal concentration increases, the uptake by the corals also increases. Two bioassays were carried out with nominal concentrations of 0, 0.01, 0.1 and 0.5 mg per litre of metal solution. Variations occurred for each dosage day. High concentrations of Pb as well as Fe seem to be accumulated in the corals for each dosage period, when compared to other metals. Pb and Fe concentrations as high as 2.5 and 0.8 ppm respectively had been transferred to the corals. There were significant differences in the uptake of the metals ($p<0.05$, for regression analysis). Zooxanthallae was lost as a result of stress on the corals.

## 4.73

**Past 100 Years Inter-Annual Sea Surface Salinity Changes in The Western Pacific Based On Coral Isotope Analysis**

**Hiroko IIJIMA*[1]**, Hajime KAYANNE[1], Nobuko NAKAMURA[1]

[1]Earth & Planetary Science, University of Tokyo, Tokyo, Japan

Salinity in the surface ocean (sea surface salinity: SSS) is changed by the balance between evaporation and precipitation, and has been utilized as an active parameter in ocean-atmosphere interactions. Tropical ocean is a region deeply related to the origin of climate change caused by the ocean-atmosphere interactions such as ENSO, and therefore reconstruction of SSS in the tropical ocean is important. Because observational SSS is limited both spatially and temporally, it is not sufficient for understanding the long-term changes in ocean-atmosphere interactions.

Oxygen isotopic composition of coral skeleton ($\delta^{18}O_{coral}$) is controlled both by sea surface temperature (SST) and by $\delta^{18}O$ of seawater ($\delta^{18}O_{sw}$), which is correlated with SSS. Therefore, $\delta^{18}O_{sw}$ is theoretically reconstructed by removing the contribution of SST from $\delta^{18}O_{coral}$. Iijima et al. [2005] reconstructed 50-year SSS variation from $\delta^{18}O_{coral}$ in Palau, located in the northwestern part of WPWP, and demonstrated its effectiveness as a paleo-salinometer. In this study, we extended this analysis to the last 100 years and calculate SSS using the local SSS calibration [Morimoto et al. (2002)].

Inter-annual variation of SSS at Palau implied both the decrease of precipitation and movements of western Pacific fresh pool, and strength of El Niño was better recorded in SSS than $\delta^{18}O_{coral}$ [Iijima et al., 2005]. We reconstructed the strength of past El Niño using the estimated SSS variation and detected its decadal change. The spatial reconstruction of salinity trends in the tropical western to central Pacific region showed freshening trend only in the central Pacific, which was explained by the recent El Niño -like condition. The result of this study suggests the strength of El Niño was recorded in annual SSS variation, but the long-term change in SSS was not affected by its interannual variation.

## 4.74

**Indian Ocean Dipole Index for the Last 115 Years Recorded in Kenyan Coral Annual Bands**

Hajime KAYANNE[1], **Nobuko NAKAMURA*[1]**, Hiroko IIJIMA[1], Timothy R. MCCLANAHAN[2], Swadhin BEHERA[3], Toshio YAMAGATA[1]

[1]Earth and Planetary Science, University of Tokyo, Tokyo, Japan, [2]Marine Programs, Wildlife Conservation Society, Bronx, NY, [3]Frontier Research Center for Global Change, JAMSTEC, Yokohama, Japan

Variability in the tropical and subtropical climate in the Indian Ocean has often been explained in relation to ENSO. However, correlation between ENSO and climate variability is not always strong. Recently, the Indian Ocean Dipole (IOD) was discovered [Saji et al., 1999], which has similar east-west SST and precipitation anomalies and periodicities that are similar to those of ENSO in the Pacific Ocean. IOD is a seasonally phase-locked interannual phenomenon, and produces precipitation anomalies in the East African short rains from October to November. The heavy rains in 1961, 1997 and 2006 were associated with positive IODs in these years [Yamagata et al., 2004].

A signal of the IOD in precipitation was detected in the coral core from Malindi, Kenya (3.2°S and 40.1°E). Luminescence intensity under UV light and oxygen isotope values dated at January, a few months after the short rain period, correlated well with anomalies in precipitation, and we assigned the oxygen value at January of the following year to coral IOD index [Kayanne et al., 2006]. To reconstruct IOD events before the instrumental observations, we extended the coral IOD index record back to 1886 A.D. The coral IOD index marked light oxygen isotope peaks (corresponding to high short rain precipitation) in 1902, 1905, 1912, 1935, 1952, 1961, 1972, 1994 and 1997, and heavy peaks (corresponding to low short rain precipitation) in 1889, 1895, 1931, 1941, 1953, 1971, 1985, 1991 and 1996. The coral index shows general lightening trend probably derived from warming, with decadal changes from relatively low amplitude of oscillation in the 1940s and 1980s to large amplitude in the 1930s, 1950s, 1970s and 1990s. Those seem to be consistent with characteristics of the instrumental IOD index in recent decades. On the other hand, the correlation between the coral index and single-ENSO years is weak.

## 4.75

**Variability Of Coral Skeletal Tin, Copper, Zinc, And Cadmium in Porites Lobata Corals From Kona, Hawaii**

Michael COLELLA[1], Jamie WARD[1], **Sarah C. GRAY*[1]**, Geoff DALY[1,2]

[1]Marine Science and Environmental Studies, University of San Diego, San Diego, CA, [2]Merkel & Associates, Inc., San Diego

Coral skeletal Cu, Zn, Sn, and Cd concentrations were measured along multiple transects (1992-1998) in coral colonies collected from two sites on the west coast of Hawaii: a moderately "anthropogenically impacted" site (Keauhou Bay) and a "control" site (Makalawena). Metal concentrations were compared between skeletal transects from the same colony (intra-colony variability), between different colonies from the same location (inter-colony variability), and between coral colonies from the two locations (site-site variability).

Cu and Zn concentrations ranged from 0.3 ppm to 7.5 ppm, and 0.1 ppm to 2.5 ppm, respectively and mean Cu and Zn concentrations were found to be significantly higher in corals from the impacted site compared to the control site. Possible sources of Cu and Zn in Keauhou Bay include anti-fouling boat paints and golf course fertilizers, which are not present at Makalawena. Mean coral skeletal Sn concentrations (non-lattice bound) from the Hawaii corals (0.19 +/- 0.25 µmol Sn/mol Ca; range: below detection to 1.75 µmol Sn/mol Ca) were comparable in concentration to those measured in other studies. Significant differences in median tin concentrations within (intra-colony variability) and between (inter-colony variability) colonies were found. The pattern of variability in tin concentrations across a single colony may be related to a colonies size and shape. The mean lattice-bound cadmium concentrations measured (5.81 +/- 9.78 nmol Cd/mol Ca) were comparable to natural background Cd concentrations measured in open ocean corals from the Galapagos (1-8 nmol Cd/mol Ca). Mean cadmium concentrations were significantly different within a coral (i.e. between transects) and the general temporal patterns in cadmium concentration could not be consistently replicated across a colony. The large intra-colony variability in Sn and Cd prevented the detection of a significant difference in mean Sn or Cd concentrations between the impacted and control sites.

## 4.76

**Sclerosponge Skeletal Growth Band As A Proxy Of Ocean Surface Environmental Change**

**Tamotsu OOMORI*[1]**, Mutsumi MORI[2], Eri HIROSAWA[2], Miyo IKEDA[2], Hiroyuki FUJIMURA[2], Takuro NOGUCHI[2], Yoshihito OHTSUKA[3], Michinari HATTORI[4], Yuichi TAKAKU[3]

[1]University of the Ryukyus, Okinawa-prefecture, Japan, [2]University of the Ryukyus, 1-Nishiharacho, Japan, [3]Institute for Environmental Sciences, Rokkasho, Japan, [4]Institute for Environmental Sciences, okkasho, Japan

Growth band of carbonate skeletons of marine organisms is considered as a suitable proxy of environmental change. Sclerosponge Acanthochaetetes wellsi survives at dark area in tropical-subtropical shallow ocean such as under water caves and forms skeletal growth band of Mg-rich calcite with growth rate of 0.4-1.2 mm/year(Oomori et.al., 1998) . Sclerosponge samples were collected from the underwater caves at Miyakojima in 2000 and studied on the possible new indicator of marine environmental change in decades. Skeletal samples were cut into thin plates with ca.5mm thickness and subjected to X-ray densitometry to observe the growth band, then cut into small stabs along with the growth band of skeletons. Powdered samples were subjected to mineral composition(XRD) , heavy metal element composition(ICP-MS) and isotope analysis of plutonium 239Pu/240Pu (HR-ICP-MS). Variation of Mg content of skeletons along the growth band were measured by EPMA.

Several advantages of sclerosponge growth band as a proxy of environmental change will be discussed in this paper. Acanthochaetetes wellsi enriches Mg, Pb and Pu and etc. in its skeleton. Mg/Ca ratio of Mg-rich calcite skeleton measured by EPMA showed a periodical variation which may correspond to temperature fluctuation in seawater. Contents of 239Pu and 240Pu in the growth band are high in the interior and decreased exponentially towards the surface, 0.78468 - 0.042925 pg/g and 0.175686-0.007298 pg/g, respectively, which corresponds to the year range 1960 to 2000. 240Pu/239Pu concentration ratio ranged from 0.2239-0.2088 at the interior (1964 to 1994), which is comparable to the bottom surface sediment of East China Sea and Okinawa Trough (0.21-0.26) to 0.1700 (1995 to 2000) which is similar to global fallout ratio (0.18: Kelly et al., 1999). Comparative study of 239Pu and 240Pu and 240Pu/239Pu ratio in coral growth band also carried on Porites sp. which corresponds to 1952-1981.

## 4.77

**Rare Species As Bio-Indicators Of Environmental Thermal Stress: Clues From A Small Coral**

Andrei SALCEDO-GREBECHOV[1], **Alberto ACOSTA*[2]**

[1]Pontificia Universidad Javeriana, Bogota, Colombia, [2]Biology, Pontificia Universidad Javeriana, Bogota, Colombia

It has been considered a priority to know the present and future status of populations of rare species because they occupy very specific habitats, and they demonstrate low tolerance to continuous stressors (i.e. global change, ENSO- thermal stress) which make them extremely vulnerable. Hence, a population of the coral *Manicina areolata* was monitored in the San Andres Island (Colombian Caribbean) during three years (2005-2007). Abundance and size of live and dead (bleached) colonies were surveyed. During low intensity and moderate frequency of ENSO sequential events, the population showed a 72% mortality (87/311 colonies) and significant differences in size-structure due to increased mortality and absence of recruitment. Fecundity showed a normal distribution pattern when compared to size. Size-based matrices were constructed and 5 simulations (~10 years) were carried out emulating diverse, possible future ENSO disturbance scenarios: 1. High intensity (assuming 85% mortality for all size classes in the matrix); 2. Moderate intensity (assuming 80% mortality); 3. Low intensity (matrix based on our monitoring period); 4. 40% decrease in fecundity; 5. Ideal scenario (zero mortality and reproduction). All simulations, except the latter, agree with the local extinction of *M. areolata* in 8,2+/-4,7 years ($\lambda<1$); the first and fourth colony size classes (0-2 cm long) being the most sensitive. The ideal scenario showed that the population could reach stability near the initial population size. The expected higher intensity and frequency of El Niño events and the consequent bleaching, plus the low probability of the natural population recovering through recruitment (zero juveniles quantified despite the high number of planulae produced per cm2 of tissue) may cause *M. areolata* population extinction in the seagrass habitat at San Andrés Island. The enhanced sensitivity of rare species to environmental change is an attribute that we can use as a key indicator of habitat and reef status.

## 4.78

**Effect of Feeding And Light On The Nitrogen Isotopic Composition Of A Zooxanthellate Coral**

**Stéphanie REYNAUD*[1]**, Fanny HOULBREQUE[2], Philippe MARTINEZ[3], Isabelle BILLY[3], Denis ALLEMAND[1], Christine FERRIER-PAGES[1]

[1]Centre Scientifique de Monaco, Monaco, Monaco, [2]STANFORD UNIVERSITY, Stanford, CA, [3]University of BORDEAUX, Talence, France

The relative importance of autotrophy and heterotrophy in the nutrition of corals has been a source of considerable controversy. Stable isotope analysis can bring new insights into this problem. Nitrogen isotopes are useful in tracing terrestrial inputs, identifying nutrient sources in reefs and determining the degree of heterotrophy. By measuring $\delta^{15}N$ within coral components, it may be possible to determine proportions of photosynthetic versus heterotrophic derived nutrients.

In order to investigate the effect of light and feeding on the $\delta$15N composition of zooxanthellae and animal tissue of *Stylophora pistillata*, a zooxanthellate coral, a set of experiments were performed, under controlled conditions. One group of corals was fed twice a week with freshly collected zooplankton and the second group was starved (control group). Each group was also cultivated under three light levels (80, 200 and 300 µmol photons m-2 s-1). $\delta$15N value of the zooplankton was measured during the course of the experiment, and was equal to 6.75 ‰. Results obtained showed that $\delta$15N values of coral tissue were significantly heavier than those of zooxanthellae: 7.65 ± 0.09 ‰ *vs*. 6.46 ± 0.10 ‰, for all culture conditions. The $\delta$15N of coral tissue measured in each light condition was not different within each group of fed (ANOVA, P=0.9) or starved colonies (ANOVA, P=0.6). When pooling data obtained under the 3 light levels, the $\delta$15N of fed coral tissue (7.36 ± 0.11 ‰) was lighter than the $\delta$15N of starved coral tissue (7.88 ± 0.12 ‰). We also observed a significant effect of feeding on $\delta$15N of zooxanthellae (ANOVA, $P<0.0001$). The mean value was 5.95 ± 0.12 ‰ for fed and 7.00 ± 0.11 ‰ for starved colonies. We confirmed that $\delta$15N can be used as a proxy in identifying trophic status of corals.

## 4.79

**Impacts Of Climate Change On Coral Reefs Of India**

**R. JEYABASKARAN*[1]**, R. RAJKUMAR[2], P.L. YENNAWAR[1]

[1]Zoological Survey of India, Marine Aquarium and Research Centre, Digha, India, [2]Zoological Survey of India, National Coral Reef Research Institute, Port Blair, India

In India, coral reefs occur in four major regions namely Andaman & Nicobar, Gulf of Kachchh, Gulf of Mannar and Lakshadweep Islands were severely affected by climate change impacts. However the impacts vary from place to place. The 26 December 2004 tsunami caused subsidence and elevation of landmass in Andaman and Nicobar Islands had led to severe shoreline erosion. Corals in 796 km2 reef flat areas were affected due to siltation and sedimentation caused by the erosion. The live coral coverage of reef flats was 20% and has been degraded further. Gulf of Kachchh reefs are facing rapid degradation due to the extreme temperature variations which is between 44.8„aC in summer and in extreme winter it reached 7.8„aC. Prolonged exposure of corals due to 4-7 meters tidal variation caused mortality of corals. Sediments are deposited at the rate of 2.5 cm per year and it had led to the coral mortality of 148 km2 reef flats. One or two colonies of corals were alive in the reef flats. Lakshadweep Islands consists of 132 km2 coastline which severely affected by the erosion. Coastal erosion led to high sedimentation in 136 km2 reef flats areas and caused mortality of corals and phase shift. Sediment deposition of 1.0 cm per year in Gulf of Mannar had led to the degradation of corals in 65 km2 reef flats. Reduction in water depth due to the sedimentation caused rise in sea surface temperature. Due to this corals were severely affected by the diseases and tumors. The other impacts of clime change on Indian coral reefs are discussed in the paper in detail.

## 4.80

**On The Causes Of Density Banding in Skeletons Of Montastraea Corals**

**Juan P. CARRICART-GANIVET*[1]**, Elizabeth DÁVALOS-DEHULLU[1], Héctor HERNÁNDEZ-ARANA[1]

[1]El Colegio de la Frontera Sur, Unidad Chetumal, Chetumal, Q. Roo, Mexico

To obtain a reliable climate reconstruction from coral skeletons it is first necessary to understand the way these grow and incorporate information. Thickness of skeletal elements (exothecal and endothecal dissepiments, costae, septa, and theca-wall) as well as the spacing between exothecal and endothecal dissepiments of the four extant Atlantic species of Montastraea (M. annularis, M. faveolata, M. franksi and M. cavernosa) were measured through high and low density bands. Our results show that growth periodicity, controlled by the effect of temperature, is expressed in changes in thickness of costae and exothecal dissepiments in the four studied Montastraea species, with no changes in endothecal elements and theca-wall thickness which, in turn, has implications for research on inclusive records using these species. Spacing between both exothecal and endothecal dissepiments resulted not significantly different between high and low density bands, and it is quite probably that their rhythmical formation is linked to lunar cycles.

## 4.81

**Reconstruction Of Environmental Conditions And Coral Nutrition Using Coral Cores**

**Cornelia RODER*[1]**, Claudio RICHTER[1]

[1]Center for Tropical Marine Ecology, Bremen, Germany

Coastal development has drastically changed the face of NE Hainan's coral reefs over the past decades. The establishment of harbours and aquaculture ponds and increasing urbanization have increased sediment, POM and nutrient loads, which together with overfishing have resulted in a phase shift from coral to algal dominated reefs.

Coral cores (*Porites lutea*) from differently impacted reefs along the East coast of Hainan allowed to reconstruct the history of pollution and to examine the impact of water quality on the growth and nutrition of the corals, where differences in intracrystalline $\delta^{13}C$ and $\delta^{15}N$ values allowed to identify fertilizer vs. sewage derived food sources. Increases in OM in the skeleton along with decreased growth rates are interpreted as increased heterotrophy by the coral host to supplement reduced photosynthetic activity with degrading water quality.

## 5.100

**The Effect Of Different Flow Regimes On The Long-Term Skeletal Growth And Physiology Of The Scleractinian Coral Galaxea Fascicularis in A Closed Aquarium System**

**Miriam SCHUTTER*[1,2]**, Max JANSE[3], Ronald OSINGA[1], Johan VERRETH[1], René WIJFFELS[2]

[1]Aquaculture and Fisheries, Wageningen University, Wageningen, Netherlands, [2]Bioprocess Engineering Group, Wageningen University, Wageningen, Netherlands, [3]Burgers Zoo, Arnhem, Netherlands

Water flow is one of the most important abiotic factors influencing the growth of scleractinian corals. Different aspects of flow, such as speed, turbulence and direction, affect prey capture efficiency, exchange rate of dissolved gasses and nutrients, and removal of sediment or mucus.

A long term experiment was performed in a closed aquarium system (Burgers Ocean, the Netherlands) to examine the effect of different flow regimes (1 cm/s, 10 cm/s, 20 cm/s and 25 cm/s, alternating, bidirectional flow) on long-term growth. Ten nubbins (single polyp clones of a coral colony) of *Galaxea fascicularis* were used for each treatment. Growth of these nubbins was measured for a 42 week period by determination of buoyant weight and by making polyp counts (every six weeks), and by image analysis for surface area (every three weeks).

In concurrent short-term incubation experiments, the feeding efficiency (uptake of *Artemia* nauplii) and the metabolic rates (photosynthesis and respiration) of these corals under the selected flow regimes was studied in a respirometric flow cell. These short term experiments may provide an explanation for the observed differences in growth.

So far, it is found that the coral nubbins grow less in the zero flow regime, while they grow most at 25 cm/s. Not much difference is found in growth between 10 and 20 cm/s. Water flow speed seems to have little effect on photosynthetic rate and a much larger effect on respiration rate. Feeding seems neither enhanced nor impaired at higher flow speeds.

## 5.101

**Segmented Gastric Cavity Of The Stony Coral**

**Michal RAZ BAHAT*[1]**, Zehava UNI[2], Buki RINKEVICH[1]

[1]zoology, National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel, [2]Zoology, Faculty of Agriculture, Hebrew University, P.O. Box 12, Rehovot, Israel, Rehovo, Israel

The digestive system of the stony coral has not been yet investigated thoroughly. The literature describes the polyp's digestive system schematically, as a blind sac divided into compartments by mesenteries lined with the gastrodermis tissue and with numerous mucus cells. This study investigates, in various methods, the detailed morphology and the enzymatic function of coral's digestive cavity.

Observing histological sections along the gastric cavity of the small-polyp coral *Stylophora pistillata,* by light microscopy, we found that the polyp's digestive system along the oral-aboral axis, is divided into several segments of different cell types and distribution. Using SAM, we investigated the structure and surface area of the gastric cavity walls, and found that they change, gradually, from the pharynx towards the basal plate. In order to elucidate whether the observed morphological characteristics are functional as well, we tested the activities of some digestive enzymes and found a differential abundance along the gastric cavity. This insight into the segmented gastric cavity provides a new perspective of the coral's digestive system.

## 5.102

**The Tropical Sea Anemone *aiptasia Pallida* As A Lab Model For The Study Of Coral Bleaching**

**Ophélie LADRIÈRE*[1]**, Stéphane ROBERTY[1], Charlotte BAUDESSON[1], Philippe COMPÈRE[2], Fabrice FRANCK[3], Mathieu POULICEK[1]

[1]Unit of Marine Ecology, Laboratory of Animal Ecology and Ecotoxicology, University of Liège, Liège, Belgium, [2]Unit of Ultrastructural Morphology, Laboratory of Functional and Evolutive Morphology, University of Liège, Liège, Benin, [3]Unit of Plant Biochemistry, University of Liège, Liège, Belgium

Bleaching is still among major events threatening coral reefs. New tools have to be developped to better understand the mechanisms leading to this pathology : we studied the use of the hermatypic anemone *Aiptasia pallida* as experimental model for coral bleaching. *Aiptasia* appears as a good candidate as it is easy to maintain in aquarium and subjected to bleaching like corals.

Both morphological and physiological approaches were performed to investigate the ultrastructure of the anemone tissues (TEM) and the zooxanthellae photophysiology (chlorophyll *a* fluorescence, respiration and pigmentation).

Experiments under light and dark stress reveal that anemone tissues ultrastructure can be differently affected. In darkness, the ectoderm activity is reoriented to capture prey by increasing cnidocyte density. In contrast, intense light affects especially the gastroderm : intercellular spaces increase, the expulsion of intact algae in the gastric cavity and the degradation of zooxanthellae inside vacuoles seem to reduce the zooxanthellae density, chloroplast thylakoids lose their parallel arrangement.

The analysis of the fluorescence induction curve appears as a powerful tool to analyse the physiological events series previous to bleaching. Although no significant zooxanthellae density reduction was observed, the decrease of pigments concentrations indicates that light or dark stresses induce anemone bleaching. Under strong light intensity, *A. pallida* zooxanthellae show an increased proportion of PSII QB non reducing, leading to partial photoinhibition. This phenomenon favours the ROS production that damages cellular structures of host and zooxanthellae. In darkness, there is no photosynthesis; anemones have therefore to find other feeding sources, as suggested by the ultrastructural approach.

As the present results confirm some of those obtained on scleractinians, *A. pallida* can be regarded as a good model for coral bleaching studies and has numerous advantages for experimentation.

## 5.103

**The Tissue-Skeleton Interface in the Scleractinian Coral Stylophora pistillata**

**Eric TAMBUTTÉ*[1]**, Denis ALLEMAND[1], Didier ZOCCOLA[1], Anders MEIBOM[2], Severine LOTTO[3], Natacha CAMINITI[1], Sylvie TAMBUTTÉ[1]

[1]Centre Scientifique de Monaco, Monaco, Monaco, [2]Laboratoire d'Etude de la Matière Extraterrestre, Museum National d'Histoire Naturelle, paris, France, [3]Centre Scientifique de Monaco, Monaco, France

Stylophora pistillata is a coral for which numerous physiological data on calcification are available through detailed laboratory studies. However, for this species, as well as for most other species, the cellular tissue is poorly described at the microscopic level. The aim of the present work is to provide histological observations of the coral tissue at the interface with the skeleton, using Stylophora pistillata as a model, and to discuss these observations in the context of the morpho-functional aspects of biomineralization. The approach is top-down, i.e., it starts from a macroscopic level with observations made on a microcolony-level and proceeds to a sub-microscopic level with observations made on the cells and the corresponding skeletal surface. Several important observations can be made: 1) At all scales of observation, there is a precise morphological correspondence between the tissues and the skeleton. 2) The distribution and density of desmocyte cells, which anchor the calicoblastic ectoderm to the skeletal surface, vary spatially and temporally during skeletal growth stages 3) The calicoblastic cell layer differs dramatically between regions corresponding to different ultra-structural components of the skeleton. From the base to the tip of coenosteal spines, the histology of coral tissues changes from four epithelial layers to two epithelial layers that completely lack endoderms. These findings have important implications for models for vital effects in coral skeletal chemistry and isotope composition.

## 5.104

**Capacity For Plastic Growth Response Of *porites Lobata* in Fluctuating Temperature Regimes Varies Between Colonies**

**Tyler WATERSON*[1]**, Daniel BARSHIS[2], Jonathon STILLMAN[3]

[1]Marine Biology, Romberg Tiburon Center, San Francisco State University, Tiburon, CA, [2]Zoology, Hawai'i Institute of Marine Biology, Kaneohe, HI, [3]Biology, Romberg Tiburon Center, San Francisco State University, Tiburon, CA

In the back reef lagoons of Ofu, American Samoa, corals thrive in temperatures (up to 360C) higher than most corals can tolerate, and daily temperature fluctuates 2-40C depending on the size and flow of the pool. A reciprocal transplant study of two massive *Porites* species showed that corals from both forereef (constant temperature) and back reef environments grow more quickly in the back reef lagoon, although native back reef corals grow more quickly in all environments relative to conspecifics from the forereef. Here we examined whether these growth differences were due to temperature or other environmental factors, and whether growth responses were correlated with genotype. We collected samples of *Porites lobata* from forereef and back reef sites, with n=5 colonies per site and 25-30 replicates per colony. We transported the corals to our laboratory and split them between two tanks imitating either the forereef (290C) or back reef (fluctuating 27-320C). After one month, new vertical tissue extension was measured. Both back reef and forereef corals had significantly higher tissue extension rates in the fluctuating tank than the constant-temperature tank, indicating phenotypic plasticity in growth in response to temperature. As in the field, back reef corals had significantly higher vertical tissue extension rates than forereef corals. However, colony-specific responses varied within each source environment. We hypothesize that this is an effect of host genetic polymorphism since no variation has been detected in the genotype of symbiodinium associated with *P. lobata* at this site (all colonies examined thus far host a similar strain of clade C). High genetic diversity has been seen in *Porites* species on this reef and we are currently examining the host genotype of the colonies studied using sequence homology of the internal transcribed spacer (ITS) region of nuclear ribosomal dna to compare growth responses with genotype.

## 5.105

**Feeding Corals in Captivity: The Role Of Prey Type And Prey Concentration**

**Ronald OSINGA*[1]**, Tim WIJGERDE[1], Fam CHARKO[1], Johan VERRETH[1], Dirk GRYMONPRE[2], Silvia LAVORANO[3]

[1]Wageningen University, Wageningen, Netherlands, [2]INVE BV, Dendermonde, Belgium, [3]Acquario di Genova, Genova, Italy

Corals feed heterotrophically to complement the nutrition they obtain through photosynthesis by zooxanthellae. Within the project CORALZOO (a collaboration between zoo's and scientists), feeding efficiencies and growth rates of five species of corals are studied using different food types and concentrations. A protocol-template for feeding of corals in captivity will be deduced from the results.

Colonies of the branching species *S. caliendrum* were used to study the uptake of live nauplii at different starting concentrations (1,000 – 20,0000 nauplii / l). Colonies of this species were incubated with nauplii in a mildly stirred, 1,5 l Perspex chamber. Uptake rates were remarkably high: a 14 ml coral colony could capture up to 10,000 nauplii within 15 minutes. At high starting concentrations, saturation occurred after 10 to 45 minutes, while at lower starting concentrations, the incubation chamber was in most cases almost cleared of nauplii after 30 minutes.

Long-term growth experiments with the branching coral *Pocillopora damicornis* showed that *Artemia* nauplii were a better food source than microalgae (*Nannochloropsis* sp.) and rotifers (*Brachionis* sp.). Most optimal was a (daily) start concentration of 2,000 nauplii per l.

The boulder-shaped *Galaxea fascicularis* was used to test the ability of corals to capture four different *Artemia*-based feeds: live nauplii, dead (pasteurized) nauplii, Selco-enriched Instar II nauplii and Selco-enriched Instar II nauplii supplemented with a test compound. The corals preferred live over dead nauplii. Capture efficiency of Instar II nauplii was lower than for freshly hatched nauplii, but not significant when normalized to carbon content. Supplemented Instar II was captured with the same efficiency as non-supplemented Instar II, which may enable development of tailor-made *Artemia*-based coral feeds in the near future.

## 5.106

**Preliminary Results: Reproduction And Zooxanthellae Of *millepora Platyphylla***

**Alan DAVIS*[1]**

1Kagman High School, Saipan, Northern Mariana Islands

Millepora spp. hydrocorals initiate reproduction by liberating medusae that develop encapsulated in ampullae within the corallum; medusae spawn and die within hours. Zooxanthellae are acquired by eggs before medusae leave the colony. Reproductive state of Millepora platyphylla was studied sporadically from 1984 through 1986 on Guam, by monitoring presence of ampullae in collected hard parts. Tissue specimens were collected for light microscopical study, and embedded in paraffin.

Medusae were released three or four days after Full Moon beginning in April in both 1985 and 1986, followed by monthly liberation for some months. M. dichotoma began showed a similar pattern, albeit later in the summer, as M. platyphylla apparently wound down its season.

Some days prior to liberation of medusae, reproducing colonies change to a marked darker brown color, and colonies' surfaces are peppered with numerous minute white rings, evidence of decalicification of overburden of ampullae.

Ordinary coccoid zooxanthellae stay near the tissue surface. Prior to liberation of medusae, certain structures appear to move through the coenosarc canals. It is proposed that these are zooxanthella swarmers, and suggested that as they move through basement layers they are able to enter the medusae and infect the egg: apparently the putative swarmers convert into coccoid zooxanthellae immediately, when they enter the medusae.

These preliminary results suggest that linked sexual reproductive cycles are crucial to the vertical transmission of zooxanthellae in Millepora spp. Further research is demanded, to elucidate the details of these events. Individual cycles of both animal and plant demand to be carefully studied, and the nature of these complex interactions and such signals as enable the coordination of their life cycles. Subsidiary observations of Millepora platyphylla likewise highlight the importance of research on these key species.

## 5.107

**Mechanisms Of Microhabitat Segregation Among Corallimorpharians: Evidence From Physiological Parameters Related To Photosynthesis And Host Cellular Response To Irradiance.**

**Baraka KUGURU*[1]**, Nanette E. Chadwick CHADWICK[2], Yair ACHITUV[3], Sophie DOVE[4], Ove HOEGH-GULDBERG[5], Dan TCHERNOV[6]

[1]Life Science, Interuniversity Institute for Marine Science, Eilat, Israel, [2]Biological Sciences, Auburn University, Auburn, AL, [3]The Mina and Everard Goodman Faculty of Life Sciences, Bar Ilan University, Tel aviv, Israel, [4]Centre for Marine Studies, University of Queensland, Australia, Australia, [5]Centre for Marine Studies, University of Queensland, Queensland, Australia, [6]Life science, Interuniversity Institute for Marine Science, Eilat, Israel

Corallimorpharians are evolutionarily important relatives to stony corals, yet little is known about their ecophysiology. We show here that variation in the photoacclimation responses of some corallimorpharians explains in part their distribution and abundance on shallow reef flats. Our experimental exposure of corallimorpharians to the synergistic effects of UVR and PAR caused reduction of zooxanthella abundance, FV/Fm, and sigma values, while it caused an increase in QM, host cellular enzymatic activity (SOD), cellular degradation (LPO), MAAs, and GFPs. The corallimorpharian *Rhodactis rhodostoma* was physiologically less sensitive than *Discosoma unguja* when exposed to the synergistic effect of PAR and UVR. While our previous study showed that zooxanthellae in both host species photoprotected the host tissues from high light pressure by quenching the excitation energies through NPQ, the present study in addition, found that the host cells synthesized UVR absorbing compounds such as MAAs and GFPs, which functionally sun-protected the zooxanthellae. The *R. rhodostoma* host synthesized MAAs which absorb in the UVB range (300nm - 320nm), while *D. unguja* synthesized MAAs which absorb in the UVA range (320nm - 340nm), explaining in part why *R. rhodostoma* is able to acclimate better than *D. unguja* in shallow areas which are characterized by high UVB. Because some species are more affected than others by increased levels of ambient UVB radiation, significant changes in community structure are likely to occur in the near future on coral reefs.

## 5.108

**Differential Expression Of Soluble And Membrane-Bound Proteins in Soft Corals**

**Ernestina TENTORI*[1]**, Murray THOMSON[2]

[1]Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Ensenada, Mexico, [2]Sydney University, Sydney, Australia

The site specific morphology of soft corals suggests that total protein and specific protein content may differ throughout parts of the organism. There are very few studies on the protein constituents of soft corals tissues, they all have extracted proteins using simple Tris-HCl buffers. These type of buffers should be efficient at extracting soluble, cytosolic proteins but are likely to be inefficient at extracting membrane-bound proteins. This is the first study comparing variations of protein content and protein profiles within colonial cnidarians.

*Sarcophyton sp and Capnella gaboensis* specimens, were sectioned into colony regions with different physiological potential, judged by their proximity to endosymbiotic algae and/or direct contact with the external medium. The tissue sections were homogenized in two different buffers, either NP40, that contained Nonidet P40 detergent and sodium deoxycholate or TRIS that did not. SDS-PAGE analysis of proteins showed significant intracolonial differences of protein content ($p<0.05$) and differences of protein profile ($p<0.05$). Furthermore, this investigation indicated that the specific proteins have a different pattern of distribution ($p<0.05$) when the tissues are processed using NP40 or Tris buffers. The differential expression of proteins shown here suggests a degree of functional specialization within the structural repetitive units of these modular organisms.

## 5.109

**Production And Elimination Of Reactive Oxygen Species in Different Symbiodinium Spp. in Culture**

**Elizabeth MCGINTY*[1]**, Laura MYDLARZ[1]

[1]Biology, University of Texas at Arlington, Arlington, TX

Reactive oxygen species (ROS) produced by symbiotic algae can be harmful to the coral holobiont and cause abnormal physiological signs. Recent evidence suggests that different zooxanthellae clades contribute to variations in coral growth rate and stress tolerance. We hypothesize that these variations may be a function of each *Symbiodinium* strain's ability to produce and scavenge ROS. To test this hypothesis we applied stress in the form of mechanical injury and elevated temperature to representative strains of clades A, B, C, D, E, and F. The amount of ROS and the anti-oxidants catalase and superoxide dismutase were measured using fluorescence and absorbance based assays and the differences between clades were evaluated. Algae respiration rates in response to elevated temperature were also measured using oxygen consumption rates of cultures. Preliminary findings show that clade C released the highest levels of ROS in response to mechanical agitation and clade A the lowest. In addition, a subset of clades produced a concomitant release of ROS in response to incremental temperature increase. These initial results suggest that there are differences between clades in their ability to produce ROS. The findings from these ongoing studies and the anti-oxidant studies, along with their relevance to understanding the mechanistic responses to disease, bleaching, and environmental changes, will be presented.

## 5.110

**A Quantitative Approach Linking Coral Mucus And Their Symbiotic Zooxannthellae in Response To Environmental Change**

**Alan M. PIGGOT*[1]**, Bruce W. FOUKE[1]

[1]Geology, University of Illinois, Urbana, IL

There is irrefutable evidence that a rapid decline is occurring in scleractinian corals due to coral diseases and bleaching. These pathogenic effectors are inhibited by the coral mucosal layer which acts as both a physiochemical disease barrier and a medium for nutrient assimilation. The integrity of this layer has been shown to be dependent upon photosynthetic symbiotic zooxanthellae, which allocate approximately 45% of their net daily fixed carbon to the mucus through the coral host. Quantification of this relationship is necessary to link physiological responses to processes involved in coral reef sustainability. Classical analyses can only obtain tissue-independent estimates of zooxanthellae without commensurate mucosal measurements. In this presentation, we illustrate a novel approach combining fluorescence spectroscopy with immunohistochemical methods to determine quantitative estimates of zooxanthellae and mucocytes within the context of the coral host *Montastrea annularis*. Preliminary results indicate that spatial correlation of these parameters exists and more importantly that alterations in mucosal amounts can be attributed to the disturbance of resident zooxanthellae.

## 5.111

**Soft Corals, Nudibranchs And Zooxanthellae: Are There Differences in Symbiont Species Found in Each Host?**

**Katie LIBERATORE*[1]**, Ingo BURGHARDT[2], Ursula SHEPHERD[3], Joshua LEFFLER[4]

[1]Department of Biology, University of New Mexico, Albuquerque, NM, [2]Department of Animal Ecology, Evolution and Biodiversity, Ruhr-University Bochum, Bochum, Germany, [3]University Honors and Dept of Biology, University of New Mexico, Albuquerque, NM, [4]Department of Wildland Resources, Utah State University, Logan, UT

This study examines the relationship between nudibranchs (genus *Phyllodesmium),* the *Xenia* corals on which they feed, and the dinoflagellate symbionts they share (genus *Symbiodinium*). These nudibranchs are known to ingest their zooxanthellae partners while feeding on *Xenia*, but little more is known about this relationship. For instance, do *Xenia* host more than one species of *Symbiodinium,* and if so, do the nudibranchs sequester the same species or do they choose a particular subset of species? We also wondered whether the two hosts might respond similarly to changes in environmental variables such as temperature. We asked whether there are multiple species of *Symbiodinium* in either *Xenia* or *Phyllodesmium* found at a single location on the Great Barrier Reef. We also asked whether *Symbiodinium* community structure differed after a winter warming event. We collected nudibranchs and corals from the intertidal zone off Lizard Island in June 2007. We took polyps and cerata from corals and nudibranchs respectively. We allowed animals to acclimate in lab aquaria, then raised temperature by 3oC over several days. New tissue samples were taken following the experiment. DNA was extracted, the *Symbiodinium* ITS2 region of 5.8s rDNA was amplified, and Denaturing Gradient Gel Electrophoresis (DGGE) was used to determine the number and kinds of *Symbiodinium* species. We found multiple *Symbiodinium* Clade C species in corals and nudibranchs, and most were shared. There was no difference in amount of *Symbiodinium* DNA before and after the temperature experiments, but community structure changed, with fewer types remaining in each. Examination of this system may assist in unraveling the likely responses of tropical marine intertidal organisms to the changes in sea surface temperature projected over the next century.

## 5.112

**Onset Of Symbiosis And Distribution Patterns Of Symbiotic Dinoflagellates in Scleractinian Coral Larvae**

**Saki HARII*[1]**, Naoko YASUDA[1], Mauricio RODRIGUEZ-LANETTY[2], Michio HIDAKA[3]

[1]Graduate School of Engineering and Science, University of the Ryukyus, Okinawa, Japan, [2]Centre for Marine Studies, University of Queensland, QLD, Australia, [3]Faculty of Science, University of the Ryukyus, Okinawa, Japan

Establishment of symbiosis in early developmental stages is important for reef-building corals. Corals spawn eggs and sperm or brood planula larvae and shed them directly into the water. Some coral eggs or planulae receive symbiotic dinoflagellates (zooxanthellae) directly from their parents, while others acquire them from the environment at each generation. Although it has been experimentally demonstrated that azooxanthellate larvae of some corals acquire zooxanthellae during larval stages, little is known about the timing and process of the establishment of this symbiotic relationship. We examined 1) uptake of zooxanthellae by larvae in six scleractinian corals and 2) both the timing of uptake and distribution patterns of zooxanthellae in the planulae of two *Acropora* species under the laboratory conditions. Zooxanthellae were isolated from adult conspecific colonies (homologous) and added to planula larvae with or without *Artemia* sp. The number and distribution pattern of zooxanthellae in the larvae were observed under a fluorescence microscopy and/or on histological sections. Planulae of all the six species *Acropora tenuis*, *A. digitifera*, *A. nobilis*, *A.* (*Isopora*) *palifera*, *Favia pallida*, and *Ctenactis echinata* acquired zooxanthellae. The uptake of zooxanthellae occurred 5 and 6 days after spawning in *A. nobilis* and *A. digitifera*, respectively. The number of incorporated zooxanthellae in the larvae increased over the experimental periods. Histological observations also showed that zooxanthellae were incorporated by larvae when they formed a well-developed mouth and coelenterons. The larvae of *A. digitifera* incorporated more zooxanthellae in the presence of homogenized *Artemia* sp. The present results suggest that coral larvae of many species can acquire zooxanthellae during the larval stage and that larval feeding behavior plays an important role in the acquisition of zooxanthellae.

## 5.113

**The Cell Ecology Of *symbiodinium* in Soritid Foraminifera**

**Scott FAY*[1]**, Michele WEBER[1], Jere LIPPS[1]

[1]Integrative Biology, University of California, Berkeley, Berkeley, CA

*Amphisorus, Marginopora, and Sorites* foraminifera host diverse lineages of *Symbiodinium* dinoflagellates. It is not uncommon for an individual foraminifer to host mixed populations of *Symbiodinium* from multiple clades. Fine-scale examination of individual foraminifera reveals a pattern where certain genotypes of symbiont are enriched towards the center of the test. In order to explore what ecological forces are at work that might explain these observations, we identify five factors that potentially determine which symbionts are found in these hosts: vertical transmission, specificity, regulation, competition between symbiont lineages, and availability from the environment.

## 5.114

**Gene Expression in The Coral, *montipora Capitata*, After Fragmentation And Transplantation: Insight Into Transcriptional Stress Response Using Real-Time Pcr**

**Marissa B. HIRST*[1]**, Anderson B. MAYFIELD[1], Ruth D. GATES[1]

[1]Department of Zoology, University of Hawaii, Manoa, Kaneohe, HI

Most tools used to assess coral health rely on biological responses that are temporally removed from the onset of stress i.e. bleaching and mortality. To manage corals more effectively, techniques that detect shifts in health earlier in the biological response are needed. Gene expression responds rapidly to the onset of stress and therefore represents a framework for developing such tools. This study explores the expression of the heat shock protein 70 (hsp70) gene as a potential biomarker in the scleractinian coral *Montipora capitata* and its endosymbiotic algae, *Symbiodinium*. Fragments of coral were removed from parent colonies (n=10) and placed at the same depth as the parent colony (8 feet) to recuperate. In order to assess the impact of fragmentation, hsp70 expression was assessed in fragments (n = 5) collected weekly during the one-month recuperation. In a second experiment, conducted post-recuperation, a subset of fragments (n = 5) were elevated three feet in the water column and controls maintained at 8 feet. Fragments were collected in a time series over one week to explore differences in hsp70 expression in the host and symbiont as a result of the depth transplantation. Gene expression was quantified using Real-Time Polymerase Chain Reaction normalized to an exogenous RNA spike and genome copy number of hsp70 in *Symbiodinium*. The expression of hsp70 was low in the coral and symbiont in fragmented corals. Hsp70 expression in coral hosts transplanted shallower was similar to control fragments, however, symbiont hsp70 was up regulated in these transplants relative to controls. These results suggest that expression of the hsp70 gene is not altered greatly by fragmentation and that hsp70 expression in *Symbiodinium* is more sensitive to changing environmental conditions than host hsp70 gene expression.

## 5.115

**An 'in Vitro' Method Of Coral Health Assessment: A New Approach**

**Maya VIZEL*[1]**, Esti KRAMARSKY-WINTER[1], Craig DOWNS[2], Yossi LOYA[1]

[1]Dept. of Zoology, Tel Aviv University, Tel Aviv, Israel, [2]Haereticus Environmental Labs, Clifford, VA

Assessing coral health in laboratory conditions can provide us with fast and easy results in a controlled environment. In order to do so, a new method for culturing coral tissue and polyp explants has been developed in this study. This method does not require the use of large aquaria for coral growth or proximity to coral reef, making it available worldwide. In order to create these tissue explants, tissue from adult coral of Fungia granulosa was mechanically removed.

Approximately 24 hours after excision tissues were transferred to FSW (filtered sea water) and optimal growth conditions were examined. Results indicate that manipulating environmental parameters such as temperature and light we can produce explants that are either maintained in a tissue state or developed into small polyps. We further succeeded in developing tissue and polyp lines by sub-culturing the explant-derived polyps, thus providing continuous cultures from single genetic lines. Because these coral tissue/polyp explants are genetically identical and can be propagated multiple times, they can be used for short or long term studies in coral health assessment. To exemplify such a use, the effect of various concentrations of the antibiotic cycloheximide, often used in agriculture, was used on a line of these genetically identical polyps and found to cause complete bleaching at concentrations as low as 10mg/L. This technique provides a method for achieving fast results concerning coral physiology and be useful in ecotoxicological studies, under laboratory conditions.

## 5.116

**Thermal Stress On Two Mediterranean Gorgonians: *eunicella Singulari* And *eunicella Cavolinii*. Consequences Of The Symbiosis On Heat Stress Resistance.**

**Pierre-Laurent MERLE*[1]**, Thamilla ZAMOUM[1], Anthony BERTUCCI[2], Marie GEMINI[1], Denis ALLEMAND[2], Paola FURLA[1]

[1]ECOMERS, Univ. Nice-Sophia Antipolis, NICE, France, [2]Centre Scientifique de Monaco, Monaco, Monaco

Global climate change has deep impacts not only on tropical marine invertebrates, but also on many tempered species. In particular, the critical heat waves recorded in the late 1999 and 2003 summers coincided with massive death events locally observed among the Mediterranean gorgonians, such as the symbiotic *Eunicella singulari*, and the non-symbiotic *Eunicella cavolinii*. This work aimed to study the early effects of strong and short hyperthermia on these two *Eunicella* species. Several biological and oxidative stress markers were analyzed (catalase activities, HSP expression, protein peroxidation and ubiquitination levels) to compare the respective responses of these two gorgonian species and to test whether zooxanthellae endosymbiosis offers higher resistance or sensitivity to thermal stress. Increasing seawater temperature from 18°C (control) to 28°C (intense short-term hyperthermia) provoked fast tissue necrosis in both species, but with a 2-day delay for the symbiotic one, which did not presented any bleaching induction. This work, which first validates the use of several stress biomarkers on these temperate gorgonians, also pointed out high inter-individual variabilities. Although *E.cavolinii* had high anti-oxidative basal defense level, heat stress induced significant protein ubiquitination. On the other hand, *E. singularis* had reduced anti-oxidative basal defense level, albeit showed more plastic response, which can partly explain their better tolerance to hyperthermia. These studies, carried out to better understand the physiological impact of thermal stress on temperate gorgonians, are a part of a wider program concerning the Mediterranean gorgonian conservation (www.medchange.org).

## 5.117

**Photobleaching Mechanism in Symbiotic *symbiodinium* Spp. Under Heat Stress**

**Shunichi TAKAHASHI*[1]**, Spencer WHITNEY[2], Shigeru ITOH[3], Tadashi MARUYAMA[4], Murray BADGER[1]

[1]ARC Center of Excellence in Plant Energy Biology, Research School of Biological Sciences, The Australian National University, Canberra, Australia, [2]Research School of Biological Sciences, The Australian National University, Canberra, Australia, [3]Division of Material Science (Physics), Nagoya University, Nagoya, Japan, [4]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokosuka, Japan

Coral bleaching, caused by heat stress, is associated with the light-induced loss of photosynthetic pigments in symbiotic dinoflagellate algae (*Symbiodinium* spp.), however the molecular mechanisms responsible for pigment loss are poorly understood. Here we show that moderate heat stress primarily causes photobleaching through inhibition of the de novo synthesis of intrinsic light harvesting antennae (chlorophyll *a*-chlorophyll *c*2-peridinin-protein complexes; acpPC) in cultured *Symbiodinium* algae and that two Clade A *Symbiodinium* species showing different thermal sensitivities of photobleaching also show differential sensitivity of this key protein synthesis process. Photoinhibition of photosystem II (PSII) and subsequent photobleaching were observed at temperatures exceeding 31°C in cultured *Symbiodinium* CS-73 cells grown at 25°C to 34°C but not in cultures of the more thermally tolerant control *Symbiodinium* species OTcH-1. We found that bleaching in CS-73 is associated with loss of acpPC that is a major antennae protein in *Symbiodinium*. In addition, its thermally induced loss is light dependent, does not coincide directly with PSII photoinhibition and is not caused by stimulated degradation of acpPC. In cells treated at 34°C over 24 h the steady state *acpPC* mRNA pool was modestly reduced ~30% while the corresponding synthesis rate of acpPC was diminished by more than 80%. Our results suggest photobleaching in *Symbiodinium* is consequentially linked to the relative susceptibility of PSII to photoinhibition during thermal stress and occurs, at least partially, due to loss of acpPC via undefined mechanisms(s) that hamper the de novo synthesis of acpPC primarily at the translational processing step.

## 5.118

**Preservation of Coral Samples in DMSO-Salt Buffer (SSDE) is Superior to Ethanol**

**Zoltan SZABO*[1]**, Marc W CREPEAU[1], Robert J TOONEN[1]

[1]Hawaii Institute of Marine Biology, Kaneohe, HI

DNA-based techniques form the basis of much of the recent global effort to quantify coral diversity and connectivity. 95% ethanol (EtOH) is the most commonly used preservative of coral samples, however transportation and storage can be a problem due to the flammable nature of EtOH. About 2 years ago, we started collecting coral samples in both a buffer consisting of 20% DMSO, 0.25M EDTA pH 8.0 saturated with NaCl (SSDE) and 95% EtOH, and used these paired samples for our study here. We compared DNA quality from representatives of both scleractinian and octocorals and found that DNA extraction from SSDE-preserved samples produced significantly more high-molecular weight DNA relative to degraded (low-molecular weight) DNA than extractions from the paired EtOH-preserved samples of the same colony. In some EtOH-preserved samples (e.g., *Pocillopora, Carijoa*) virtually no high-molecular weight DNA was visible on agarose gels. Additionally, our preliminary data suggest that higher quality DNA will provide more copies of intact DNA molecules available for amplification, resulting in fewer misincorporated nucleotides in PCR products. Based on these results, we expect to see less DNA sequence variation from DMSO preserved samples than from the paired EtOH preserved ones. Experiments are under way to compare the matched DMSO/EtOH samples for sequence variation in PCR applications, and will be presented at the conference. Coral DNA is notoriously difficult to work with, and we hypothesize that some of this reputation may result from poor success with EtOH-preserved coral samples. We have found that switching from EtOH to SSDE buffer in the field tends to yield much higher quality DNA in the lab across a broad range of hard and soft coral species, and that SSDE preservation results in far fewer problems with subsequent PCR applications of preserved coral samples.

## 5.119

**Ratiometric Imaging Of Gastrodermal Lipid Body in Cnidaria-Dinoflagellate Endosymbiosis**

**Yi-Jun LUO*[1]**, Hui-Ju HUANG[2], Li-Hsueh WANG[1,2], Wan-Nan UANG[3], Lee-Shing FANG[4], Chii-Shiarng CHEN[1,2]

[1]Institute of Marine Biotechnology, National Dong Hwa University, Pingtung, Taiwan, [2]Coral Research Center, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [3]Biological Science and Technology, I-Sou University, Kaohsiung, Taiwan, [4]Cheng Shiu University, Kaohsiung, Taiwan

Cnidaria-dinoflagellate endosymbiosis is the phenomenon that an autotrophic symbiont lives inside the endodermal cell of animal host. The molecular mechanism that regulates this association remains unclear. Using quantitative microscopy, we now provide evidence that the dynamic lipid change in endodermal "lipid body" (LB) reflects the symbiotic status between the host cell and its symbiont in the hermatypic coral *Euphyllia glabrescens*. By ratiometric imaging with a solvatochromic fluorescent lysochrome, nile red (9-diethylamino-5H-benzo[ ]phenoxazine-5-one), we show that the *in situ* distribution of polar *versus* non-polar lipids (*i.e.* "red" over "green" fluorescence of nile red, or R/G ratio) of LB or retained symbionts in living endodermal cells can be analyzed. R/G ratio in individual LB increases during the bleaching process, indicating a retardation of non-polar lipid accumulation in endodermal cells. On the other hand, non-polar lipids accumulation inside the symbiont results in gradual decreases of R/G ratio. Interestingly, patterns of R/G ratio shift in symbionts are different between bleaching and starvation processes. In the later, little lipid accumulation in symbionts and results in no R/G ratio shift. These results suggest that a membrane lipid trafficking must underlie to regulate the endosymbiotic association between the host cells and symbionts.

## 5.120

**Surface Proteins Identification Of Symbiotic Gastrodermal Cells in Hermatypic Coral Euphyllia Glabrescens**

**Chih-Yao CHANG*[1]**, Shao-En PENG[1,2], Chii-Shiarng CHEN[1,2]

[1]Institute of Marine Biotechnology, National Dong Hwa University, Pingtung, Taiwan, [2]Coral Research Center, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan

Regulatory mechanism of marine symbiosis in Cnidarian-dinoflagellate association remains unclear notwithstanding decades of research. Symbiotic gastrodermal cell membrane may play important roles in the process of initiation and maintainence of this endosymbiosis. In order to investigate interactions between symbionts and their host, preparation of homogeneous gastrodermal cells and culture are prerequisite. Here, we first examine cell surface proteins of symbiotic gastrodermal cells by a chemical biotinylation process. The intactness of symbiotic gastrodermal cells and successful protein biotinylation are shown by confocol microsopy and transmission electron microscopy. We next to seek identify these biotinylated symbiotic gastrodermal cells surface membrane specific proteins by 2D SDS-PAGE. Furthermore, two-dimensional distribution pattern of biotinylated proteins of symbiotic gastrodermal cells are affected by light irradiation, and show significant difference from that of cultural *Symbiodinium*. It indicates a specific labeling of surface proteins and a high light sensitivity of the isolated gastrodermal cellular membrane. Ongoing work focuses on the identification of biotinylated proteins, and their future usage in identifying aposymbiotic gastrodermal cells.

## 5.121

**Symbionts Are A Deadly Burden For Coral Larvae**

**Andrew BAIRD*[1]**, Irina YAKOVLEVA[2]

[1]James Cook University, townsville, Australia, [2]Institute of Marine Biology, Vladivostok, Russian Federation

Mutualisms are often viewed as reciprocal exploitations that nonetheless provide net benefits to each partner. Any feature that aligns the interests of the partners should promote long-term stability in the association. For example, passing symbionts directly from parent to offspring should benefit the host by reducing conflict between diverse symbionts, and benefit the symbiont by guaranteeing transmission. However, in some symbiotic associations, such as those between corals and zooxanthellae, vertical transmission is rare, suggesting a substantial cost. Here we show that coral larvae with zooxanthellae had lower survivorship than larvae of the same species that lacked zooxanthellae when exposed to high levels of temperature and ultraviolet radiation (UVR). Higher activity of antioxidant defenses and higher levels of oxidative cellular damage observed in symbiotic larvae under high temperature and UVR exposures suggest that reactive oxygen species, produced by the overload of the photosynthetic apparatus of the zooxanthellae, are responsible for these higher rates of mortality. Symbionts are clearly a costly burden early in the life history of broadcast spawning corals under stressful environmental conditions.

## 5.122

**Telomerase Activity And Telomere Sequence in The *cassiopea* Jellyfish**

**Michiko OJIMI*[1]**, Naoko ISOMURA[1], Michio HIDAKA[1]

[1]University of the Ryukyus, Nishihara, Japan

The scyphistome of the jellyfish *Cassiopea* sp. form vegetative buds, which detach from the scyphistome and metamorphose into polyps (scyphistomes). Once polyps are infected with zooxanthellae, they form medusae via strobilation. While the asexual reproduction cycle via asexual propagules seems to continue endless in a laboratory condition, medusae, which do sexual reproduction, might be mortal. The underlying mechanisms of this difference in the life span between the polyp and medusa stages are not understood.

Telomeres, the repetitive nucleotide sequences with associated proteins at the ends of eukaryotic chromosomes, generally become shortened during cell division and the length of teleomeres is considered to reflect age of the cells. As the first step to understand the different life spans of the polyp and medusa stages of *Cassiopea* sp., we measured telomerase activity in polyps and young medusae using the stretch PCR method, which was designed to amplify DNA fragments with telomere sequence, (TTAGGG) n. We found telomerase activity in tissues of aposymbiotic and symbiotic polyps, asexual propagules and young and adult medusae, though the success rate of detection varied between stages. We cloned and sequenced the PCR products and the amplified fragments contained (TTAGGG) n. The present finding that the *Cassiopea* jellyfish has the  evertebrate f telomere motif of (TTAGGG) n is consistent with recent studies on corals and other cnidarians (Sinclair *et al*. 2006; Traut *et al*. 2007). Although the telomerase activity was detected in both polyp and medusa stages, further quantitative analyses of telomerase activity might reveal the underlying mechanisms of different life span of the polyp and medusa stages of the jellyfish.

## 5.123

**The Effect Of Temperature On The Zooxanthellae Cell Proliferation**

**Yi-Cheng LEI*[1]**, Li-Hsueh WANG[1,2], Hsieh-He LI[1], Chii-Shian CHEN[2]

[1]Institute of Marine Biotechnology, National Dong Hwa University, Hualien, Taiwan, [2]Coral Research Center, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan

Coral reefs turn visibly pale, also known as coral bleaching, due to loss of their symbiotic dinoflagellate while exposed to high light intensity and elevated water temperature. Under these stresses, dysfunctional zooxanthellae were released from the cnidarian hosts. Depending upon the cnidarian species, there are various levels of bleaching in response to the same temperature, suggesting that there may be difference in temperature tolerance for each specific zooxanthellae. To understand how temperature affects zooxanthellae and induces coral bleaching, we examined cell proliferation and photosynthetic efficiency in zooxanthellae under various temperatures. Our results revealed that at lower temperatures (i.e. 19□), the percentage of cells in $G_2$/M phase dropped in the first L/D cycle, and recovered in the second L/D cycle. At 28□, the percentage of cells in $G_2$/M phase increased to 1.5 folds of control group in both the first and second L/D cycles. However, at 32□, the percentage of cells in $G_2$/M phase decreased to 0.4 to 0.5 fold of control group in the first L/D cycle and 0.2 fold of the control in the second L/D cycle. The quantum yield of zooxanthellae was lower at 32□ than at control temperature (i.e. 25□), and the amount of glycerol accumulation in the cell was less at 32□ than at 25□, suggesting that the capacity of photosynthesis and carbon-fixation were reduced under elevated temperature. The data indicate that four zooxanthellae examined exhibit similar responses with different temperatures. In conclusion, at low temperature, cell proliferation slows down but eventually recovered. On the other hand, cell proliferation is permanently inhibited at 32□. Therefore, elevated water temperature poses a real threat to the population of zooxanthellae.

## 5.124

**Different sensitivity of zooxanthellae types isolated from the corals Madracis and Agaricia to increasing temperature**

**Petra VISSER*[1]**, Pedro FRADE[2], Rolf BAK[2]

[1]Aquatic Microbiology, University of Amsterdam, Amsterdam, Netherlands, [2]Marine Ecology & Evolution, NIOZ, Den Burg-Texel, Netherlands

The coral genera Madracis and Agaricia are abundant in the Caribbean reefs and harbour zooxanthellae of clade B and C, respectively. Madracis corals hardly bleach, while Agaricia corals bleach frequently. Can this difference be explained by the physiological response to temperature of the Symbiodinium types they harbour? First, we investigated by genetical analysis which zoox types are present at different depths and in different coral species of these genera. Second, we performed experiments with coral fragments and zooxanthellae isolated from these coral genera at different temperatures. We hypothesized that the zoox from the coral Agaricia lamarcki, which bleaches more frequently than Madracis senaria, have a higher temperature sensitivity than the zoox from M.senaria. Experiments were performed in which the photosynthetic yield was measured after small steps of increasing temperature. We didnot observe a difference between the species in the average temperature at which the photosynthesis yield collapsed, but we did find a faster decrease in photosynthesis yield in the range 26-32 degrees. To investigate this further, we will compare the lipid composition (ratio of unsaturated and saturated fatty acids) and the formation of ROS of the symbionts at high temperature.

## 5.125

**Genetic Diversity within the Endolithic Alga Ostreobium quekettii that Harbor the Scleractinian Corals Skeleton**

**Eldad HOCH*[1,2]**, Maoz FINE[1,2]

[1]Bar-Ilan University, Ramat Gan, Israel, [2]The Interuniversity Institute for Marine Science, Eilat, Israel

For a couple of decades researchers had focused on the symbiotic dinoflagellate alga Symbiodinium, residing in the endodermal tissue of reef building corals. Another associate partner which has been largely over looked is the green alga Ostreobium. Endolithic in nature, this alga reside in the skeleton of scleractinian corals, forming a distinctive green band, a few millimeters beneath the coral tissue. It has been demonstrated, that this alga plays a role in the physiology and metabolism of corals. An Uptake of photoassimilates by the coral has been shown using a carbon tracer in azoxanthellate corals. Furthermore, in bleached coral colonies, the endolithic alga can be an alterative source of energy as they increase their biomass in the bleached areas of the colony and help the coral to survive during a low energetic state period. This alga is well dispersed among the marine environment, from colder environments of the North-Western Pacific to warmer climates including the Mediterranean Sea and tropical oceans. The alga is abundant in almost all corals species (98%). Ostreobium is also present in corals over a wide scale water depth gradient, from the shallow to the depths of more then 100 meters.

Except for one study that questioned the genetic variability of Ostreobium based on morphology only, most studies refer to it as quekettii or sp. across oceans and regions. In this study we aimed to characterize the genetic variability of Ostreobium based on DNA phylogenetic markers ITS1 and ITS2. We successfully extracted DNA from skeletons of several corals belonging to 6 species of corals from the Mediterranean Sea and the Red Sea. Screening these amplified markers showed variability between Ostreobium from different regions, depth and species. We hypothesize that a vast genetic variability of Ostreobium exists between regions and ecological niches.

## 5.127

**Pigments As Indicators Of Stress Mechanisms in Corals**

**Kathleen MCDOUGALL*[1]**, Angela SQUIER[1], Kenneth BOYD[1], Stuart GIBB[1], Craig DOWNS[2], Barbara BROWN[1,3]

[1]Environmental Research Institute, North Highland College, UHI Millennium Institute, Thurso, United Kingdom, [2]Haereticus Environmental Laboratory, Clifford, VA, [3]School of Biology, University of Newcastle, Newcastle upon Tyne, United Kingdom

The loss of algal pigments from zooxanthellae is associated with environmental stress in corals, however, relatively little attention has been paid to these pigments as biomarkers to investigate the mechanisms that operate during such stress events. We have previously proposed a suite of chlorophyll *a*-like compounds as early biomarkers of stress in coral zooxanthellae. Generation of the chlorophyll-*a* like compounds was first noted through retrospective data analysis of high performance liquid chromatography (HPLC) pigment analyses of algal symbionts from the shallow water coral *Goniastrea aspera* in Phuket, Thailand. Higher concentrations of a sub-set of these chlorophyll *a*-like products were observed in response to both elevated light and temperature, providing significant potential as biomarkers of stress in corals. These compounds have subsequently been seen in the branching corals *Porites compressa* and *Pocillopora damicornis* under laboratory conditions and been shown to be more sensitive than the xanthophyll ratio or fatty acid profiles as indicators of stress. In order to investigate these compounds further we proposed to develop model systems to study their formation. Utilising the macroalga *Enteromorpha linza* as a readily available model of a photoautotroph which undergoes bleaching in response to high levels of solar irradiance, we have found the same chlorophyll *a*-like compounds present under different environmental conditions as in the coral zooxanthellae. Additionally, the compounds can be generated *in vitro* from chlorophyll *a* using copper and hydrogen peroxide. Using liquid chromatography-atmospheric pressure chemical ionisation multistage mass spectrometry (LC-APCI MSn) the compounds produced were identified as the chlorophyll *a* oxidation products 132(*R*)- and 132(*S*)-hydroxychlorophyll *a* and Mg-purpurin-7 dimethyl phytyl ester. The characterisation of these compounds and the evidence that they are produced under oxidative conditions indicates their potential as biomarkers of oxidative stresses in corals.

## 5.128

**Regulation Of Gfp-Like Protein Expression in Reef-Building Corals**

**Joerg WIEDENMANN*[1,2]**, Cecilia D'ANGELO[2], Andrea DENZEL[2], Alexander VOGT[2], Mikhail MATZ[3], Franz OSWALD[2], Anya SALIH[4], Ulrich NIENHAUS[2]

[1]National Oceanography Center, University of Southampton, Southampton, United Kingdom, [2]University of Ulm, Ulm, Germany, [3]University of Texas, Austin, TX, [4]University of Western Sydney, Sydney, Australia

GFP-like fluorescent and colored proteins are responsible for the startling colorful appearance of hermatypic corals, yet the physiological function of these pigments remains unclear. Precise understanding of the mechanisms driving their expression is imperative to use these proteins as intrinsic optical markers of physiological conditions and/or genetic affinity. We have analyzed the influence of different environmental factors on the regulation of major classes of GFP-like pigments in corals of the taxa Acroporidae, Merulinidae and Pocilloporidae. The differential expression patterns were studied by spectroscopic measurements on animals, through immunochemical analysis of purified extracts and by semiquantitative RT-PCR analysis. We found that light excerted a strong control of the pigment levels in the tissue of all studied species. Exposure of the animals to different light qualities established that the increase in coral pigmentation is primarily dependent on blue light. GFP-like proteins were also differentially regulated at the transcriptional level by environmental stress factors like heat and cold stress.

## 5.129

**Variable Thermal And/or Irradiance Stress Responses Of Photosystem Ii Among *symbiodinium* Spp. Isolated From Different Invertebrate Species**

**Ranjeet BHAGOOLI*[1,2]**, Andrew C. BAKER[3], Peter RALPH[4], Michio HIDAKA[5]

[1]BioSciences, University of Mauritius, Reduit, Mauritius, [2]The Biodiversity and Environment Institute, Reduit, Mauritius, [3]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [4]Department of Environmental Sciences, University of Technology, Sydney, Sydney, Australia, [5]Department of Chemistry, Biology & Marine Sciences, University of the Ryukyus, Nishihara, Okinawa, Japan

We used Pulse Amplitude Modulated (PAM) fluorometry to measure the photophysiological stress responses of symbiotic dinoflagellates (*Symbiodinium* spp.) from 9 host species (one tridacnid clam, one anemone and 7 corals) from Zamami and Sesoko Islands, Okinawa, Japan. We measured the maximum quantum yield of photosystem II (PSII) in freshly isolated algae exposed to four different temperature treatments (26oC, 29oC, 32oC and 34oC) and three different light treatments (0, 110 and 170 ìmol quanta m-2s-1). Chlorophyll fluorescence ratios (dark-adapted Fv/Fm) showed significant variability in PSII response to both thermal and irradiance stress. We used denaturing gradient gel electrophoresis (DGGE) analysis of ITS-2 ribosomal DNA to identify the *Symbiodinium* used in our experiments, and found members of clade A, C and D in these hosts. Photophysiological responses showed consistent differences between distinct *Symbiodinium* types based on ITS-2 sequences. Hierarchical cluster analysis of the combined responses of PSII to all temperature and/or irradiance treatments revealed the following hierarchy, from most tolerant to least tolerant: D1a (*Pavona varians*) = C9b (*Platygyra ryukyuensis*), A6 (*Tridacna* spp.) = C70 (*Aiptasia* spp.), C21a (*Galaxea fascicularis*) = C1 (*Stylophora pistillata* and *Pachyseris rugosa*), C3 (*Acropora microphthalma*) = C1c (*Pocillopora damicornis*). It is noteworthy that *Symbiodinium* C1 responded similarly irrespective of the host (*Pachyseris rugosa* or *Stylophora pistillata*) from which they were isolated. These data suggest that different *Symbiodinium* ITS-2 types vary in stress tolerance, and that this tolerance is consistent among hosts. Additional, data for isolates from Florida (USA), Heron Island (Australia) and Mauritius are being analyzed.

## 5.130

**Searching For Sulfur in *symbiodinium*: Dmsp Implications For Coral Symbioses**

**Denise YOST*[1]**, Carys MITCHELMORE[1]

[1]Center for Environmental Science, Chesapeake Biological Laboratory, University of Maryland, Solomons, MD

Symbiodinium, like other dinoflagellates, produce considerable amounts of dimethylsulfoniopropionate (DMSP; mM concentrations intracellularly). DMSP evolution from corals as dimethylsulfide (DMS) gas to the atmosphere can be substantial, although it is unclear if this is via algal loss and/or translocation of DMSP/DMS through coral tissues. DMSP lyase is present in some, but not all, DMSP producers and is responsible for enzymatic cleavage of DMSP into DMS and acrylate. The roles and functions of DMSP, DMSP lyase and DMSP breakdown products remain unclear in Symbiodinium and coral symbioses as a whole. It is unknown if Symbiodinium contain DMSP lyase. In addition, DMSP lyase has not been isolated from any coral species, but has been isolated from other symbiotic organism host tissues (e.g. clams and flatworms). DMSP and its breakdown products, DMS, dimethylsulfoxide (DMSO), methane sulfinic acid (MSNA) and acrylate have antioxidant capabilities in other algal species. Given the potential role of oxidative stress in coral bleaching, we focus on the role of DMSP as an antioxidant. DMSP levels vary considerably in symbiont and host and may reflect a coral's sensitivity to bleaching events. Our findings indicate that DMSP lyase is present in the Symbiodinium cultures examined and that baseline levels of DMSP and lyase vary with Symbiodinium strain. In preliminary experiments, DMSP levels changed following exposure to oxidative stressors (hydrogen peroxide, UV light). To characterize DMSP production and lyase potential further, we collected various hard corals from Bermuda, some of which were exposed to copper (a known elicitor of oxidative stress) for 48 hours, which induced DNA damage. We will further analyze a variety of oxidative stress endpoints coupled with DMSP and DMSP lyase assessments to investigate the role of DMSP as an antioxidant in these corals.

## 5.131

**A Mechanism Of Alloimmune Response in Primitive Phylum: Apoptosis in The Gorgonian Coral Swiftia Exserta**

Miguel MENDOZA[1], **Charles BIGGER*[1]**

[1]Florida International University, Miami, FL

Previous studies on the Gorgonian Coral *Swiftia exserta* (Cnidaria, Anthozoan) immunology have revealed specific intraspecific (alloimmune) responses to foreign tissue (Salter-Cid and Bigger, 1991). These findings suggest that primitive forms of alloimmunity may have existed prior to the deuterostome/ protostome phylogenic split. This study focused on the determination of an apoptotic associated immune response in allograft tissue rejection in *S. exserta* using the flow cytometry assay Guava PCA™ TUNEL Assay to indicate and quantify an apoptotic response in induced cells. Following a five day induction period under closely monitored conditions, dissociated cells from normal, autograft (self-graft) and allograft tissue samples were examined for the presence of apoptosis. Flow cytometry data depicted pattern shifts in allograft samples indicative of apoptotic activity. The results from the TUNEL Assay are supportive of the hypothesis of apoptosis as the mechanism of tissue death in the allogeneic response of the Gorgonian coral *S. exserta*.

## 5.132

**Xenobiotic Metabolizing Enzymes in The Reef Building Coral Pocillopora Damicornis**

**Luc ROUGEE*[1]**, Abby COLLIER[2], Robert RICHMOND[1]

[1]Kewalo Marine Laboratory, Pacific Biosciences Research Center, University of Hawaii at Manoa, Honolulu, HI, [2]Department of Tropical Medicine, Medical Microbiology and Pharmacology, University of Hawaii at Manoa, Honolulu, HI

We examined the presence and rate of reaction of particular xenobiotic metabolizing enzymes (XME) in the reef building coral *Pocillopora damicornis*, in order to develop a mechanistic model for interpreting coral cellular profiles in response to pollutant exposure. The use of pharmacological and cellular diagnostic tools, commonly implemented in determining xenobiotic metabolism in humans, has proved successful in providing information of the potential for analogous enzymes in corals. Previously established kinetic assays for Phase I (Cytochrome P450 (CYP450) 1A, 2C9, 2D6, 2E1, 3A4 and CYP450 reductase) and Phase II (UDP-glucuronosyltransferases, β-glucuronidase, Glutathione-S-transferase, and Sulfotransferase) enzymes were optimized for the S9 postmitochondrial fraction of coral protein. Positive results for members of both Phase I (CYP450 1A, 2E1, CYP reductase) and Phase II (β-glucuronidase, Glutathione-S-transferase, and Sulfotransferase) enzymes has revealed the presence of XME in corals. Enzymatic rates of reaction have been derived for a reference time point and throughout the reproductive lunar cycle. Isolation and characterization of select individual proteins will be investigated to confirm the specificity of these enzymes' activities.

The ability to measure enzyme activity by proteins responsible for detoxification of pollutants provides a means of identifying cause-and-effect relationships between particular stressors and coral "health." Additionally, examining changes in these activities allows the identification of stress effects at the sublethal level, when management intervention has the greatest chance of effectiveness. Finally, quantifying the magnitude and rate of cellular responses to xenobiotic-induced stress allows for measuring the efficacy of mitigation responses. By determining changes to the metabolic pathways, that cause internal variations within in a coral which otherwise visually appears 'healthy', we may be able to understand the cellular effects of xenobiotics present in the environment.

## 5.133

**Ecology Of "Solarpowered"nudibranchia (Mollusca:gastropoda) And Their Potential To Be An Alternative Model Organism For Understanding Bleaching**

**Ingo BURGHARDT*[1]**, Joshua LEFFLER[2], Katie LIBERATORE[3], Ursula SHEPHERD[3]

[1]Department of Animal Ecology, Evolution and Biodiversity, Ruhr-University Bochum, Bochum, Germany, [2]Department of Wildland Resources, Utah State University, Old Main Hill, UT, [3]University Honors Program, University of New Mexico, Albuquerque, NM

In contrast to the well-known symbiosis between different Cnidaria and zooxanthellae (genus *Symbiodinium*) the symbiosis between Nudibranchia (Mollusca: Gastropoda) and *Symbiodinium* is hardly investigated. Most of these nudibranchs obtain their symbionts by feeding on zooxanthellate prey (mainly octocorals). As is true in cnidarians, *Symbiodinium* is housed intracellulary, inside the cells of the nudibranchs' digestive gland. Depending on the nudibranch species the slugs are able to keep zooxanthellae photosynthetically active for a certain period of time and benefit from the photosynthetic products.

By means of PAM (Pulse Amplitude Modulated Fluorometry) data, long-term experiments (under starvation conditions) demonstrated that some species survive solely on the assimilates of their symbionts for almost one year. Therefore these nudibranchs are called "solarpowered". Additionally, interspecific differences in the efficiency of this symbiosis was proven, reflecting different stages in its evolution. Histology and ultrastructural investigations clarify special adaptations of these symbiotic species. The genus *Phyllodesmium* was used as a model organism to investigate the ecology and evolution of this mutualism.

The symbiosis between solarpowered nudibranchs and zooxanthellae seems to be an ideal model to investigate general bleaching processes. Two very different holobionts (coral and mollusc) with the same symbionts and their response to different environmental stressors (high water temperatures, high irradiances, low salinity, low pH) can be directly compared by means of PAM data, histology and electron microscopy. The impact of higher water temperatures and irradiances was already demonstrated for three solarpowered nudibranch species by means of PAM data. Future investigations will show whether the zooxanthellae composition inside the two different holobionts (corals and nudibranchs) shifts after exposition to stressors and whether isolated and cultivated *Symbiodinium* will respond differently to these factors.

## 5.134

**Regulation Of Host Innate Immunity Plays A Role in Cnidarian-Dinoflagellate Symbiosis**

**Olivier DETOURNAY*[1]**, Santiago PEREZ[2], Virginia WEIS[1]

[1]Zoology, Oregon State University, Corvallis, OR, [2]Dept. of Genetics, Standford University School of Medicine, Stanford, CA

Cnidarians have long been considered simple organisms lacking many of the complex cellular pathways that are present in higher metazoans. However, these animals are able to differentiate between invading pathogens and the beneficial, photosynthetic dinoflagellate *Symbiodinium*. These dual tasks are only possible if a high level of recognition and specificity exists that allows the host immune system to eliminate pathogens and tolerate symbionts. Recent reports have begun to reconcile this obvious paradox, suggesting that symbiosis is maintained by a complex cross talk between the host and symbiont. Moreover, genomic evidence has demonstrated that cnidarians possess homologues to many innate immunity genes from higher vertebrates. These studies suggest that immunity genes, normally implicated in pathogens clearance, are regulated in order to maintain the beneficial association. The objective of this study was to explore the role of immune regulatory mechanisms in specific symbiont tolerance mediated by the host. We examined the role of host immunity in the symbiosis between the model anemone *Aiptasia pallida* and the dinoflagellate *Symbiodinium* sp., in particular pro- and anti-inflammatory components of the immune system. Symbiotic and aposymbiotic *A. pallida* stimulated with lipopolysaccharide (LPS), a common elicitor of an immune response, present different profiles of activation as measured by production of nitric oxide (NO). We show evidence that this production is regulated by a cytokine known to play a key role in immune regulation in vertebrates. We hypothesize that the presence of symbionts blocks LPS induction of an effector mechanism leading to the production of NO through the secretion of an anti-inflammatory cytokine.

## 5.135

**Immunodetection And Partial Characterization Of Two Putative Signal-Transduction Proteins in *symbiodinium Kawagutii***

**Marco VILLANUEVA*[1]**, Claudia MORERA[1], Roberto IGLESIAS-PRIETO[1], Patricia THOMÉ-ORTIZ[1], Tania ISLAS-FLORES[2]

[1]Unidad Académica Puerto Morelos, Instituto de Ciencias del Mar y Limnología-UNAM, Puerto Morelos, Mexico, [2]Plant Molecular Biology, Instituto de Biotecnología-UNAM, Cuernavaca, Mexico

Two proteins were localized in total extracts of *Symbiodinium kawagutii* cells through the use of antibodies directed to proteins potentially involved in signal-transduction. We used antibodies (termed anti-DP) directed towards a twenty-residue peptide from the C-terminal sequence of Grb2 (Growth Factor Receptor-Bound Protein 2), which is an adaptor protein from the signal-transduction cascade of the growth factor stimulus in mammalian cells. Another set of antibodies (termed anti-RT) were raised against an eight-residue peptide from a protein originally isolated from common bean (*Phaseolus vulgaris*), on a Phosphotyrosine-Sepharose column, implicating thus, a putative SH2 domain for signaling on this protein. We observed by western blot analyses, that the anti-DP antibodies recognized a 40 kDa protein in total extracts of *Symbiodinium kawagutii*, and in the same extracts, the anti-RT antibodies cross-reacted with a 28 kDa protein. The 28 kDa protein was found to be enriched in soluble and insoluble detergent fractions extracted from microsomal preparations, suggesting that it may be a membrane-bound protein. These results show the presence of orthologues of putative signal-transduction proteins in *Symbiodinium* and it will be of great interest to study their function and interactive protein partners in these cells, both during their life cycle and in the symbiotic process.

## 5.136

**Response Of Coral Fluorescence To Environmental Changes: Insights Into The Function Of Coral Fluorescent Proteins**

**Melissa ROTH*[1]**, Nancy KNOWLTON[1,2], Michael LATZ[1], Dimitri DEHEYN[1]

[1]Scripps Institution of Oceanography, UCSD, La Jolla, CA, [2]Smithsonian Institution, Washington D.C.

Despite their potential roles in photo-protection and photo-acclimation, the function of fluorescent proteins remains poorly understood. Fluorescent proteins are host-based pigments that are homologous to the green fluorescent protein (GFP), which was originally isolated from a hydromedusa and is now widely used in biology and biochemistry. Fluorescent proteins are pervasive in scleractinian corals and can constitute a significant portion of the total protein content (up to 14%). Fluorescent proteins inherently alter the internal light microenvironment of the coral by absorbing higher-energy photons and emitting lower-energy photons. This study examined the coral fluorescence response in *Acropora yongei* during experimental manipulations of environmental conditions, primarily light and temperature. Our preliminary results show that the amount of coral fluorescence was dynamic, and many environmental changes can induce a response in coral fluorescence. The coral fluorescence response was reversed when initial environmental conditions were restored. Understanding the role of these prevalent fluorescent proteins could elucidate mechanisms of coral physiological responses to environmental changes. Consequently, this research will indicate whether field monitoring of fluorescence could be useful as a noninvasive measure of coral health, specifically to identify early signs of coral stress.

## 5.137

**Wound Healing in The Gorgonian Coral Swiftia Exserta**

**Charles BIGGER*[1]**, Cecile OLANO[2]

[1]Biological Sciences & Comparative Immunology Instiitute, Florida International University, Miami, FL, [2]USDA ARS, Miami, FL

Gorgonian corals, like all sessile marine organisms, are susceptible to tissue damage from predators, mechanical impact and abrasion. In addition to a need for sealing the wound to maintain integrity and homeostasis, these animals have an additional threat if the axial skeleton is exposed. Exposed axial skeleton can provide a substrate for larval settlement and a subsequent possibility for overgrowth or other negative interaction. Accordingly, on-going examinations are being made of the wound healing/regeneration process in the gorgonian coral, Swiftia exserta, a gorgonian lacking zooxanthellae.

Colonies of S. exserta from the Southeast coast of Florida were maintained in the laboratory at FIU. This study was designed as a time series of gross and histological observations of the response to a 5 mm removal of all tissue from the axial skeleton of a 2.5 cm colony branch. Eight series were fixed and processed for histology at times: 1 hr, 12 hrs, 1 day, 3 days, 5 days, 6 days and 1 week.

Details will be presented correlating the changes at the cellular level with observations at the organismal level. In summary, the sequence of observed events was: a rapid sealing of the tissue openings; formation of specialized moving fronts, mostly composed of granular amoebocytes, that travel across the bare axial skeleton; fusion of the two fronts; and a subsequent filling-in and restoration of the normal anatomy in the wound area, without scaring. While there did appear to be a migration of cells into the area in the process, there was also evidence for a tissue spreading not seen in another investigation with the gorgonian Plexaurella fusifera.

These observations confirm that Swiftia exserta is well adapted to recover from injury under normal conditions and provide information concerning the underlying process and cell functions.

## 5.138

**Micro-Niche Partitioning And The Photobiology Of *symbiodinium* Associated With *montastraea Faveolata***

**Dustin KEMP*[1]**, Xavier HERNANDEZ-PECH[2], Roberto IGLESIAS-PRIETO[2], Gregory SCHMIDT[3], William FITT[1]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]Unidad Academica Puerto Morelos, Puerto Morelos, Mexico, [3]Department of Plant Biology, University of Georgia, Athens, GA

The dominant Caribbean reef building coral *Montastraea faveolata* has been known to associate with multiple genotypes of *Symbiodinium* for over a decade. The unique ability to simultaneously host diverse assemblages of *Symbiodinium* makes *M. faveolata* an ideal species to examine the physiology of genetically different coral-symbiont associations. Using micro-sampling techniques we identified up to three distinct genotypes representing three different clades of *Symbiodinium* co-occurring within *M. faveolata* from the northern portion of the meso-american barrier reef in Puerto Morelos, Mexico. Coral colonies were screened for symbiont diversity using denaturing gradient gel electrophoresis (DGGE) of the ITS-2 region of nrDNA and specific zones were chosen reflecting *Symbiodinium* diversity. *Symbiodinium* zonation patterns were primarily determined by locally prevalent light fields on *M. faveolata* colonies. We found *Symbiodinium* type B17 to be the dominant symbiont found in high-light areas within the colony, while type C7 was found to be the dominant symbiont in low-light areas. Intermediately, *Symbiodinium* type A3 was found to be mixed among some of the high-light samples but was never observed as the dominant symbiont. Coral samples were collected four times a year from various zones and a series of physiological parameters were measured examining *Symbiodinium* population structure and photobiology. Photo-physiological responses as determined by *P vs E* curves revealed genetically different symbiont types displayed differential high-light or low-light photoacclimatory responses. Further investigation of specific light zones using common coral-symbiont parameters including symbiont cell densities, chlorophyll content, and absorbance spectra analysis confirmed a high degree of *Symbiodinium* niche specialization and photoacclimation processes emerging annually within *M. faveolata* colonies.

## 5.139

**Various Symbiodinium Spp. Distributed Among Differing Morphotypes And Genotypes Of Porites Panamensis From The Gulf Of California, Mexico**

**David Arturo PAZ-GARCÍA*[1,2]**, Todd C. LAJEUNESSE[3], Héctor Efrain CHÁVEZ-ROMO[1,2], Francisco CORREA-SANDOVAL[2], Hector REYES-BONILLA[4]

[1]Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico, [2]Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Ensenada, Mexico, [3]Department of Biology, The Pennsylvania State University, Pennsylvania, PA, [4]Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico

The degree of specificity between coral hosts and endosymbiotic dinoflagellates in the genus *Symbiodinium* (zooxanthellae) affects the potential for responses to environmental change through partner recombinations. We examined the diversity of zooxanthellae populations in two morphotypes of *Porites panamensis* in the southern of the Gulf of California. Additionally, we analyzed the host genetic information by allozyme electrophoresis in order to demonstrate if the species of symbiont corresponds with the genotype and/or morphotype of the host individual. The specimens (N = 20) were colleted at shallow coral communities (1-2 m). *Symbiodinium C66a* and *C1* associated with columnar colonies of *P. panamensis* while *C66* occurred commonly in massive forms. We found no host genotypes specific for species of symbiont. However, differences on host genotype frequencies were observed by Markov chain method between massive *C66* and columnar *C1* colonies ($X^2$= 21.378, d.f. = 10, $p < 0.01$). An UPGMA cluster analysis using between samples showed massive *C66* and columnar *C66a* symbionts clustered together before joining the columnar *C1*. These data indicate that differences in host genetic make-up may, in part, explain the presence of different *Symbiodinium* among individuals of a host population existing in the same environment. The potential influences of brooding and maternal transmission to the coevolution of specific partner combinations could be generating the pattern observed.

## 5.140

**Rapid And Highly Precise Measurements Of *symbiodinium* Number Using A Coulter Counter**

**Carlo CARUSO*[1]**, Joshua MEISEL[2], Santiago PEREZ[1], John PRINGLE[1]

[1]Stanford University, Stanford, CA, [2]University of Queensland, St. Lucia, Brisbane, Australia

Our lab is focused on helping develop the *Aiptasia-Symbiodinium* model system for studies of the molecular and cellular biology underlying the cnidarian-dinoflagellate symbiosis. A major part of our current effort is to develop methods that will allow more facile, versatile, and rigorous experimentation. A limitation for many kinds of studies has been that the methods available for determining symbiont loads (i.e., the number of symbionts per unit of host material) have been time-consuming, imprecise, and/or inaccurate. Using the Coulter Counter and well established assays of total protein, we have developed a rapid, highly precise, and probably highly accurate (although this is more difficult to judge) method for determining symbiont loads. The method can be used with cultured *Symbiodinium* or with algae isolated by homogenization of host tissue. It can also be used with fresh, fixed, or frozen material, so that samples can be analyzed after an experiment is completed and, if necessary, using an instrument at a remote location. The method allows changes in the symbiont load to be detected with at least 8-fold more precision and at least 25 times more rapidly than is possible with a counting chamber (hemocytometer). This dramatically improves researchers' ability to detect small changes in algal density during time-course experiments or between treatment groups. The method also has some limitations, which will be discussed.

## 5.141

**Effect Of Irradiance And Increased Temperature On Differential Gene Expression In Dinoflagellate**

Nedeljka ROSIC[1], Mauricio RODRIGUEZ-LANETTY[1], William LEGGAT[1], **Ove HOEGH-GULDBERG*[1]**

[1]The University of Queensland, Brisbane, Australia

Using microarray technology, with over 3000 ESTs, we assessed gene expression profiles in symbiotic dinoflagellate from culture after exposure to elevated temperature and light level. Cultures of the coral symbionts, Symbiodinium sp. from clade C1 have been exposed to elevated temperatures (29ºC and 32ºC) under high (100 µmole quantum/m2/s Photosynthetic Active Radiation) and low (15 µmole quantum/m2/s) light level. As a result we discovered some interesting genes involved in stress respond in dinoflagellate. Heat shock proteins such as DnaJ molecular chaperone (HSP 40), which is involved in protein translation and folding, then serine/threonine-protein kinase have been up regulated with increased temperature. Light level effected expression of various genes such as actin, ammonium and nitrate transporters. Also, a list of potential house keeping genes has been established from this sequence as a good basis for further gene expression studies in symbiotic dinoflagellate. These preliminary microarray data should provide more information and highlight future directions towards better understanding of the process involved in the breakdown of coral-algal symbiosis.

## 5.142

**Genetic Diversity Of The Zooxanthellae Symbionts Of Corals From Reunion Island**

**Fabien GUÉRIN*[1]**, Laury DIJOUX[2], Xavier HOENNER[2,3], Vianney DENIS[2], Henrich BRUGGEMANN[2], Mireille GUILLAUME[2,4]

[1]UMR PVBMT, Université de la Réunion, Saint Denis, Reunion, [2]ECOMAR, Université de la Réunion, Saint Denis, Reunion, [3]Te mana o te moana, Moorea, French Polynesia, [4]Milieux et Peuplements Aquatiques, UMR 5178 CNRS-UPMC-MNHN, Muséum National d'Histoire Naturelle, Paris, France

In the Western Indian Ocean extinction of coral reefs in response to global change has been predicted within the next 50 years. Reefs at Reunion, a high island in an exposed oceanic setting at high latitude (21° S), were hitherto little affected by the strong 1997-98 ENSO event. Although recurrent bleaching events are occurring since, they probably still contain 'naïve' coral communities with original species composition, locally dominated by Acropora. The future of these communities depends of the capacity of corals to adapt or acclimatize to climate change. Zooxanthellae clade D has been shown to impart greater tolerance to high temperatures.

This is the first study of genetic diversity and distribution of zooxanthellae at Reunion Island, aiming to better understand the potential of its coral reefs to cope with the SST increase. From January to April 2007 a minimum of ten replicate coral colonies of some abundant species was sampled on both top and side parts from each colony. After holobiont DNA extraction, samples were analysed by PCR-RFLP (Polymerase Chain Reaction – Restriction Fragment Length Polymorphism) on small and long subunit ribosomal nRNA of symbionts using TaqI and HhaI as restriction enzymes. Zooxanthellae RFLPs were classified in clades according to Rowan and Powers (1991) and Baker et al. (1997). Clade C was dominant in Acropora austera, A. gemmifera, A. muricata, Porites lutea and P. (Synarea) rus. Branch tips in three colonies of A. gemmifera were bicladic, harbouring clade C and A. Clade D was also found in Montipora circumvallata, a species characteristic of degraded coral reef flat communities. So far, these results suggest a higher potential for resilience to SST increase in A.gemmifera and M. circumvallata than in other coral species.

## 5.143

**Seasonal Acclimation in Photosynthetic Efficiency Of Coral Holobiont Photosynthesis**

**Angela LAWTON*[1]**

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia

Faced with current predictions of 2 C warming by 2050, many people hope that corals will be able to acclimate to the increased temperature, but little is known about the acclimatory ability of the coral holobiont.

In order to determine if the coral holobiont is able to acclimate its photosystems and metabolism to seasonally varying environmental conditions, PI curves from *Pavona decussata* and *Stylophora pistallata* were measured at the end of summer (February) and the end of winter (August) for 3 years using fast-responding microsensors and the light-dark shift method of Revsbech (1989). The gross and net photosynthetic rates of nubbins of *Pavona decussata* and *Stylophora pistilata* were measured over a range of temperatures during both the summer and winter to determine if the effect of temperature of the gross and net photosynthetic rates was different from summer to winter.

It was determined that corals are able to adjust their metabolisms in order to maximize the amount of photosynthesis occurring in both the summer and winter. Also, the tolerance to extreme temperature was reduced in the winter. These results indicate that the coral holobiont does use acclimatory mechanisms to maximize the amount of C gained seasonally. The mechanisms of seasonal acclimation may be able to be used to acclimate to warmer conditions, but there is no indication what the maximum range of acclimation is.

## 5.144

**Survival At The Surface: Enhanced Photoprotection Pathways in Shallow Water *symbiodinium***

**Jennifer McCabe REYNOLDS*[1]**, Brigitte BRUNS[2], William FITT[1], Gregory SCHMIDT[2]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]Department of Plant Biology, University of Georgia, Athens, GA

Photoprotections are necessary for the survival of the coral-dinoflagellate symbiosis. However, not all symbiont phylotypes display the same sensitivity to the enhancement of photosynthetic loss at high light and temperatures. We have found that members of different clades in the genus *Symbiodinium* exhibit distinct physiological responses as measured by a novel serial irradiation pulse (SIP) PAM fluorometry method. We monitored fluorescence patterns indicative of photoprotections using the SIP method from March 2006 to August 2007 in three coral species in symbiosis with different *Symbiodinium* clades to determine seasonal changes in photosynthetic physiology as ocean temperatures fluctuated naturally and light intensity was increased artificially.

The synergism of sustained high light and increased temperature underlies damage to the coral-dinoflagellate symbiosis by causing photosynthetic loss in *Symbiodinium* cells. Unlike Clades B and C, Clade A *Symbiodinium*, in culture and *in hospice*, show enhanced capabilities for alternative photosynthetic electron transport pathways including cyclic and/or chlororespiratory electron transport. Clade A *Symbiodinium* also undergo pronounced light-induced dissociation of antennae complexes from Photosystem II reaction centers as a major component of non-photochemical quenching. Cnidarians harboring Clade A *Symbiodinium* exhibit sustained cyclic activities coincidental with diminished bleaching during periods of elevated temperature and high light.

Supported by NSF grant OCE-0137007 to Fitt and Schmidt and a NOAA Dr. Nancy Foster Scholarship to J.C.M. Reynolds.

## 5.145

**The Effect Of Salinity On The Wound Healing Rate Of The Gorgonian Coral Swiftia Exserta**

**Maria GONZALEZ*[1]**, Ana RESTREPO[1]

[1]Dept. of Biological Sciences & Comparative Immunology Institute, FIU, Miami, FL

To protect their integrity, gorgonian coral colonies have the ability to repair tissue damage inflicted by other organisms or mechanical injury. To avoid the potential for harmful larval settlement it is important for the colony to cover bare axial skeleton as well as maintain the tissue integrity. This study examined the effect of different salinities on the rate of wound healing in the gorgonian coral, *Swiftia exserta*. Three trials were performed with nine *S. exserta* colonies (n=9). In each trial, a 4 cm branch from each colony was suspended in aquaria at salinities of 30, 35 and 40 0/00 for the first trial and 32, 35, and 40 0/00 for the second and third trials. In the center of each branch the tissue over a 4 mm length was totally removed from the axial skeleton. The branches were scored daily until the two tissue fronts met. That time, in days, was used as the endpoint. The healing rates were compared within each trial using a 0.05 significance level.

In the first trial there was no healing and significant branch death at 30 0/00. Accordingly, 32 0/00 was used in the other trials. There was no significant difference between the healing rates at 32 and 35 0/00. The healing was significantly faster at 40 0/00 than either 32 or 35 0/00. These data suggest that a non-lethal difference in salinity may affect gorgonian coral defense systems.

## 5.146

**Functional Genomic Approaches To The Study Of Coral Immunity**

**Morgan MOUCHKA*[1]**, Jason ANDRAS[1], Drew HARVELL[1]

[1]Ecology and Evolutionary Biology, Cornell University, Ithaca, NY

Sea fan aspergillosis, a disease caused by the fungal pathogen *Aspergillus sydowii*, has caused extensive mortality in the sea fan coral *Gorgonia ventalina* in the Caribbean for the past 15 years. One hypothesis to explain disease outbreaks is that host immunity is compromised by environmental stress. Although the sea fan-*Aspergillus* pathosystem has been well studied, we still lack a basic understanding of the physiological mechanisms that underlie coral immunity. We are developing cDNA microarrays to identify genes involved in the *G. ventalina* immune response. Here we report results from preliminary steps, including the construction of cDNA libraries, sequencing of clones to generate Expressed Sequence Tags (ESTs), and annotation of the ESTs to identify candidate genes to be printed on microarrays. Annotation of EST's has already identified a number of immune related genes, such as those that encode for superoxide dismutase (antioxidant defense), fibronectin (wound healing), ficolin (pattern-recoginition), immunophilin (immunosuppressant agent and heat shock protein binder), and techylectin (non-self recognition). Work is ongoing to verify and quantify the expression patterns of these genes in response to experimental immune challenge. The final results of this study will provide insight into the complex molecular responses that occur from the onset of sea fan infection to the ultimate fate of survival or mortality. This information will prove valuable not only to the study of other coral pathosystems, but also to the study of invertebrate innate immunity in general.

## 5.147

**The Genetic Structure Of The Coral May Control Host-Symbiont Specificity in The Sea Of Cortez**

**Jorge H. PINZÓN C.*[1]**, Tye PETTAY[2], Todd C. LAJEUNESSE[2]

[1]Department of Biology, Penn State University, State College, PA, [2]Department of Biology, Penn State University, University Park, PA

Coral-symbiodinium symbioses in the Sea of Cortez (Gulf of California) appear to have high levels of specificity. Different colonies of *Pocillopora* spp. contain unique and stable associations with either symbiodinium type D1 or type C1b-c. The establishment and evolution of unique host-symbiont associations has been attributed to several factors including environmental conditions, geographical isolation, the taxonomic identity of the host and the symbiont, or combinations of the aforementioned. In La Paz, Baja California, *Pocillopora* spp. colonies with holobiont combinations similar to those found elsewhere in the Eastern Pacific are coexisting under the same environmental conditions. This indicates that neither the environment nor geographical isolation have played a primordial role in the formation of coral-symbiodinium associations in the Gulf. Genetic analysis using two microsatellite markers suggests that different allele frequencies in *Pocillopora* spp. may be associated with the dominant type of symbiont (D1 or C1b-c). Differences among host genotypes may explain, in part, the distribution of one species of symbiont over another in colonies exposed to identical environmental conditions and evolutionary processes.

## 5.148

**Photosmoregulation: Evidence Of Host Behavioral Photoregulation Of An Algal Endosymbiont By The Acoel *convolutriloba Retrogemma* As A Means Of Non-Metabolic Osmoregulation**

**Thomas SHANNON*[1]**

[1]Ecology, University of Georgia, Athens, GA

This study of the acoel *Convolutriloba retrogemma* suggests that observed basking behaviors of the animal function not only in photoregulating its algal endosymbiont, but serve as a novel method of host osmoregulation. The study further shows that intercellular change in osmotic pressure resulting from photosynthesis is the photoregulatory stimulus. The term "photosmoregulation" is offered to describe the process. The study examines the photobehaviors of the acoel, the factors affecting these behaviors, their regulatory functions, and how they affect or are affected by the acoel's algal endosymbiont. The first behavior detailed is a step-up, photophobic response to sudden increases in light; this variable response is blue-light-mediated and triggered by visual, photic stimuli. The second behavior detailed is a phototactic-photoaccumulative behavior responsible for observed mass basking formations; this behavior is regulated by the photosynthetic activity of the algal endosymbiont. The effects of holozoic starvation are examined, particularly as they apply to host phototactic and photoaccumulative behavior. The data show that contrary to expected behavior, starved acoels do not seek out areas of high intensity light, but instead retreat to areas of lower intensity. The results of this study support a hypothesis that the basking behaviors of these acoels serve as methods of photoregulating their algal endosymbionts. The results further suggest that starved acoels have diminished capabilities for processing translocated algal photosynthates and that under high-light conditions a build-up of these compounds results in hyposmotic stress in the animals.

## 5.149

**Quantum Efficiency For Light Enhanced Ros Production in Corals; A Physiological Approach To Predict Bleaching**

**Racheal HOWARD*[1]**, Paul FALKOWSKI[2,3]

[1]SIO, UCSD, La Jolla, CA, [2]IMCS, Rutgers, New Brunswick, NJ, [3]IMCS, Rutgers, New Brunswick

Existing probability models for coral bleaching report sea surface temperature anomalies, but are limited by the absence of a mechanistic understanding of the photophysiological contribution to bleaching. Light is critical for Scleractinian corals, yet the ability to evolve oxygen in close proximity to high potential redox carriers invites the production of extremely damaging oxidizing molecules, particularly at high photon densities. We show evidence that photosynthetically derived reactive oxygen species (ROS) induce bleaching. We provide a mechanistic model derived from in situ quantitative measures for light dependent ROS production, corrected for temperature, to be incorporated with existing probability based satellite data to predict global bleaching events.

## 5.150

**Pocillopora Genotypes May Determine Colony Specificity Between Two Symbiont Species in The Eastern Pacific**

**Jorge PINZÓN*[1]**, Todd LAJEUNESSE[1]

[1]Biology, Pennsylvania State University, University Park, PA

Pocillopora in the eastern Pacific associate with two species of Symbiodinium. Different colonies of Pocillopora spp. contain unique and stable associations with either symbiodinium type D1 or type C1b-c. The establishment and evolution of unique host-symbiont associations has been attributed to several factors including environmental conditions, geographical isolation, the taxonomic identity of the host and the symbiont, or any combination of them. In La Paz, Baja California, Pocillopora spp. colonies with similar partner combinations to those found elsewhere in the eastern Pacific coexist under the same environmental conditions. This indicates that external environmental conditions have limited influence on the formation and stability of these associations. Genetic analysis using two microsatellite markers suggests that the population of Pocillopora colonies that host Symbiodinium D1 have different alleles and allelic frequencies than the population of colonies hosting C1b-c. Differences among host genotypes may explain, in part, the distribution of one species of symbiont over another in colonies exposed to identical environmental conditions. Such patterns suggest the importance of co-evolution in the formation of specific interactions among corals and their endosymbionts.

## 5.151

**Zooxanthellae Population Dynamics And Temporal Coral Growth Rate Variations in *acropora Formosa* From The Mauritian Waters**

**Ranjeet BHAGOOLI*[1]**, Indurlall FAGOONEE[1]

[1]Department of BioSciences, University of Mauritius, Reduit, Mauritius

We quantified temporal and spatial variations in zooxanthellae (endosymbiotic dinoflagellates, *Symbiodinium* spp.) density, zooxanthellae volume, zooxanthellae mitotic index (MI) in the highly common coral *Acropora formosa* and coral linear extension rate at three Mauritian lagoons namely Balaclava Marine Park, Flic-en-Flac and Trou aux Biches to monitor the health of coral reefs. Physical parameters such as temperature, dissolved oxygen, nitrate, nitrite and phosphate concentrations, ultraviolet radiation, pH and salinity were also monitored. Monthly sunshine and rainfall data were also gathered. Data collected from 1991 to 1998 on a weekly basis showed a three-fold higher zooxanthellae density, smaller zooxanthellae volume, lower MI and lower linear coral branch extension rates than in summer. The nitrogen to phosphate (N: P) ratio, temperature, UVB and amount of sunshine hours were higher in summer. These results suggest that a non-carrying capacity zooxanthellae density level along with a normal summer maximum temperature and high N: P ratio allowed *Acropora formosa* to grow at its optimal level in the lagoonal waters of Mauritius.

## 5.82

**Heat Shock Protein 90 and nitric oxide co-regulate thermally-induced bleaching in the soft coral Eunicea fusca**

**Cliff ROSS*[1]**, Lory SANTIAGO[2]

[1]Dept. of Biology, University of North Florida, Jacksonville, FL, [2]School of Science and Computer Engineering, University of Houston, Clear Lake, Houston, TX

Heat-shock protein 90 (Hsp90) is a molecular chaperone involved in cellular signaling in a variety of metabolic systems. While thermotolerance studies in corals have been successful in designating heat shock proteins as useful biomarkers for measuring abiotic stress, studies evaluating their plausible functional role(s) in situ are still lacking. In this study, using the soft coral Eunicea fusca, we demonstrate that thermally-induced stress causes an upregulation in HSP90. In turn, HSP90 shows a concomitant ability to activate nitric oxide synthase. The resulting production of nitric oxide (NO) may act as a signaling molecule capable of inducing zooxanthellae expulsion.

Using nitric oxide synthase (NOS) and Hsp 90 polyclonal antibodies, thermally stress induced-HSP 90 was shown to co-immunoprecipitate with a constitutive isoform of nitric oxide synthase. The specific blocking of Hsp90 activity, with the HSP90 inhibitor geldanamycin, was capable of inhibiting NO production suggesting the involvement of a coordinated regulatory system.

## 5.83

**The Effects Of Salinity Stress On The Physiology And Protein Content Of The Hermatypic Coral - *Acropora pruinosa In Hong Kong***

**William BUT*[1]**

[1]Swire Institute of Marine Science, The University of Hong Kong, Hong Kong, Hong Kong

The effects of low salinity on the scleractinian coral *Acropora pruinosa* were investigated in this study. 100% coral mortality and significant drops in percentage protein content were observed in *A. pruinosa* exposed to the salinity of 15 psu. No mortality occurred in *A. pruinosa* fragments at 18 psu salinity level. The data suggested that 15 psu salinity level is the mortality threshold for *A. pruinosa*. The crude protein content measured in the 18, 22 and 25 psu salinity treatment groups are not significantly different from that in the 35 psu salinity control group. While no statistically significant difference in the amount of crude protein per unit surface area was detected, sub-lethal behavioural responses were observed at salinity level of 18 psu and above. Increasing tissue swelling and polyp retraction characterized salinities between 22 and 18 psu but were not observed at higher salinities, suggesting that these are traumatic, but not necessarily fatal salinity levels.

Salinity is quite likely to be the major environmental factor that affecting the coral community distribution in a regional context. Freshwater excursions from the Pearl River and seasonal monsoon downpours establish a salinity gradient across Hong Kong waters. The sharp mortality threshold at low salinity in *A. pruinosa* might provide us insight into the spatial distribution patterns of corals in Hong Kong waters. On top of that, the data from this study might help us to predict the possible consequence of Hong Kong's corals under the influence of global climate change.

## 5.84

**Sources and metabolism of essential fatty acids in Scleractinian corals**

**Mark TEECE*[1]**, Diego LIRMAN[2], Mary Alice COFFROTH[3]

[1]Chemistry, SUNY-ESF, Syracuse, NY, [2]RSMAS/MBF, University of Miami, Miami, FL, [3]Geology, State University of New York at Buffalo, Buffalo, NY

Invertebrates such as corals require essential fatty acids for growth and reproduction and can obtain them either through direct feeding on zooplankton and particulates, or through translocation from their symbiotic zooxanthellae. We used the naturally occurring stable isotopes of carbon to trace the sources and metabolism of essential fatty acids in four corals from varying water quality environments. Comparative analyses of symbionts and hosts from Siderastrea siderea, Porites astreoides, Montastrea faveolata, ,and Montastrea cavernosa collected in the Florida Keys, USA revealed considerable differences in the abundances of these essential compounds in individual symbiont-host associations. The relative abundances of these polyunsaturated fatty acids (PUFA) was significantly higher in P. astreoides than S. siderea and accounted for more than 38% of total fatty acids in this coral species. The high abundances of these PUFA attest to the importance of their function in corals. Concentrations of PUFA in cultured zooxanthellae clades spanned a considerable range, accounting for more than 45% of total fatty acids in specific clades. We measured the stable isotope compositions of individual fatty acids in corals and symbionts to determine metabolic routing of these essential compounds in the natural environment. Our analyses revealed that some corals, including P. astreoides, obtain fatty acids from both zooxanthellae and direct feeding, and may also be able to synthesize long chain length fatty acids from shorter precursors obtained from their symbionts. Other corals including S. siderea, rely to a greater extent on their symbionts for their source of essential fatty acid.

## 5.85

**The Development Of Fluorescently-Labeled *symbiodinium* To Investigate Symbiont Acquisition And Flexibility in Coral-Algal Symbiosis**

**Nitzan SOFFER*[1]**, Patrick GIBBS[1], Michael C. SCHMALE[1], Andrew C. BAKER[1]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric science, University of Miami, Key Biscayne, FL

Symbiosis is a defining characteristic of reef-building scleractinian corals. During times of environmental stress, such as increased temperature, these symbioses can break down, jeopardizing the survival of affected corals. Corals can recover from these "bleaching" events if their symbiont populations are able to recover. However, for scleractinian corals, the source of these symbionts remains debated: do symbionts proliferate from residual populations, or can they also acquire symbionts *de novo* from the environment? Answering this question fills a critical gap in our understanding of symbiont population dynamics, helps us understand recovery trajectories of corals, and has significant implication for corals' response to continued climate change. To help answer this question, we are developing fluorescently-labeled *Symbiodinium* for use as tools to test hypotheses of symbiont acquisition and flexibility in scleractinian corals. Initial attempts to use viable stains to selectively visualize symbionts showed mixed success, and we have now begun transforming symbionts with DNA vectors. Cultured *Symbiodinium* in clades A, B, C and D have been electroporated with vectors containing Bactin, metallothionein and/or heat shock promoters driving expression of green and red fluorescent proteins (GFPs, RFPs), as well as neomycin resistance to help select successful transformants. To overcome problems associated with symbiont autofluorescence, other vectors containing sequences for cyan or yellow fluorescent proteins (CFPs, YFPs) and luciferase are also being targeted. We believe that the development of fluorescent or luminescent *Symbiodinium* will be of broad potential use in a variety of marine invertebrate symbioses, and will help address critical outstanding questions concerning the survivorship trajectories of reef corals in the current era of climate change.

## 5.86

**The Influence Of Habitat On Nitrogen Acquisition And Status in A Temperate Cnidarian-Dinoflagellate Symbiosis**

Shyam MORAR[1], Sarah BURY[2], **Simon DAVY*[1]**

[1]School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand, [2]NIWA, Wellington, New Zealand

Nitrogen deficiency is a well-known feature of tropical cnidarian-algal symbioses that inhabit oligotrophic seas. In contrast, temperate seas have plentiful supplies of nutrients, and a number of temperate symbiotic cnidarians inhabit high-sediment localities. The symbiotic sea anemone *Anthopleura aureoradiata* is abundant on mudflats around New Zealand where it lives attached to cockle shells, often buried under the sediment surface; it is also common on rocky shores. We tested whether the mudflat habitat provides a source of particulate matter that enriches the nitrogen status of the algal symbionts, and whether anemones living on rocky shores are nutritionally starved by comparison. $^{15}$N-labelled sediment was provided to anemones, and $^{15}$N-enrichment was detected for both anemone and algal partners. $NH_4^+$ enhancement of dark $^{14}$C fixation showed that while sedimentary particulate nitrogen can ultimately be acquired by the algae there was no discernible effect of this uptake on their nitrogen status. Indeed anemones maintained in mud but otherwise unfed for up to 8 weeks contained algae that were as N-deficient as those in anemones starved in the absence of mud. In contrast, symbiotic algae in the field were N-sufficient when on the mudflat but markedly N-deficient when on the rocky shore. Our results suggest that this symbiosis can assimilate particulate nitrogen from the surrounding mud but that this source is less important than other potential ones such as interstitial ammonium and nitrate. Furthermore, the nutrient-rich mudflat environment enhances the N-status of symbiotic algae far more than does the rocky shore. We will consider the implications of these trends for the functional biology of the symbiosis, and use our findings to speculate on the likely scenarios for those reef corals that live in relatively low sediment and more 'marginal', high-sediment locations.

## 5.87

**Growth Rate, Survivorship and Stress Tolerance of Primary Polyps of *Acropora digitifera* Infected with Zooxanthellae of Different Genotypes**

**Ryota SUWA*[1]**, Michio HIDAKA[2]

[1]Department of Marine and Environmental Sciences, Graduate School of Engineering and Science, University of the Ryukyus, Nishihara-cho, Japan, [2]Department of Chemistry, Biology and Marine Science, Faculty of Science, University of the Ryukyus, Nishihara-cho, Japan

The objective of this study was to examine the effects of zooxanthella genotypes on the growth rate and stress susceptibility of the coral *Acropora digitifera* during the early stages of development. Aposymbiotic primary polyps of *A. digitifera* were infected with zooxanthellae isolated from various hosts and their growth rate and survivorship were observed under different conditions. The rate of infection varied depending on zooxanthella genotypes. Clade A zooxanthellae isolated from the giant clam *Tridacna crocea* were most rapidly incorporated by the polyps and the algal density increased even under high temperature conditions, while homologous zooxanthellae (clade C) were incorporated only very slowly. The growth rate of the polyps was different among polyps harboring zooxanthellae of different types. The highest growth rate was observed in polyps harboring clade A zooxanthellae from *T. crocea*. The stress tolerance of primary polyps harboring the clade A zooxanthellae was higher than polyps harboring clade C zooxanthellae from the sea anemone *Aiptasia pulchella* or than uninfected polyps. Thus the clade A zooxanthellae from *T. crocea* appear most beneficial for primary polyps of *A. digitifera* and association with this zooxanthellae is expected to be predominant in the reefs. However, corals harboring clade A zooxanthellae are rare in the study site, where *T. crocea* is abundant. This is probably because suitable symbiont type is different between juvenile and adult colonies, and/or juvenile corals are more flexible with symbiont types than adult colonies. Another possibility is that clade A zooxanthellae were not selected by the coral because symbionts with a much faster growth rate than host may present a risk of parasitism for the host coral.

## 5.88

**Ultraviolet-Induced Dna Damage And Its Subsequent Repair in Field-Collected *aiptasia Pallida* as Monitored By Single-Cell Gel Electrophoresis**

**Claire HUDSON*[1]**, Drew FERRIER[1]

[1]Department of Biology, Hood College, Frederick, MD

Ultraviolet radiation (UVR) is a commonly occurring genotoxic stress in tropical marine environments. Shallow-water organisms have a variety of defenses against UVR. However, DNA damage from UVR still occurs. The exposure to UVR creates unique forms of damage, primarily as cyclobutane pyrimidine dimers and 6-4 photoproducts. These types of damage can subsequently be restored by nucleotide excision repair (NER) or via light-mediated reactions. Single-cell gel electrophoresis (the comet assay) can be used to quantitate DNA strand breaks created during NER. We optimized the comet assay to monitor DNA damage in host cells of the zooxanthellate sea anemone *Aiptasia pallida*. Following optimization, we documented the extent of DNA damage and the subsequent repair response in freshly collected *A. pallida* under simulated field conditions at the Bermuda Institute for Ocean Sciences. We also determined the types and amounts of mycosporine-like amino acids (MAAs) that confer protection from UVR-induced DNA damage. We found that host tissue of field anemones contain a variety of MAAs, tentatively identified as mycosporine-2-glycine, mycosporine glycine, shinorine and porphyra-334. Repair of DNA damage incurred from a daily dose of UVR occurred within eight hours after sunset, with NER taking place during the first 2 hr of recovery in the dark. These findings suggest that under natural conditions, DNA damage incurred from UVR does not accumulate from one day to the next in *A. pallida*.

## 5.89

**Effect Of Caffeine On Coral Symbionts**

**Kelly POLLACK*[1]**, Kimberly BALAZS[2], Oladele OGUNSEITAN[3]

[1]School of Social Ecology, University of California, Irvine, Irvine, CA, [2]School of Biological Sciences, University of California, Irvine, Irvine, CA, [3]School of Social Ecology & Program in Public Health, University of California, Irvine, Irvine, CA

Caffeine is a ubiquitous tracer of urban wastewater but its ecological effects have not been adequately studied. Here we report the effect of caffeine on the growth and protein synthesis in four species of coral algae endosymbionts. We hypothesized that caffeine exposure is associated with coral bleaching. After 40 days of incubation with various concentrations of caffeine (0 to 100 mg/L) we estimated the minimum inhibitory concentration (MIC) of caffeine are 30 mg/L for Clade C *Symbiodinium goreaui* (C), 30 mg/L for Clade B *Symbiodinium* sp. from *Pseudoterogorgia bipinnata* (B7), 50 mg/L for Clade A *Symbiodinium microadriaticum* (A), and 75 mg/L for Clade B *Symbiodinium* sp. from *Aiptasia pallida* (B6). To explore the effect of caffeine on proteins we used 2-D gel electrophoresis and peptide mass spectrometry to identify sensitive proteins. The results show 12 polypeptide spots upregulated and 37 polypeptide spots downregulated in C, 19 upregulated and 6 downregulated in B7, 14 upregulated and 13 downregulated in A, and 22 upregulated and 7 downregulated in B6. The heat shock protein HSP70 is among the commonly affected proteins indicating that stress from caffeine exposure in natural waters may exacerbate the effects of stress from other environmental factors.

## 5.90

**Dna Repair in *aptasia Pallida* Following Laboratory Exposures To Ultraviolet Radiation**

**Drew FERRIER*[1]**, Claire HUDSON[1]

[1]Department of Biology, Hood College, Frederick, MD

Cnidarians that inhabit shallow marine environments in tropical latitudes receive substantial exposure to ultraviolet radiation (UVR). It is well known that UVR damages the DNA of exposed organisms by creating cyclobutane pyrimidine dimers and 6-4 photoproducts. Damage may be subsequently repaired through nucleotide excision repair (NER) or directly by light-mediated reactions using photolyase. Neither of these mechanisms has been well-studied in cnidarians. We employed the comet assay to document DNA damage from UVR and subsequent DNA repair under laboratory conditions in the sea anemone *Aiptasia pallida*. We used aposymbiotic animals in initial studies. Anemones cultured in the laboratory contain very low levels of UVR-absorbing mycosporine-like amino acids and thus serve as ideal models for investigating damage due to UVR. At levels of exposure < 62 kJ $m^{-2}$, DNA damage in animal nuclei increased with increasing exposure to UVR. However, at higher levels of exposure, DNA damage reached an asymptote. To assess the time-course of repair we subjected anemones to ~ 30 kJ $m^{-2}$ of UVR and then kept them in the dark. These animals exhibited a delay of approximately 4 hours in the initiation of NER. However, this repair mechanism, once initiated, reduced DNA damage to near pre-exposure levels within 8 hours. Simultaneous exposure of anemones to both UVR and visible light greatly reduced the amount of DNA damage. This suggests that light-mediated DNA repair also plays an important role in anemones and is likely the first line of defense against cumulative DNA damage by UVR in these animals.

## 5.91

**Potential Implication Of Host/symbiont Recognition Mechanisms in Coral Bleaching**

**Jérémie VIDAL-DUPIOL*[1]**, Guillaume MITTA[2], Emmanuel ROGER[2], Denis ALLEMAND[3], Christine FERRIER-PAGÈS[3], Paola FURLA[4], Renaud GROVER[3], Pierre-Laurent MERLE[4], Eric TAMBUTTÉ[3], Sylvie TAMBUTTÉ[3], Didier ZOCCOLA[3], Ophélie LADRIÈRE[5], Mathieu POULICEK[5], Laurent FOURÉ[6], Mehdi ADJEROUD[2]

[1]Biologie Ecologie Tropicale et Mediterranéenne, UMR 5244 CNRS-UPVD-EPHE, Perpignan, France, [2]Biologie Ecologie Tropicale et Mediterranéenne, UMR 5244 CNRS-UPVD-EPHE, Perpignan Cedex, France, [3]Centre Scientifique de Monaco, Monaco-Ville, Monaco, [4]UMR-112 UNSA-INRA ROSE, Nice Cedex 02, France, [5]Laboratoire d'écologie animale et écotoxicologie, Unité d'écologie marine, Liège (Sart Tilman), Belgium, [6]Aquarium du Cap d'Agde, Cap d'Agde, France

Bleaching in corals can be attributed to loss of endosymbiotic zooxanthellae and/or loss of photosynthetic pigments within zooxanthellae. This major disturbance of the reef ecosystem is principally induced by increases in water temperature. Since the beginning of the 80's and the onset of global climate change, this phenomenon has been occurring at increasing rates and scales, and with increasing severity. In this study, we focused on finding early regulated genes involved in bleaching. In aquaria, one set of *Pocillopora damicornis* nubbins was subjected to a gradual seawater temperature increase from 28°C to 32°C over 15 days, and a second control set remained at constant temperature (28°C). Bleaching was monitored by measuring zooxanthellae density. The mRNA differentially expressed between the stressed state (sampled just before the onset of bleaching) and the non stressed state (control) were isolated from the nubbins by Suppression Subtractive Hybridization. The corresponding cDNA were sequenced and confronted to sequence databases to obtain gene similarities. Finally, transcription rates of the most interesting genes were conducted by Q-PCR. Two particularly interesting candidate genes showed an important decrease in their transcription rates following thermal stress and before zooxanthellae loss. These two genes show similarities with genes involved in host/symbiont and host/parasite models. The implication of these molecular actors suggests a possible role of recognition mechanisms between the host and its symbiont, in the breakdown of the symbiosis during the bleaching phenomenon. Experiments such as RACE-PCR, *in situ* hybridization and immunohistochemistry are currently underway to confirm our hypotheses.

## 5.92

**Influence Of Mg Calcite–associated Proteins On The Formation Of Sclerites in Soft Corals**

**M. Azizur RAHMAN*[1]**, Tamotsu OOMORI[1]

[1]Chemistry, University of the Ryukyus, Nishihara, Japan

Non-reef-building soft corals contain small spicules of calcium carbonate called sclerites. To date, the Mg calcite–associated proteins that are key for the formation of non-reef-building corals have not been identified. The goal of this research was to study the involvement of Mg calcite proteins in the morphology of calcium carbonate deposition in sclerites, the vital controlling factor for growth of soft corals. Prior to isolation of proteins from the sclerites of *Lobophytum crassum*, calcitic polycrystals, including Mg calcite, had been identified using an Electron Probe Micro analyzer, X-ray diffractional analysis, and Raman spectroscopy. A mineral phase in the precipitated crystals resulting from protein interaction in the calcification process was identified as Mg calcite. Here we show that the crystals' nucleation form in sclerites has a rhombohedral morphology in the presence of Mg calcite proteins. We also show the interesting phenomenon of a transition of crystals from the aragonite to calcite phase in the presence of Mg calcite proteins. We investigated the interaction of Mg calcite proteins in the formation of surface on crystal sheets during calcification using atomic force microscopy. Electrophoretic analysis of Mg calcite proteins extracted from the soluble and insoluble organic matrices of sclerites revealed four proteins, with one of them of 67 kDa possibly being glycosylated. Calcium binding analysis of the Mg calcitic proteins in these fractions indicated that the 67-kDa protein can bind Ca2+, which is requisite for sclerite formation. The N-terminal amino acids of this newly identified protein were sequenced, and subjected to bioinformatics analysis involving identification of similarities to other animal proteins. Thus, understanding the role of Mg calcite proteins in non-reef-building corals may provide important information about the biological mechanisms of mineralization, and this could prove to be of much interest to those in the fields of materials science and biomineralization.

## 5.93

**Comparative Genetics Of *aiptasia* Anemones And Their Dinoflagellate Symbionts Reveals High Specificity in An Invertebrate-*symbiodinium* Symbiosis**

**Yu XIANG*[1]**, Scott SANTOS[1]

[1]Biological Sciences, Auburn University, Auburn, AL

Marine invertebrates and their symbiotic dinoflagellates in the genus *Symbiodinium* have been intensively studied in recent years. However, the degree of specificity and flexibility between partners remains unclear. To explore this, we first utilized inter-simple sequence repeats (ISSRs) to develop sequence characterized amplified region (SCAR) markers for anemones in the genus *Aiptasia*. Data from seven SCAR markers found Florida *Aiptasia* to be genetically distinct from all other localities, suggesting the genus is comprised of two "genetic" species. Notably, the distribution of the "genetic" species does not coincide with the range of the morphologically described species *A. pulchella* (Pacific and Indian Oceans and Red Sea) and *A. pallida* (Atlantic Ocean and Caribbean Sea). Coinciding with this, restriction fragment length polymorphism (RFLP) analyses of symbiont populations from 426 *Aiptasia* collected from 17 localities worldwide found Florida *Aiptasia* hosting either *Symbiodinium* Clades A, B or mixtures of both A and B simultaneously while *Aiptasia* from all other locations harbored Clade B only. To quantify fine-scale population structure and genetic differences among symbiont populations, six microsatellite loci specific for Clade B were utilized on 326 individual *Aiptasia*. We found that 18 out of 50 (36%) Florida *Aiptasia* thought to harbor only Clade A by RFLP analyses also possessed low levels of Clade B symbionts when examined by microsatellite analyses, suggesting background symbiont populations of a host may escape detection depending on the utilized technique. Strong population structure in Clade B populations was observed since most genotypes were unique to a specific locality. However, no sequence variation was observed in the flanking regions of these loci, suggesting an identical *Symbiodinium* Clade B phylotype associates with *Aiptasia* on a worldwide scale, which implies high specificity in this invertebrate-algal symbiosis.

## 5.94

**Cell Cycle Pattern Of Free-Living Zooxanthellae: Effect Of Light**

**Li-Hsueh WANG*[1,2]**, Chii-Shian CHEN[1], Li-Shing FANG[3], Hui-Ju HUANG[1], Shao-En PENG[1], Yi-Yuong HSIAO[1]

[1]Coral Research Center, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [2]Institute of Marine Biotechnology, National Dong Hwa University, Hualien, Taiwan, [3]Department of Kinesiology, Health and Leisue Studies, Cheng Shiu University, Kaohsiung, Taiwan

The cell cycle, one of the most comprehensively studied biological processes, is normally characterized by a round of DNA replication (S phase) followed by mitosis and cytokinesis (M phase) and separated by two gap phases (G1 and G2). Many marine cnidarian are known to harbor dinoflagellate named zooxanthellae as symbiont inside the gastrodermal cells. Regulation in the numbers of zooxanthellae in the host is an essential feature under steady state conditions. Mechanisms of this cell cycle regulation were studied by culturing free-living zooxanthellae, Symbiodinium spp, originally isolated from Euphyllia glabrescens, under different treatments, and cell cycle distribution was determined by flow cytometry. Our results showed that about 40%~50% of free-living zooxanthellae proliferated, whereas only <3% of symbiotic zooxanthellae divided under 12h light/12h dark cycle. This light-induced cell proliferation was sensitive to blue light and inhibited by photosystem II inhibitor, DCMU. Cell division activity was correlated with adenylyl cyclase activity. Furthermore, free-living zooxanthellae proliferation decreased with the addition of green fluorescence protein which may also be present in marine cnidarian naturally. These results suggest that marine cnidarian can inhibit zooxanthellae proliferation via masking blue light.

## 5.95

**Defenses Against Oxidative Stress in Zooxanthellate Symbioses**

**David TAPLEY*[1]**

[1]Biology, Salem State College, Salem, MA

Photosynthesis by zooxanthellae within cnidarian symbioses produces hyperbaric oxygen tensions within the animal hosts. As a result, the host organisms experience elevated exposure to reactive oxygen species (ROS), including superoxide, hydrogen peroxide, and the hydroxyl radical. The primary defenses against ROS in most metazoans include the enzymes superoxide dismutase (SOD) and catalase (CAT) as well as several low-molecular-weight organic molecules such as ascorbate, glutathione, and urate. Unlike most metazoans, including other cnidarians, sea anemones in the genus *Aiptasia* do not regulate activities of SOD and CAT in response to artificially elevated oxygen tensions or light intensities. In fact, SOD activity is remarkably low in this genus. Instead, the primary defenses against ROS in these symbioses appear to be saturating concentrations of uric acid, a potent scavenger of hydroxyl radicals, and constitutively elevated activities of CAT. Furthermore, CAT activity is inversely correlated with acclimation irradiance, indicating that direct photoinactivation of catalase in zooxanthellate symbioses occurs. Given that defenses against ROS in other cnidarian zooxanthellate symbioses follow different patterns, including more robust enzymatic defenses, studies of such defenses among coral reef cnidarians need to consider the exact pattern of defenses for the species under consideration.

## 5.96

**Nutrient Transfer in A Multi-Level Mutualism: Contributions Of Anemonefish To Host Anemone And Zooxanthella Nutrition**

Modi ROOPIN[1], **Nanette CHADWICK*[1]**

[1]Biological Sciences, Auburn University, Auburn, AL

Many coral reef symbioses consist of multiple partners, but most of the empirical and theoretical work on symbioses has been limited to 2-way systems. This limitation extends to cnidarian-zooxanthella symbioses, in which most research has ignored the nutritional impacts of additional partners, such as obligate fish or mobile invertebrate residents. We used the anemone-fish-zooxanthella symbiosis as a model system to assess the potential contribution of large ectosymbionts to the nutritional budget of cnidarian hosts and their zooxanthellae. Under both laboratory and field conditions, anemonefish excreted large quantities of ammonia, mostly during the daytime after consumption of zooplankton. Host anemones rapidly absorbed most of the ammonia excreted by the fish, and did so almost exclusively during the daytime, suggesting that this process is driven by zooxanthella photosynthesis. In controlled laboratory experiments, the ammonia waste products of resident anemonefish allowed the maintenance of high zooxanthella levels in host sea anemones, and significantly retarded the catabolism of host tissue reserves. These results provide a physiological mechanism to explain our field observations that host anemones with few or no fish shrank over several years, while those with large resident fish grew substantially. In the Red Sea, localized concentrations of ammonia near sea anemones with resident fish were significantly higher than those in the surrounding oligotrophic waters. We conclude that zooplanktivorous fishes and crustaceans that form symbioses with cnidarians serve as an important link between open water and benthic ecosystems, by importing particulate nutrients from the plankton and releasing them in dissolved form near benthic hosts. These multi-level symbioses connect associates in a complex web of interactions that buffer adverse impacts of environmental variation, thereby enhancing reef diversity and productivity.

## 5.97

**The Photobiology of *Symbiodinium* Indicates Populational Differences in Hyposaline Tolerance in *Siderastrea radians* from Florida Bay, Florida, USA**

**Kathryn M. CHARTRAND*[1]**, Michael J. DURAKO[1]

[1]Department of Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC

Studies of coral populations along gradients in physical-environmental conditions may provide insights as to how future climate patterns may affect coral symbioses. In this mesocosm study, *Siderastrea radians*, collected from five distinct basins in Florida Bay along a northeast-to-southwest salinity gradient, was used to assess effects of chronic hyposalinity on the photophysiology of *Symbiodinium* as an indicator of holobiont stress. Colonies from each basin were assigned four salinity treatments (30, 20, 15, and 10) and salinities reduced 2 d-1 from ambient (30) to simulate a natural salinity drop. Maximum and effective quantum yields were measured using PAM-fluorometry at dawn and noon, respectively. There was generally no decrease in yields for 20 and 15 treatment colonies versus controls (i.e. 30) up to five days post-target salinity. This indicates a greater ability to withstand reduced salinity for relatively extended periods of time in *S. radians* compared to other reef species. When salinity of 10 was reached, colonies showed significant reduction in maximum yields versus those at 20 and 30, indicating a critical threshold for hypo-saline tolerance. At salinity of 10, colony yields from the most salinity-variable northeast Blackwater Sound (BLK) versus the most marine southwest Twin Key basin (TWN) were significantly different, suggesting a populational shift in salinity tolerance linked to historical basin salinity ranges. Subcladal ID of *Symbiodinium* for each basin population was completed using PCR-DGGE analysis of the ITS2 region. TWN colonies possessed a distinct symbiont type versus those in BLK, further correlating with differences in photobiology measured during hyposalinity experiments. These findings suggest that long-term differences in basins salinities lead to differential responses in the holobiont, which are related to a shift in symbiont photophysiology and colony symbiont association.

## 5.98

**Cladal Diversity in Zooxanthellae Harbored By Sponges Of The Clionaidae: A Case Study Involving Cliona Varians.**

**Malcolm HILL*[1]**, April HILL[1], Ericka POPPELL[1], Blake RAMSBY[1]

[1]Biology, University of Richmond, Richmond, VA

Among the Porifera, zooxanthellae are primarily restricted to a single family (Clionaidae), which includes major bioeroders on tropical reefs. Zooxanthellae have been found to benefit their host sponges by elevating growth rates through photosynthetic activities. Early work also demonstrated that at least one species of zooxanthellate-sponge was capable of switching partners when exposed to stressful conditions. Despite this early work, very little is known about the types of zooxanthellae harbored by these sponges. To address this deficit in our understanding, we examined the zooxanthellar diversity present in different species of clionaid sponges from the Florida Keys. Attention was focused on three morphotypes of Cliona varians that occur in disparate habitats. Our findings indicate that the level of specificity between host and symbiont varies among sponge species. Some species appear to harbor a single type of zooxanthellae (e.g., Cliona caribbea, Cervicornia cuspidifera) while others (e.g., Cliona varians) harbor multiple clades. Data will also be presented relating zooxanthellar densities, chlorophyll concentrations, and phophotochemical efficiencies to the cladal diversity uncovered among sponge species. Our data will be placed in the context of current hypotheses proposed to explain the nature of associations that involve multiple partners. These data may also provide important insights into the relative stability of sponge-zooxanthellar symbioses on tropical coral reefs.

## 5.99

**High-Performance Liquid Chromatographic Analysis Of Photosynthetic Pigments in Corals: An Existence Of A Variety Of Epiphytic And Endolithic Algae**

**Kazuhiro DAIGO*[1]**, Yoshikatsu NAKANO[2], Beatriz CASARETO[1], Yoshimi SUZUKI[1], Yuzo SHIOI[1]

[1]Shizuoka University, Shizuoka, Japan, [2]Ryukyus University, nago, Japan

Plant pigments of corals were analyzed by high-performance liquid chromatography (HPLC) to investigate the secondary symbiotic algae of zooxanthella (dinoflagellate). Coral samples were collected from Sesoko, Okinawa, Japan. HPLC analysis was performed using a Waters Symmetry C8 column and a programmed binary gradient elution with a photodiode array detector according to the method reported by Zapata et al. (2000). The pigments were quantitatively analyzed and identified by comparison with the standards. HPLC analysis achieved the separation of more than 60 peaks of the pigments from more than 25 species of corals and about 30 pigment species of them were identified. In addition to marker pigments of dinoflagellate, a variety of pigments including chlorophyll *d*, chlorophyll *b*, chlorophyll $c_1$, zeaxanthin, and lutein were detected. After brushing of corals to remove epiphytic algae, the pigment composition in corals was analyzed. However, most of algae were unable to remove. These findings suggest that in addition to the pigments from dinoflagellate, some of the pigments are probably due to epiphytic or endolithic algae growing in corals such as cyanobacteria, green algae and diatoms. However, we had no information on the secondary symbiotic algae in zooxznthella. From these facts, corals are not merely habitat of symbiotic dinoflagellates, but also community of a various diversity of phytoplanktons. This further means that corals having such a various diversity of production structure are not negligible in terms of energy production in a whole coral ecosystem. It would be necessary that we do not only investigate usual relationship between corals and symbionidium, but also interrelationship between corals and its community composed of a various phytoplanktons.

Zapata, N. et al. (2000) Mar. Ecol. Prog. Ser. 195: 29-45.

## 6.152

**Validation of Reference Genes for Quantitative Real-time RT-PCR Normalization In Stress-Induced Pocillopora meandrina.**

**Lauren PAGARIGAN*[1]**, Misaki TAKABAYASHI[1]

[1]University of Hawaii Hilo, Hilo, HI

Normalization of quantitative real time RT-PCR (qRT-PCR) is needed to obtain accurate estimates of gene expression. Today, the most commonly used method to normalize target genes is through the use of reference or housekeeping genes. Reference genes however, need extensive validation to show constitutive expression under different conditions and between tissue types. qRT-PCR has only been used for a handful of anthozoa gene expression studies and even smaller amount of gene expression studies evaluating natural and anthropogenic stressors. In these studies, often only one reference gene was used. Commonly used reference genes for anthozoa include beta-actin, 18S, and EF1 alpha. In this study we used common reference genes found in past studies (18S, B-actin, EF1 alpha) in addition to POU homeodomain protein brn1 and putative senescence associated protein for the evaluation of quality reference genes for anthozoa exposed to stress. This study characterized the expression of these five candidate reference genes for the scleractinian coral, P.meandrina, after a chronic exposure to ammonium and heat shock treatments. All five reference genes exhibited variable expression. GeNorm was used to choose three housekeeping genes with the most stable expression ratio in our samples for the calculation of an RT-PCR normalization factor that is more stable than using one reference gene alone.

## 6.153

**Field Characterization Of Stress Gene Expression Patterns in Hermatypic Corals Exposed To Effluent From The Delray Beach Outfall**

**Tonya SHEARER*[1]**, Sara EDGE[2]

[1]School of Biology, Georgia Institute of Technology, Atlanta, GA, [2]Robertson Coral Reef Program, Harbor Branch Oceanographic Institute, Ft. Pierce, FL

Degradation of coral reef systems is an increasing concern throughout the world with multiple synergistic factors contributing to the decline of reef habitats. Nutrient enrichment is one of many stressors that has been demonstrated to directly and indirectly negatively impact coral reef organisms in controlled laboratory and *in situ* experiments. Recently, a local environmental group has correlated nutrient-rich effluent from Delray Beach (South Florida) ocean outfall with persistent blooms of cyanobacteria at nearby, Gulf Stream Reef (GSR). In order to determine whether nutrient enrichment directly (by suppression/enhancement of physiological functions) and/or indirectly (by physical contact with blooming cyanobacteria) influences expression of stress genes, *Montastraea cavernosa* colonies have been sampled from GSR and reef habitats upstream and downstream from this outfall. Using microarray technology, differential expression of stress genes in corals from potentially impacted sites relative to unaffected sites was measured to determine if different populations are reacting to various levels of stress and whether a nearby wastewater treatment outfall may be contributing to the deterioration of certain reef communities.

## 6.154

**Quantification Of Algal Endosymbionts (Symbiodinium) in Coral Using Real-Time Pcr**

**Jos MIEOG*[1]**, Madeleine VAN OPPEN[2], Ray BERKELMANS[2], Wytze STAM[1], Jeanine OLSEN[1]

[1]University of Groningen, Haren, Netherlands, [2]Australian Institute of Marine Science, Townsville, Australia

Understanding the flexibility of the endosymbioses between scleractinian corals and single-cell algae of the genus *Symbiodinium* will provide valuable insights into the future of coral reefs. Here, a real-time PCR assay is presented to accurately determine the cell densities of *Symbiodinium* clades C and D in the hard coral *Acropora millepora*, which can be extended to other coral-symbiont associations in future. The assay targets single- to low-copy genes of the actin family of both the coral and algal symbiont. Symbiont densities are expressed as the ratio of *Symbiodinium* cells to each host cell (S/H ratio, error within 30%), but can also be normalized to coral surface area. Greater accuracy in estimating ratios of associations involving multiple clades (error within 60%) is achieved compared with similar assays based on high-copy ribosomal DNA loci (error within an order of magnitude). Healthy adult *A. millepora* containing ~1.4 x $10^6$ zooxanthellae per $cm^2$ (as determined by haemocytometer counts) had S/H ratios of ca. 0.1, i.e., ~1 symbiont cell per 10 host cells. In severely bleached colonies this ratio decreased to less then 0.005. Because of its capacity to accurately determine both densities and ratios of multiple symbionts within one sample, the assay will open the door for novel research into the mechanisms of symbiont shuffling and switching.

## 6.155

**Functional Potential Of Microbial Communities Associated With *pseudopterogorgia Americana* From The Southern Coast Of Puerto Rico**

**Nikole E. KIMES*[1,2]**, Joy D. VAN NOSTRAND[3], Jizhong Z. ZHOU[3], Ernesto WEIL[4], Pamela J. MORRIS[1,2]

[1]Marine Biomedicine and Environmental Sciences, Medical University of South Carolina, Charleston, SC, [2]Hollings Marine Laboratory, Charleston, SC, [3]Department of Botany and Microbiology, University of Oklahoma, Norman, OK, [4]Department of Marine Sciences, University of Puerto Rico, Mayaquez, Mayaquez, Puerto Rico

Coral-associated microbial communities are increasingly recognized as important components of the coral holobiont that influence coral health and disease. It has been suggested that these communities contribute to the health of the coral ecosystem through energy and nutrient cycling, as well as provide corals with protection against pathogens. There are few studies, however, that directly address the functional role of these communities and their ecological potential. In the present study, we examined the functional gene potential of the coral-associated microbial community found in the surface mucopolysaccharide layer (SML) of a common Caribbean coral, *Pseudopterogorgia americana*. SML samples were collected in March of 2006 off the southern coast of Puerto Rico at La Paguera. DNA was extracted and amplified for use in a functional gene array, the GeoChip, which contains 24,000 probes targeting 10,000 functional genes associated with key biogeochemical processes. Our preliminary data indicate that this microbial community possesses 1189 genes known to play a role in numerous ecological processes. These processes include carbon degradation/fixation (159 genes), dissimilatory sulfite reduction (94 genes), metal homeostasis (203 genes), methane generation and oxidation (50 genes), nitrogen fixation/reduction (145 genes), ammonification (94 genes), and organic chemical degradation (444 genes). This data, strongly suggests that the coral-associated microbial community found in the SML of *P. americana* may play an active role in maintaining the coral holobiont through cycling of key nutrients, metals and organic contaminants. In on-going studies, we are evaluating the functional potential of healthy as well as diseased *Montastrea faveolata* SML samples from the same region.

## 6.156

**Using BACs to compare the genomes of two Caribbean corals, Acropora palmata and Montastraea faveolata**

**Collin CLOSEK*[1]**, Christian VOOLSTRA[1], Michael DESALVO[1], Shinichi SUNAGAWA[1], Alejandro REYES[1], Monica MEDINA[1]

[1]Natural Sciences, University of California, Merced, Merced, CA

We have constructed Bacterial Artificial Chromosome (BAC) libraries of two Caribbean coral species, *Acropora palmata* and *Montastraea faveolata*. These BAC clones allow the possibility of having stable large insert libraries for genomic studies. The constructed libraries are estimated to have a10X coverage, and an average insert size of 130kb. We are currently using 454 sequencing of several homologous BAC clones. Our target chromosomal regions were chosen because they contain genes that were differentially expressed in transcriptome experiments with multiple developmental stages and stress conditions (i.e. thermal bleaching, disease). We intend to use these data for cnidarian comparative genomics (i.e. identify potential regulatory regions, gene annotation, synteny analysis). To our knowledge, this is the first study in which large genomic regions of corals belonging to the complex and robust lineages will be sequenced. We can now take advantage of the availability of the complete genomes for the sea anemone *Nematostella vectensis* and the hydrozoan *Hydra magnipapillata* to study not only scleractinian, but also cnidrian genome evolution. This study is a building block towards the completion of these corals' genomes.

## 6.157

**The Symbiodinium Genome Sequence: A Progress Report**

**Mary Alice COFFROTH*[1]**, Thomas DOAK[2], Jodi SCHWARZ[3], Mónica MEDINA[4]

[1]Geology, University at Buffalo, Buffalo, NY, [2]Dept of Biology, Indiana University, Bloomington, IN, [3]Biology, Vassar College, Poughkeepsie, NY, [4]School of Natural Sciences, UC-Merced, Merced, CA

We (TG Doak, RB Moore, C Delwiche, O Hoegh-Guldberg, & MA Coffroth) submitted two proposals to the National Health Genome Research Institute (NHGRI) in fall 2003, one for a BAC library for *Symbiodinium*, and one for complete genomic sequence of one or more isolates. As a result of the BAC white paper, NHGRI approved funding for BAC library construction. This project will result in an arrayed set of BAC clones, with matching blots that researchers can request for probing. In response to the sequencing white paper, NHGRI approved exploratory sequencing, to determine the feasibility of sequencing a complete genome. This is ongoing at the Washington University St. Louis Genome Center under the direction of Sandra Clifton. You can obtain the genome white paper here: http://www.auburn.edu/~santosr/pdf/Symbiodinum_WPl+Appendix_v2.pdf.

For the initial efforts, we have focused on a Caribbean clade B strain isolated by Mary Alice Coffroth, which is also the subject of an EST project that is ongoing at the Joint Genome Institute, directed by Mónica Medina. Modern annotation of genomes depends both on good EST sets for gene finding, and on the comparison of related genomes. We hope to include an additional clade isolate, and are looking for collaborators who can provide DNA for a strain that also has an ongoing EST project. We will report on the ongoing efforts to provide DNA in adequate quantity and quantity to keep these genome projects moving. This aspect of a genome project is not specifically funded, but rather depends on volunteer efforts by the interested community of researchers. Thus, we are very much interested in talking to researchers with expertise in these areas. We have hoped that one salient outcome of this project will be a focused meeting of people doing molecular biology in dinoflagellates, irrespective of what dinoflagellate.

## 6.158

**Development Of Improved Diversity Arrays Technology (idart) For Whole-Genome Genotyping Of Corals**

**Shi WANG*[1]**, Naila ALIEVA[1], Lingling ZHANG[1], Elisha MEYER[1], Galina AGLYAMOVA[1], Tom JUENGER[1], Mikhail MATZ[1]

[1]Section of Integrative Biology, School of Biological Sciences, University of Texas at Austin, Austin, TX

Molecular marker technologies are useful tools for assessing important ecological and evolutionary issues such as genetic diversity, gene flow and speciation. We are currently developing a novel microarray-based whole-genome genotyping technology called iDART. iDART make it possible to simultaneously discover and genotype as many as 200-300 co-dominant genetic markers in a single hybridization experiment, and thus is easily applicable to non-model organisms such as corals. We have recently demonstrated the feasibility of this approach in the model study and currently developing the DNA chips for *Acropora millepora* and several other corals, along with the procedures for genotyping individual coral larvae. The first iDART application will be the genome-wide association study of the stress resilience and dispersal potential in the coral *A. millepora*. The spatial and population genetic structure of the identified genomic loci will be analyzed for the evidence of recent natural selection related to the ongoing climate change.

## 6.159

**Diversity in Populations Of Free-Living *symbiodinium* From A Caribbean And Pacific Reef**

**Mackenzie MANNING*[1]**, Ruth GATES[1]

[1]Hawaii Institute of Marine Biology, Kaneohe, HI

The presence and diversity of free-living dinoflagellates belonging to the endosymbiotic genus *Symbiodinium* was explored in seawater samples collected above coral reefs in Kāne'ohe Bay O'ahu, Hawai'i, USA, and Puerto Morelos, Quintana Roo, Mexico. Two genetic markers were used to assess *Symbiodinium* diversity in the water column; the internal transcribed spacer 2 region of the nuclear ribosomal array (ITS2), and a hyper-variable region in Domain V of the large subunit (23S) of the chloroplast ribosomal array (cp23S-HVR). Sequencing of cloned gene fragments reveals that clade B, C, D and H *Symbiodinium* are detectable in the seawater samples. In addition to the previously described types B1, C3, C15, C21 and D1, novel *Symbiodinium* sequences belonging to clades B and C were also retrieved. The majority of *Symbiodinium* sequences recovered from Kāne'ohe Bay belonged to clade C and those from Puerto Morelos to clade B, a pattern that reflects the dominant types of *Symbiodinium* found in endosymbiosis with scleractinian corals in these two areas. This study represents the first direct assessment of *Symbiodinium* diversity in waters adjacent to coral reefs located in the Caribbean and the Pacific and confirms the presence of *Symbiodinium* in this compartment of the ecosystem. These data provide context for future studies examining spatial and temporal patterns in the availability of *Symbiodinium* in the water column, work that will ultimately promote a greater understanding of the interactions between symbiotic dinoflagellates and their environmentally sensitive benthic hosts.

## 6.160

**Intracolonial Genotypic Variations And Heterozygosity Excess Of A Scleractinian Coral Pocillopora Damicornis**

Shang-Ru YEOH[1], **Chang-Feng DAI*[1]**

[1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan

The naturally occurring intraorganismal genetic heterogeneity (IGH) and heterozygosity excess of Pocillopora damicornis populations were studied in southern Taiwan. Two populations of P. damicornis were sampled exhaustively in a fine-scale and an additional population was sampled randomly for index comparisons (n = 107). Identities of colonies were characterized genotypically with seven microsatellite markers. Both genuine clonemates (colonies with identical multilocus genotypes) and genotypic varieties that differed only slightly from them were found. In order to discern whether these genotypic varieties were the coincidental products of sexual reproductions, we redefined the clones into clonal lineages (genuine clonemates and their closely-related clonal varieties) with a threshold value determined from the frequency histogram of pairwise genotypic distances between all multilocus genotype (MLG)-pairs under the infinite allele model (IAM). Ten distinct clonal lineages (C1 to C10) were defined and intracolonial genetic variations were observed in all but one clonal lineage, suggesting that autonomous genetic changes such as somatic mutations and mitotic gene conversions might occur frequently in the clonal population of P. damicornis. Moreover, allele-sharings among several clonal lineages were also observed, implying that allogeneic fusions might occur between individuals of newly settled larvae and young colonies, either intraclonally or interclonally. In addition, heterozygosity excess, a phenomenon that was rarely observed in the sessile marine invertebrates, was found to prevail in all three populations. This observation was probably a result derived from an interplay between negative assortative mating, selection for heterozygotes, and asexual reproductions.

## 6.161

**Comparative Coral Mitogenomics And Its Application To Phylogenetic, Population Genetic And Biodiversity Studies**

**Jean-François FLOT*[1]**, Simon TILLIER[1]

[1]Département Systématique et Evolution, Muséum National d'Histoire Naturelle, Paris, France

The mitochondrial genomes of scleractinian corals used to be considered uniform in terms of gene content and order (Medina et al. 2006) as all corals sequenced had been found to conform to the *Acropora tenuis* model (van Oppen et al. 2002). Moreover, the apparently slow rate of evolution of coral mitochondrial DNA (Shearer et al. 2002) was generally thought to preclude its use in population genetic studies (Hellberg 2006).

New data, however, have started to emerge that challenge this view: the mitochondrial genome of *Pocillopora* contains two hypervariable regions, located respectively in an intergenic region and in a novel open reading frame (ORF) (Flot and Tillier 2007). This ORF is also present in *Madracis*, *Seriatopora* and *Stylophora*, and we have observed other original gene arrangements involving for instance the duplication of a tRNA gene. In *Pocillopora*, hypervariable regions appear variable enough for population genetic studies: this shows that, in some groups of corals at least, mitochondrial sequence markers can be much more useful than previously thought.

Flot J-F, Tillier S (2007) The mitochondrial genome of *Pocillopora* (Cnidaria: Scleractinia) contains two variable regions: The putative D-loop and a novel ORF of unknown function. Gene 401:80-87

Hellberg M (2006) No variation and low synonymous substitution rates in coral mtDNA despite high nuclear variation. BMC Evol Biol 6:24

Medina M, Collins AG, Takaoka TL, Kuehl JV, Boore JL (2006) Naked corals: skeleton loss in Scleractinia. Proc Natl Acad Sci U S A 103:9096-9100

Shearer TL, van Oppen MJH, Romano SL, Wörheide G (2002) Slow mitochondrial DNA sequence evolution in the Anthozoa (Cnidaria). Mol Ecol 11:2475-2487

van Oppen MJ, Catmull J, McDonald BJ, Hislop NR, Hagerman PJ, Miller DJ (2002) The mitochondrial genome of *Acropora tenuis* (Cnidaria; Scleractinia) contains a large group I intron and a candidate control region. J Mol Evol 55:1-13

## 7.162

**Disease Ecology And Local Patterns Of Yellow Band Syndrome in A Caribbean Reef**

**Susanne SOKOLOW*[1]**, Patrick FOLEY[2], Janet FOLEY[1]

[1]University of California Davis, Davis, CA, [2]California State University Sacramento, Sacramento, CA

Yellow band syndrome (YBS) is a potentially devastating, emerging problem in Caribbean coral that has not been definitively associated with a specific infectious pathogen. Host and environmental factors may be important components of the disease process in coral, and spatial patterns can provide important epidemiological information. Here, we evaluate multiple host and environmental factors for associations with YBS, including colony size, host density and spatial configuration, depth, temperature, salinity, water nutrients, and the local reef community. The prevalence of YBS in this reef was high, with considerable spatial and temporal variation. Average prevalence was 28.6%, 55.9%, and 10.5% among transects repeatedly sampled in 2002, 2003, and 2004, respectively. Analysis for spatial clustering documented that *Montastraea* spp. colonies were locally spatially clustered, compared to complete spatial randomness; however, colonies with YBS tended to be less clustered (i.e. more regular) than expected by chance, a spatial pattern that is not consistent with transmission by simple contagion. YBS prevalence was not detectably associated with any specific reef organism, scleractinian richness, host density, nor local environmental conditions. However, the composition of the reef community was significantly associated with YBS prevalence, in addition to depth, nitrogenous compounds, and spatial location, when evaluated by multivariate analysis. The detected association between disease and community composition suggests that the disease plays a role in the local community ecology, but the nature of the interaction between disease and reef composition remains unclear. This work underscores the importance of considering the complex and synergistic effects of pathogens and environmental stressors within the reef community. Understanding the causes and impacts of YBS on Caribbean coral reefs across multiple scales remains an important research challenge.

## 7.163

**Catastrophic Losses in Coral Cover in Us Virgin Islands Follow 2005-06 Coral Bleaching And Disease Event**

**Jeff MILLER*[1]**, Erinn MULLER[2], Caroline ROGERS[3], Andrea ATKINSON[4], Rob WAARA[4], Andy DAVIS[1], Kevin R. T. WHELAN[4], Matt PATTERSON[4], Tony SPITZACK[3]

[1]National Park Service, St. John, Virgin Islands (U.S.), [2]Florida Institute of Technology, Melbourne, FL, [3]US Geological Survey, St. John, Virgin Islands (U.S.), [4]National Park Service, Village of Palmetto Bay, FL

While the loss of coral cover from disease is not uncommon, the rapid, catastrophic losses of coral cover recorded in the US Virgin Islands (USVI) associated with the 2005-06 bleaching and disease event were truly devastating. Prior to this event, monitoring coral cover at seven sites in the USVI from 1999 through spring 2005 revealed three sites with statistically significant increases in coral cover, one site decreasing, and three remained the same. During the record-breaking hurricane season of 2005, no storms came within 75 miles of the USVI and water temperatures reached record-warm levels, triggering massive coral bleaching (>90% coral cover bleached). Annual monitoring was accelerated to bi-monthly to quarterly at five of the seven sites and showed corals began regaining color as water temperatures cooled (October 2005). However, a subsequent, catastrophic outbreak of coral disease, primarily white plague, led to a 51-fold increase in number of disease lesions and a 12.6-fold increase in the area killed by disease when compared to pre-event levels. Above normal disease levels were observed from September 2005 to July 2006. Surviving corals remained partially bleached throughout this time as water temperatures returned to 'normal'. Coral diseases were found on 19 species, over depths ranging from 3.7m to 18.9m. Statistically significant declines occurred in coral cover of most species with several decreasing over 50% (e.g., *Montastraea annularis* complex, *Colpophyllia natans,* and *Agaricia agaricites*). Mean coral cover at the seven sites declined an average of 47.3% (range: 34.1% – 61.8%) in 12 months; and 56.3% in 24 months. Coral cover at the South Fore Reef site in Buck Island Reef National Monument declined 79.3% in just two years (19.8% to 4.1%).

## 7.164

**Status Of Coral Reef Diseases And Decline Of Coral Reefs in Puerto Rico**

**Ernesto WEIL*[1]**, Aldo CROQUER[2], Emmanuel IRIZARRY[1], Kathleen FLYNN[1], Isabel URREIZTIETA[1]

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico, [2]Department of Marine Sciences, University of Puerto Rico, lajas, Puerto Rico

Infectious diseases and bleaching have become major players in the decline dynamics of coral reefs in Puerto Rico and the Caribbean. A Nested design and well stablished sampling protocols were used to assess spatial and temporal variability in number and distribution of diseases, prevalence, host range, rates of advance and impact on corals, octocorals, sponges and crustose coralline algae (CCA). Six reefs have been surveyed since 1999, nine reefs were surveyed twice a year since 2003 in La Parguera, sixteen reefs were surveyed island-wide during the summer-fall of 2005-06 and at least 20 other reefs have been qualitatively surveyed over the years. Overall, 21 diseases/syndromes have been identified in scleractinian corals (11), octocorals (4), zoanthids (2), sponges (2) and CCA (1). Intensive bleaching events in 1998-99, 2003 and 2005 affected increasing numbers of taxa producing differential mortalities in crustose octocorals, zoanthids, hydrocorals and some corals. One black band, two patchy necrosis, three white plague (WP-II), and ongoing yellow band, aspergillosis and crustose-coralline white band epizootics have produced significant tissue and colony mortalities over the last ten years. White band keeps killing newly growing colonies of A. cervicornis. The most important reef-building genera (Montastraea, Acropora, Diploria, Siderastrea, Colpophyllia, Stephanocoenia and Millepora) have been the most affected. Reefs off La Parguera Natural Reserve lost 53% of their coral cover in the last 4 years.Similar losses occurred in other areas. Epizootics and disease prevalence varied significantly (<1% – 33%) across small (habitats and reefs) and geographical spatial scales and over time. Prevalence of YBD in Montastraea increased significantly (<1% to 45%) in some reefs since 1999. Together with increasing coastal degradation and global warming, diseases seriosly compromise the potential for recovery of most coral reef communities in Puerto Rico.

Keywords: Coral diseases, prevalence, epizootics, Puerto Rico, reef decline

## 7.165

**Requiem Or Recovery? --Long-Term Effects Of Black Band Disease, *phormidium Corallictum* On Survival Of *montastraea Faveolata* At Looe Key Reef, Florida Keys National Marine Sanctuary, Florida.**

**J. Harold HUDSON*[1]**, Billy D. CAUSEY, PH.D. [2], Jeff ANDERSON[3], Bill GOODWIN[4]

[1]Damage Assessment and Resource Protection, Florida Keys National Marine Sanctuary (Retired), Miami, FL, [2]Southeast Atlantic, Gulf of Mexico and Caribbean Region, National Marine Sanctuary Program, Key West, FL, [3]I.M. Systems Group, Inc., Contractor to Florida Keys National Marine Sanctuary, Key Largo, FL, [4]Damage Assessment and Resource Protection, Florida Keys National Marine Sanctuary, Key Largo, FL

Black band disease was first reported on Florida Reefs by Antonius in 1978. That finding went virtually unnoticed in the scientific community until the summer of 1986, when Billy Causey, then Manager of Looe Key National Marine Sanctuary, discovered a massive outbreak of this pathogen at Looe Key Reef. Dozens of white, plate-sized, infection sites, devoid of live tissue, were observed throughout the reef, mainly on the Mountainous Star Coral, *Montastraea faveolata*. The senior author (then a U.S. Geological Survey employee) was retained under a NOAA contract to assess the magnitude of the outbreak and test possible remedial actions to control the disease. Infection sites on all corals were documented with close-up photography with scale to calculate tissue loss. Several *M. faveolata* were also monitored by placing clear Mylar plastic sheeting over the affected area and tracing an outline of the disease's black boundary band with a grease pencil. Repetitive tracings over the course of the study enabled progressive loss of live tissue on individual corals to be mapped with considerable accuracy. The project began in 1986 and was concluded in 1989 after the black band epidemic had subsided. A remedial treatment was developed in 1987 and used successfully during the study. This report focuses on the Mylar recorded ravages of *P. corallictum* on a 2 m high *M. faveolata* during the outbreak, and after 21 years, the cumulative effects of massive tissue loss and bioerosion on survival and regrowth in this species.

## 7.166

**Rapid Coral Reef Decline in The Southwest Coast Of Puerto Rico.**

**Ernesto WEIL*[1]**, Emmanuel IRIZARRY[1], Aldo CROQUER[2], Isabel URREIZTIETA[1]

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico, [2]Department of Marine Sciences, University of Puerto Rico, lajas, Puerto Rico

Fast degradation of coral reefs due to bleaching and infectious diseases is a recent Caribbean problem. Impact of diseases and bleaching was assessed in 9 reefs in La Parguera Natural Reserve, southwest coast of Puerto Rico between 2003 qnd 2007. Live coral cover and abundances were estimated in six 1m² quadrats randomly distributed along each of four 20m long transects in each of four depth intervals (N=96) in each of 3 inshore and 3 mid-shelf fringing reefs, and at one deep habitat (>15m) in 3 shelf-edge bank reefs in 2003 and 2007. Disease prevalence was estimated using the CARICOMP protocol along 20m² band transects in the first 10m of the same transects. Two bleaching events, three white plague (WP-II), two patchy necrosis and ongoing yellow band (YBD), aspergillosis and crustose-coralline (CCA) white band outbreaks occurred during this period. Outbreaks were differentially distributed across depths and reefs and over time. Strickinly, reefs off La Parguera lost an average 53% (40 – 65%) of live coral cover in four years. Media Luna and Turrumote, two well developed mid-shelf fringing reefs dominated by large, abundant M. faveolata and M. franksi colonies lost 65 and 57% coral cover respectively. Similarly, off-shore Weimberg and Buoy bank reefs dominated by the same species lost 52.5 and 52.3% coral cover. Mid-shelf and shelf-edge reefs (2 and 8 km from shore respectively) lost significantly higher coral cover (56.6 ± 6.2 and 55.7 ± 10.1 % respectively) compared to near-shore reefs (48.8 ± 7.7 %). Coral cover losees in deep habitats were mostly produced by WP-II, and by combined outbreaks of WP-II, bleaching and ongoing YBD at intermediate depths. Agaricia and Millepora mortalities were mostly bleaching-related. Ongoing epizootics together with overfishing, increasing coastal degradation and global warming could seriously impair short- and long-term recovery of these reefs.

## 7.167

**How Does Black Band Disease Affect The Benthic Ecology Of Reefs in Los Cayos Cochinos, Honduras?**

**Jonathan SHRIVES*[1,2]**, Martin SPEIGHT[1]

[1]Zoology, University of Oxford, Oxford, United Kingdom, [2]Operation Wallacea, Lincolnshire, United Kingdom

This study investigates Black Band Disease (BBD) incidence and effects upon the reef benthic communities of the Marine National Monument, Cayos Cochinos (MNMCC).

Searches for BBD used 80m x 40m plots at three different sites, representing a spectrum of site quality. The benthic community was analysed using photo-quadrats, and incidence figures were calculated. Colonies displaying BBD were tagged and photographed repeatedly to quantify the progression rate of disease. These same colonies were then re-photographed over the next two years to record colonisation and succession data on the revealed skeletons.

Incidence of BBD in MNMCC is low, with an impacted site showing only 0.1% of hosts infected. The healthiest site had an even lower incidence of BBD at 0.03%. The intermediate site had the highest incidence of BBD at 0.38%. BBD was found to follow linear and asymptotic patterns of progression rate. There is a positive correlation ($R^2$=0.75) between size of BBD band and amount of skeleton rendered bare for colonisation.

Initial conclusions suggest that in MNMCC, infections are not dependent on host abundance or site quality and are not clustered by host distribution. Not all BBD bands progress or behaved in a uniform manner. BBD bands of greater surface area yielded more skeleton for colonisation, though macroalgae were not necessarily the dominant or climax community of post-BBD corals.

## 7.168

**Prevalence Of Coral Disease And Partial Mortality Patterns in Coral Colonies Of Montastraea Annularis, Diploria Strigosa And Siderastrea Siderea in The Back Reef Of Puerto Morelos Q. Roo, Mexico.**

**Miguel MALDONADO*[1]**, Eric JORDAN[2]

[1]Sistemas Arrecifales Coralinos, Universidad Nacional Autonoma de Mexico, Puerto Morelos, Mexico, [2]Instituto de Ciencias del Mar y Limnologia, Universidad Nacional Autonoma de Mexico, Puerto Morelos, Mexico

The partial mortality is a dynamic and fundamental process in modular organism. In coral colonies is induced for natural disturbance, anthropogenic influence and, in general, by extreme environmental change. It is also caused by physiological dysfunction as bleaching and infection pathogens. In this study we explore patterns in the prevalence of signs of disease and the degree of partial mortality in coral colonies of three key species in the Mexican Caribbean: Montastraea annularis (species of this complex). Diploria strigosa y Siderastrea siderea. The survey was conducted in the back reef of a coral barrier within a Natural Protected Area. Four sites were arranged for permanent monitoring. 310 colonies of this species were photographed subdividing their corallum in quadrants. The projected area of corallum and coral tissue was determined by digital analyses of images to estimate size and degree of partial mortality. Montastraea sp presented larger colonies and higher degree of partial mortality, as well as, the increased prevalence of disease. While the prevalence of black-band and white-plague diseases was low a new sign, that we named the thin dark line, had relatively high prevalence in all the sites. The distribution patterns in the prevalence of diseases are related to the distribution of partial mortality in all cases. The size frequency distribution of corallum reflects differences associated with the life history of each species. In Montastraea sp. partial mortality and fission events determine differences between the size structure of corallum and the tissue cover fragments. Using these parameters as indicators of the current status of these species can be concluded that Montastraea sp. face a complex process deterioration that could affect characteristics associated with its life history, such as growth and reproduction.

## 7.169

**A Four Year Fine Scale Record Of A Coral Disease Outbreak in The Marshall Islands**

**Dean JACOBSON*[1]**

[1]College of the Marshall Islands, Majuro, Marshall Islands

An outbreak of coral disease restricted to tabulate Acroporid species (i.e., *A. cytherea, A. paniculata, A. clathrata*, etc.) on Majuro atoll, RMI, has been monitored for four years, from Nov 2003 to 2007, for the purpose of forecasting future mortality. Most infections are restricted to the southern shore of Majuro, where large tables are widely abundant, with smaller "patches" in the northern lagoon near the deep pass and on neighboring Arno atoll, where tables are much more localized. Disease incidence appears to correlate with sources of pollution (solid and human waste) on heavily populated Majuro. Disease signs consist of a straight, uniform front or "white band" of killed issue typically having a 2-4 cm/day spreading rate; the disease nearly always kills the entire colony. Brown band ciliates are found on some infected colonies. Colony-to-colony transmission is common. (A bacterial pathogen was isolated in 2004 by a collaborator, Meir Susseman, and has been shown to be sufficient and necessary to kill coral, overnight, in the laboratory; it was then identified by DNA sequencing as *Vibrio corallilyticum*.) A sensitive sampling strategy for detecting temporal changes in disease incidence (photographic mapping of a large, 20 meters by 110 meters permanent transect, involving 970 colonies, along with a second smaller transect) has revealed pronounced year to year variation (ranging from 3 to 20% coral mortality, by coral surface area). During 2004 the condition of all infected colonies was photographically documented (with size calibration) each week, allowing estimation of spreading rate; this revealed frequent pauses in disease progression. The year-to-year disease variation correlates positively with water temperature; in fact, the two peaks in disease incidence (in 2004 and 2007) both followed episodes of coral bleaching. The relative importance of temperature and water quality will be discussed.

## 7.170

**Coralline Algal Disease in The U.s. Affiliated Pacific Islands**

**Bernardo VARGAS-ANGEL*[1]**

[1]Coral Reef Ecosystem Division, NOAA, Honolulu, HI

Coralline algae are an important component of tropical coral reef systems, representing as much as 30 to 50% of the live benthic cover. On many reefs, the Corallinaceae play a pivotal role as major builders and consolidators of carbonate material. Additionally, encrusting coralline red algae have been implicated in providing essential chemical cues and substrate for coral larval recruitment. Growing consensus pertaining to the threat of increased disease in coral reef ecosystems has focused on scleractinian disease characterization and prevalence. Little is known about coralline algal diseases, distribution, abundance, and the potential implications of declining crustose coralline algal flora. During rapid ecological assessments on 25-m belt transects, coralline algal disease was surveyed at 326 discrete sites at 40 US affiliated Pacific islands/banks/atolls between 2006 and 2007. Five major disease categories were enumerated and disease densities (# cases per 100 $m^2$ of reef area) were estimated. For most locations, where present, disease density exhibited considerable spatial variability. No diseases were observed in the remote Johnston and Wake Atolls, or at Howland, Baker, Jarvis, or Swains Islands. Coralline algal diseases were also absent in the main Hawaiian Islands, and were rare in the Northwestern Hawaiian Islands (< 1 case/100 $m^2$). Conversely, diseases were common in Guam and the Commonwealth of the Northern Mariana Islands (3–10 cases/100 $m^2$). The highest densities of disease were detected in American Samoa (13–28 cases/100 $m^2$) at Tutuila and Ofu-Olosega, respectively, where the coralline lethal orange disease accounted for more than 85% of cases. In contrast, at Kingman and Palmyra Atolls, coralline fungal disease ranked the highest, totaling densities of 2 cases/100 $m^2$. Results indicate a need for further studies on coralline algal disease dynamics, monitoring, and assessment of potential risks to reef building communities.

## 7.171

**Black Band Disease Outbreak in Nikko Bay, Palau**

**Alma RIDEP-MORRIS*[1]**

[1]School of Marine & Tropical Biology, James Cook University, Townsville, Australia

Coral diseases have dramatically increased in recent years and are now recognized as one of the key threats to coral reefs worldwide, having considerable negative impacts on the structure and health of coral reefs. In spite of this awareness, very little is known about the epizootiology and etiology of most coral diseases on Indo-Pacific reefs. To predict the impacts of Black Band Disease (BBD) on the coral reefs of Palau, knowledge of the ecology and dynamics of BBD, particularly the progression and spread of the disease, is critical. The objective of this research is to monitor a BBD outbreak on *Pachyseris speciosa* in Nikko Bay, Palau. Three permanent quadrats ~10mx10m were set up in January 2007. 64 colonies of *P. speciosa* were tagged and photographs were taken of each colony at monthly intervals to gain insights into the spread and mode of disease transmission, to examine seasonal patterns in the abundance of BBD, and to determine the impacts of disease on population dynamics. Temperature, sedimentation and salinity will be monitored to identify environmental drivers of disease. Preliminary results show that the mean rate of progression of BBD across corals is 3mm/day in fast moving bands. Seasonal patterns in rates of linear progression indicate that virulence and mean abundance of BBD are clearly correlated with warm sea surface temperatures (SST), being greatest during the warmer months of May-June when SST reached 29.9ºC (29 cases/100$m^2$; 37% prevalence) and least during the cooler months of January when SST was 28ºC (16 cases/100$m^2$; 20% prevalence). My results show that BBD outbreaks are causing significant mortality on local Palauan reefs, are more likely to occur during warmer summer months, and that assessments of reef health in Palau should carefully consider seasonal variability in BBD abundance.

## 7.172

**The Black Band Disease Of Indonesian Coral Reefs**

**Agus SABDONO*[1]**, Ocky RADJASA[2]

[1]Marine Science, Diponegoro University, Semarang, Indonesia, [2]Center for Tropical Coastal and Marine Studies, Diponegoro University, Semarang, Indonesia

Indonesia is the world's largest archipelagic country with approximately 17,508 islands containing valuable coastal and marine resources such as coral reefs. The majority of Indonesia's 210 million people live near the coast and million of people rely on coral reefs for livelihood. One of the important issues currently related to Indonesian coral reef ecosystems is the disease emergence. One of them is Black Band Disease (BBD).

Black band disease (BBD) is a virulent disease primarily affecting scleractinian corals. Eventhough the BBD bacterial mat is dominated by a cyanobacterium, the quantitative composition of the BBD bacterial mat community has not described previously. The bacterial community associated with black band disease (BBD) of the branching corals Acropora sp. in this study was examined using culture-dependent techniques. A complementary molecular techniques of 16S rDNA genes [amplified 16S ribosomal DNA) was used to give a comprehensive characterization of the community. On the basis of the results of sequen analysis, our data show that BBD1 isolate was closely related with *Myroides odoratimimus (99.0%), BBD2* isolate was Bacillus algicola (99.6%) and BBD3 isolate was Marine *Alcaligenaceae bacterium (96.0%).* Of the three bacteria identified, these were not previously found in other studies. This result will allow the dominant BBD bacteria to be targeted for isolation and culturing experiments designed at interpreting the disease etiology.

Key words: Black Band Disease, Acropora sp., 16S rDNA

## 7.173

**Coral And Crustose Coralline Algae Disease On The Reefs Of American Samoa**

**Greta AEBY*[1]**, Thierry WORK[2], Douglas FENNER[3], Eva DIDONATO[4]

[1]Hawaii Institute of Marine Biology, Kaneohe, HI, [2]USGS, Natl Wildlife Health Center, Honolulu, HI, [3]American Samoa Dept of Marine and Wildlife Resources, Pago Pago, American Samoa, [4]National Park Service, Sullivan's Island, SC

Coral disease is emerging as a problem worldwide. In 2003, a disease outbreak on table acroporids occurred on the reefs of Tutuila, American Samoa and so in June 2004 we initiated disease surveys at seven sites around Tutuila. In February 2005, we re-surveyed the sites on Tutuila and surveyed five stations within Ofu Lagoon. The objectives of this study were to: 1) determine the types, distribution and abundance of disease in reef corals and crustose coralline algae (CCA) on the reefs of Tutuila and Ofu Lagoon; 2) look for seasonal differences in levels of disease; 3) compare levels of disease between the relatively pristine reefs of Ofu Lagoon and the more impacted reefs of Tutuila; 4) systematically describe gross and microscopic morphology of lesions in reef corals and develop a standardized nomenclature for identifying and designating coral disease. Fourteen coral diseases and two diseases of CCA were documented from the reefs of Tutuila. Five coral diseases and one CCA disease were found in Ofu. *Acropora* white syndrome, *Acropora* growth anomalies (GA) and coralline lethal orange disease, were the most common diseases on the reefs of Tutuila whereas *Porites* GA was the most common disease in Ofu. There were no significant differences in overall disease levels between Tutuila and Ofu. No seasonal differences were found in overall prevalence of coral or CCA disease, however, the types and frequency of occurrence of some diseases varied. Histological analyses of coral lesions found that microscopic changes in tissues can be used to distinguish tissue loss due to trauma from changes due to disease. The discoloration indicative of dark spot disease was associated with endolithic hypermycosis. Six distinct types of growth anomalies were seen in *Acropora* and on histology, proliferation of the basal body wall was found to be the hallmark of the disease.

## 7.174

**Coral Disease Prevalence and Dynamics in the Wakatobi Marine National Park, South-East Sulawesi, Indonesia**

**Jessica HAAPKYLA*[1]**, Adrian S. SEYMOUR[2], David SMITH[3]

[1]School of Marine Biology and Aquaculture, James Cook University, Townsville, Australia, [2]Operation Wallacea, Spilsby, United Kingdom, [3]Coral Reef Research Unit, University of Essex, Colchester, United Kingdom

A study on coral diseases was conducted in 2005 and 2007 in the Wakatobi Marine National Park (WMNP), South-East Sulawesi. This first study on coral diseases in the area aimed to investigate coral disease prevalence and coral health in this remote area situated in the center of the world's biodiversity hotspot.

Three replicates of 20x2 m belt transect were used at three reef zones at five sites across a diversity gradient. Results indicate a decrease in disease prevalence from 0.57% in 2005 to 0.24% in 2007. In 2005, only two known syndromes occurred within the sampling unit, white syndrome (0.42%) and tumours (0.15%). An increase in the number of diseases was observed in 2007 but their prevalence remained very low: white syndrome (0.14%), *Porites* ulcerative white spot disease (0.06%), tumours (0.03%) and black band disease (0.01%). The most common lesions in 2005 were previously undescribed conditions (9.7%) compared to only 0.6% in 2007. Pigmented responses, which are thought to be a common coral stress sign decreased from 3.99% in 2005 to 2.47% in 2007. In 2007 they were significantly more common in the degraded site than in other sites. The impact of these lesions on coral health is unknown and represents an important area for future studies.

The results of this study highlight the low disease prevalence in the area. However, the transect method used may have left localized disease outbreaks unnoticed. To better understand the role of coral diseases in the area, prevalence studies in the warm season when the water temperature is approximately 5 °C warmer should be conducted. Higher water temperatures may increase disease prevalence and, due to climate change, coral disease outbreaks may threaten coral populations in the future in this area.

## 7.176

**Preliminary Results On Coral Disease Prevalence in East Africa**

**Mohammed MOHAMMED*[1]**, Narriman JIDDAWI[1]

[1]Institute of Marine Sciences, University of Dar es salaam, Zanzibar, Tanzania

Coral reef ecosystems are among the most diverse and most productive in the marine environment, being compared only with terrestrial rain forests. Besides its richness and the benefits it provides it is increasingly becoming threatened by natural and human induced factors. Incidences of coral bleaching caused by global warming, coral diseases outbreaks and crown of thorn starfish infestation have increased in the last few decades, threatening well being of reef systems. Prevalence of coral diseases have been investigated on Bawe, Chumbe and Kizimkazi reefs in Zanzibar Island by using 2x20m belt transect at 2-5m and 6-9m depth profiles. Preliminary results show that 83% out of 3142 coral colonies surveyed are on healthy condition. 7.4% are being smothered by algae, 2.4% show signs that resemble ulcerative white spots disease, 1.3% has pigmentation response.3.2% showed unknown dead band. Other diseases that were found at very low prevalence < 1% are unusual bleaching patterns, reddish colouration patch on *Porites*, black band disease, tumors, coral overgrown by corallimopharians, worms and predation scars. Preliminary results show disease prevalence on surveyed reefs is very low; however, long term monitoring is required over a wider area so as to have a comprehensive knowledge of the disease prevalence in the region.

## 7.177

**Impact Of Aspergillosis On The Reproduction Of The Sea Fan Gorgonia Ventalina**

**Kathleen FLYNN*[1]**, Ernesto WEIL[1]

[1]Department of Marine Science, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico

There is little information on the impact of the fungal disease aspergillosis on the reproductive biology of the sea fan *Gorgonia ventalina*. Histological techniques were used to assess the normal reproductive cycle of the species and compare healthy and diseased colonies. Once a month for twelve months, tissue samples were collected from the central area of healthy colonies (n=17), and from the dark-purple, actively diseased area (ADA), the transition area (TA) immediately adjacent to the ADA and the healthy looking area (HA; >10cm from ADA and the edge) of each of five diseased colonies. Twenty polyps from each histological sample were randomly selected and the presence of eggs and/or spermaries was noted. *G. ventalina* is gonochoric and reproductive colonies were found year-round. Healthy colonies peaked in the number of reproductive polyps from fall to early spring with male colonies peaking later than females (G-tests, $p<0.05$). However, HA areas of diseased colonies had more reproductive polyps in the summer and fall with the fewest in the winter (G-tests, $p<0.05$). There was a significant decrease in the overall number of reproductive polyps between healthy colonies (41%) and HA areas of diseased colonies (34%). The number of reproductive polyps also significantly decreased between HA, TA (12%) and ADA (4%) areas in diseased colonies. Healthy female colonies had a higher number of eggs per polyp in winter months than summer months, while the opposite was true of HA females (Kruskal-Wallis, $p<0.001$). The number of eggs per polyp was higher in healthy colonies than in HA samples except in the summer months. These results indicate that aspergillosis severely affects the fecundity of *G. ventalina* which could reduce recruitment and survivorship of populations affected by the disease with potential ecological and evolutionary consequences.

## 7.178

**Seasonality Of Halofolliculina Sp. Infections in Acropora Palmata At Los Roques National Park, Venezuela**

**Sebastian RODRIGUEZ*[1]**, Carolina BASTIDAS[1], Aldo CROQUER[2]

[1]Universidad Simon Bolivar, Caracas, Venezuela, [2]Universidad de Puerto Rico, Mayaguez, Puerto Rico

Ciliates in the genus Halofolliculina have been recently observed affecting Caribbean corals, and infection signs suggest that ciliate are related with coral mortality in more than 26 scleractinian corals. However, the relationship between ciliate infections and the loss of tissue in their corals hosts, and the epizootiological parameters of ciliate infections have not been described so far. In this study, the seasonal variability of epidemiological parameters of ciliate infections (CI) were investigated in Acropora palmata populations, under the overall prediction that these infections will (1) harm corals and (2) that the epizooetiological parameters (prevalence, incidence, recovery and virulence) will be more harmful for it hosts in warmer than in coolest months. Sampling program spanned three sampling times (roughly 60 d apart) at each of two seasons (warmer vs. coolest), and two zones (~1 km apart) at each of two sites (~10 km apart). Ciliate infections produced tissue mortality in all colonies, showing a dark cluster of sessile ciliates between living tissues and recently-exposed coral skeleton on the 143 colonies studied (8-12 colonies per zone and sampling). Virulence varied among seasons, showing the highest rate of tissue mortality in summer (2.6±1.5, n=64 cm.mes-1), when doubled that of winter (1.2±0.6, n=64 cm.mes-1). Prevalence, incidence and recovery rate showed their higher variability among sampling times; the highest values of prevalence and incidence of CI (25%, 5.2%, respectively) ocurred on the third sampling of warmer season, when incidence rate showed the lowest values (4%). Interestingly, CI prevalence and incidence increased after the highest prevalence of White Diseases (WD), suggesting that poorly conditions of the host, like the presence of lesions or other diseases, can increase coral susceptibility to CI. Although CI was much more harmful for corals during warmer months, the process and mechanisms that promote this rise of infection severity remain unknown.

## 7.179

**Physiological Effects Of Aspergillosis in A Gorgonian From Bermuda**

**Lisa RODRIGUES*[1]**

[1]Geography & the Environment, Villanova University, Villanova, PA

Lipids and other energy reserves (i.e., carbohydrates and protein) are often utilized by scleractinian coral species to survive and recover from coral bleaching events. As a significant energy store in corals, lipids may be important in surviving other stressful events, including disease. The importance of lipid stores to diseased corals has not been previously investigated and may provide evidence of disease resistance or coral recovery. Aspergillosis, a disease caused by the fungus, *Aspergillus sydowii*, has impacted gorgonian populations throughout much of the Caribbean, including Bermuda. Visibly diseased and healthy samples were collected from *Gorgonia ventalina* colonies from a near-shore reef in July 2007. Healthy samples were also collected from *G. ventalina* colonies from an off-shore reef location, where there was no visible incidence of disease on the reef. The proportion of purpled sclerites was measured for each sample and verified the severity of disease for each colony. Diseased sections of *G. ventalina* have lower lipid concentrations than healthy sections of the same colony, suggesting that lipid stores are selectively utilized within each colony. Interestingly, healthy sections of near-shore colonies where disease was present have more lipid stores than healthy sections of off-shore colonies where disease was absent. These preliminary results suggest that consumption of lipid stores may be a species-wide physiological strategy amongst corals for coping with stressful events.

## 7.180

**International Registry of Coral Pathology**

**Shawn MCLAUGHLIN*[1]**, Dorothy HOWARD[1], Kathy PRICE[2], Cheryl WOODLEY[3]

[1]Cooperative Oxford Laboratory, NOAA National Ocean Service, Oxford, MD, [2]None, Stevensville, MD, [3]Hollings Marine Laboratory, NOAA National Ocean Service, Charleston, SC

An International Registry of Coral Pathology (IRCP) has been established by NOAA at Cooperative Oxford Laboratory in Oxford, Maryland, USA to serve as a research tool and resource of voucher materials for the coral research community. Diseases of coral have increased significantly in frequency and distribution over the last decade; however, the etiologies of many coral diseases remain unknown. An important function of the coral registry is to facilitate the sharing of histology materials and related information among coral pathologists worldwide to better understand causes and mechanisms of coral disease. More than 2500 specimens of healthy and diseased scleractinian and soft corals representing over 30 species from 20 geographic locations have been accessioned into a collection of nearly 8000 microscope slides. This unique resource provides coral researchers the opportunity to routinely apply histopathology techniques to new coral health investigations and to examine tissues and related data collected in earlier investigations by other researchers. Further, IRCP in collaboration with the Coral Disease and Health Consortium is using this resource to develop a collection of virtual histology slides. This technology provides a high resolution digital image of an entire glass slide that can be viewed, scanned, zoomed, and annotated on a computer individually or via web conferencing groups. Virtual slide technology allows educators, experts, and students to view microslides across the internet using web browsers enabling distance learning, 'grand rounds among pathologists' and case reviews. IRCP collaborates with coral researchers in disease investigations, participates in responses to coral mortality events, conducts research on coral histology techniques, and provides training in histological techniques to researchers and students. Information gained from utilization of IRCP products is useful to managers, researchers, and students and provides insights into the causes and mechanisms of coral disease and the measures needed to preserve and protect coral reef ecosystems.

## 7.181

**Distribution And Morphology Of Growth Anomalies in Acropora From The Indo-Pacific**

**Thierry WORK*[1]**, Greta AEBY[2], Steve COLES[3]

[1]National Wildlife Health Center, US Geological Survey, Honolulu, HI, [2]Hawaii Institute of Marine Biology, University of Hawaii, Kanehoe, HI, [3]Zoology, Bishop Museum, Honolulu, HI

We assessed the distribution and prevalence of growth anomalies (GAs) in Acropora from French Frigate Shoals (Hawaii), Johnston Atoll, and Tutuila (American Samoa), developed a nomenclature for gross morphology, characterized GAs at the cellular level, and obtained preliminary indices of their spatial patterns and progression within coral colonies. Acropora GAs were found in all three regions, but the distribution and prevalence of Acropora GAs was highest in American Samoa. GAs were grouped into 7 gross morphologies (exophytic, bosselated, crateriform, nodular, vermiform, fimbriate, or annular). On histology, GAs consisted of proliferating basal body wall (calicodermis, mesoglea, and gastrodermis apposed to skeleton) with three distinct patterns of necrosis. There was no evidence of anaplasia or mitotic figures (common but not necessarily required morphologic indicators of neoplasia). Compared to normal tissues, GAs had significantly fewer polyps, zooxanthellae within the gastrodermis of the coenenchyme, mesenterial filaments, and gonads but significantly more necrosis. On two colonies with GAs monitored at two points over 11 months, numbers of GAs per colony increased from 90 to 300%, and significant clustering of GAs occurred within colonies. The evidence of GAs being true neoplasias (tumors) is mixed, so a cautionary approach is urged in use of morphologic terminology.

## 7.182

**Description Of New Putative Coral Diseases Infecting Corals in The Tropical Eastern Pacific.**

**Raul NAVAS-CAMACHO*[1]**, Alberto RODRÍGUEZ-RAMÍREZ[1], Diego GIL-AGUDELO[2]

[1]Biodiversity and Marine Ecosystems, Instituto de Investigaciones Marinas y Costeras INVEMAR, Santa Marta, Colombia, [2]Conservation Biology and Strategies, Instituto de Investigaciones Marinas y Costeras INVEMAR, Santa Marta, Colombia

The first report of coral diseases in the tropical eastern Pacific (TEP) took place by the end of 1990´s in the Island of Malpelo, an oceanic island located almost 400 Km from the nearest point in continental Pacific coast of Colombia. Almost ten years later, the number of diseases affecting the TEP, their characteristics, occurrence and incidence, continue to be less studied than those in Caribbean or Indo-Pacific reefs. Recently, our research group performed the first survey of coral diseases in the area, determining the occurrence of at least two putative diseases affecting *Pocillopora capitata*, and their extent of damage on the reefs of Malpelo Island. Both diseases have a low spreading rate, no more than a couple mm per week, one of them progressing towards the tip of the branch while the other progresses towards the center of the colony. Although the incidence of these diseases in considered low, their presence in the area is intriguing, due to the geographic isolation, the small human presence and the absence of pollution sources. Beside coral diseases, recordings of coral tumors and a possible coralline algae disease were also performed in the area. These coral and algae alterations in these reefs are a major cause of preoccupation, since these coral formations are isolated, with little connectivity with other reefs and a major disease outbreak can cause massive loss of coral cover, with little possibility of recuperation.

## 7.183

**Identifying Potential Pathogens Of *montipora* White Syndrome Through Microbial Community Profiling**

**Ashley SMITH*[1]**, Teresa LEWIS[1], Greta AEBY[1], Thierry WORK[2], Jo-Ann LEONG[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, [2]USGS-BRD-NWHIC, Honolulu, HI

*Montipora* White Syndrome (MWS) is a tissue loss disease that affects the common reef coral, *Montipora capitata*, in Kaneohe Bay, Oahu Hawaii. This disease was first identified in the main Hawaiian Islands in 2004 and is the target of an investigation characterizing MWS using field, histology and molecular microbiological techniques. The objective of this component was to identify the bacterial communities in healthy and diseased *Montipora capitata* to establish a baseline for further experiments. Serial dilutions of coral mucus were plated on Glycerol Artificial Seawater (GASW) and Thiosulfate Citrate Bile Sucrose (TCBS) media to determine CFU/ml of culturable bacteria as well as relative abundance of *Vibrio* spp. Colony count data revealed an average 1.6 x103 CFU/ml of mucus in healthy fragments whereas mucus collected from the diseased front had 2.0 x104 CFU/ml. Comparison of samples from healthy and MWS samples revealed a five-fold increase of *Vibrio* spp. in the MWS samples, from an average 0.546% increasing to 2.67% *Vibrio* spp. respectively. Molecular analysis of 16S rDNA from individual colonies provides bacterial community profiles from healthy and diseased *Montipora* mucus samples. Uncultured bacteria from mucus have been identified by analysis of clone libraries. Based on these profiles, potential pathogens will be selected for challenge experiments with *Montipora capitata* fragments in an attempt to induce MWS.

Research support funded by NOAA HCRI-RP #NOA06NOS4260200

## 7.184

**The Unknowns in Coral Disease Identification: An Experiment To Assess Consensus Of Opinion Amongst Experts**

**Edward HIND*[1]**, Alasdair LINDOP[1]

[1]Marine Science and Technology, Newcastle University, Newcastle upon Tyne, United Kingdom

This is not the normal format for an abstract submission. This is a request to perform an actual experiment at the upcoming 11th ICRS. As postgraduate students fairly new to the subject of coral disease we were amazed in a recent seminar on identification of these diseases at how hard it was to visually identify what the diseases were with certainty. We asked the question of more senior academics and they confirmed that there is still much debate in circles of expertise over actual identification. This intrigued us and further study showed us that there was very little study on these potential uncertainties. We were thus enthused to undertake a study ourselves. We conferred with the ICRS scientific organisers and in particular those organising the coral disease mini-symposium and believe a poster presentation would be an excellent format for undertaking this research. Instead of portraying any results the poster would have large pictures of approximately twenty coral assemblages with disease, lesions or damage. We would then ask passing experts at the conference a few questions about their experiences with coral diseases before getting them to assess the pictures on the poster. The questions would be asked via an anonymous hard copy questionnaire. We would not be looking for correct answers as such, but for the level of agreement between respondents. The high volume of potential respondents with expert knowledge at the ICRS would allow for statistically significant results to be derived. We would look to publish these results to advance understanding in coral disease research.

## 7.185

**A Gall-Forming Copepod Causes Localized Bleaching Of The Coral Porites**

**Hideyuki YAMASHIRO*[1]**

[1]Bioresources, Okinawa National College of Technology, Nago, Japan

I found a small circular white spot on the surface of a coral *Porites* spp. on the reef flat of Okinawa Japan. This white spot resembles its color and size in PUWS (Porites Ulcerative White Spot Syndrome) reported from Philippine. However the white spot observed in Okinawan *Porites* was not PUWF disease, and found that a copepod *Xenomolgus varius* lives in the skeleton under the spot (Hoi and Yamashiro (2007). *X. varius* was found from the formalin-washout of the coral *Porites* in Mauritius (Humes and Stock, 1973) and it has not been unclear where this species live. The individuals situate in the skeleton and the head is set upward. Coral soft tissue has a small hole, through which they may get something and release larvae. The present study is to elucidate the reason why the copepods bleach coral tissue. To observe the relationship between copepod and symbiotic algae, histological sections were made. Furthermore the gut content of the copepod was investigated with a fluorescent microscope. This parasitic copepod did not affect coral reproduction. Observation showed that the copepod eats symbiotic algae of the host coral. To get sufficient food, they must need culture algae around them under dim light. The copepods have to inhibit the growth/photosynthesis of upper symbiotic algae as a curtain, because they need much sunlight for lower algae as a food. This cryptic copepod has highly organized strategies; transformation of the coral skeleton to live in, inhibition of symbiotic algae to uptake sunlight and culture. Although the effect of copepod inhabitation on host coral seems not to be serious at present, continuous monitoring is needed.

## 7.186

**The Infection Of A Parasitic Copepod, Xarifia Obesa On Corals**

**Ming-Jay HO*[1]**, Yu-Rong CHENG[1], Chang-Feng DAI[1]

[1]Institue of Oceanography, NTU, Taipei, Taiwan

86 species of xarifiids in four genera have been discovered associated with corals. They are widely distributed in the tropical Indo-Pacific region with an apparent absence from the central and eastern Pacific. To date, xarifiids have been known to live in the gastrovascular cavity of polyps of both hermatypic and ahermatypic scleractinians. However, how do xarifiids establish their association with corals and what do they consume are still unknown. When studying the parasitic copepods on corals from Taiwan, we observed the behavior of *X. obesa* by re-infecting it to a pocilloporid coral, *Stylophora pistillata*. The extension of coral tentacles were induced gradually when *X. obesa* was approaching a coral polyp. This phenomenon suggests that the xarifiids may be immuned to the nematocysts of corals and release some chemicals resulting in the relaxation of coral polyps. In addition, we also observed *X. obesa* with many zooxanthellae cells and pigments inside its body. It suggests that the xarifiids may consume zooxanthellae in addition to coral mucus. This may further induce negative effects to corals particularly when corals are under environmental stresses of bleaching.

## 7.187

**Characterizing Surface Microorganism Diversity In Healthy And Diseased *Gorgonia Ventalina* With Universal 16S Rdna Primers.**

**Jason MACRANDER*[1]**

[1]University of Puerto Rico-Rio Piedras, San Juan

Over the past three decades there has been an increase in the severity of coral diseases. Throughout the Caribbean *Gorgonia ventalina* are suffering from a disease called Asprogillosis. Recent discoveries in coral microbiology have emphasized great diversity in coral surface-dwelling microorganisms and their possible roles in pathogen defense. The diversity of microorganisms on corals may allow for rapid adaptation and selection for the most beneficial microbial communities in the surface mucopolysaccharide layer. The aim of this study is to characterize diversity of surface dwelling-microorganisms found on *G. ventalina* using non-culture PCR methods. Tissue samples were collected from an equal number of healthy and diseased specimens from 3 coral reefs in waters surrounding Puerto Rico. The initial screen for bacterial communities was derived using 16S rDNA primers in PCR. The sequences were subjected to BLAST and compared with species (or closest related species) found in the NCBI sequence database. The initial screening indicates tremendous diversity of bacteria present on *G. ventalina* surface. Currently I am comparing derived bacterial communities from these results between healthy and diseased specimens. These results may aid in the identification of bacterial communities which are prevalent in healthy and diseased *G. ventalina* in waters surrounding Puerto Rico. I am also using microsatellites in genotyping coral specimens to see if there is a correlation between relatedness and bacterial communities. In the future I hope to use additional molecular markers (AFLPs) to reinforce genotyping and explore possible sources of innate immunity to assist our understanding of coral disease resistance. Results from this study will aid in our understanding of coral defense against disease and serve as a model for other species.

## 7.188

**Ultrastructural And Histological Analysis Of Dark Spot Syndrome (Dss) in *siderastrea Siderea* And *agaricia Agaricites***

**D. Abigail RENEGAR*[1]**, Patricia L. BLACKWELDER[1,2], Deborah J. GOCHFELD[3], Alison L. MOULDING[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania, FL, [2]RSMAS, University of Miami, Miami, [3]National Center for Natural Products Research, University of Mississippi, University, MS

Dark Spot Syndrome (DSS) typically manifests in scleractinian corals as lesions of varying color, size, shape and location that can result in tissue death and skeletal changes. A causative agent has not yet been identified. The objective of this study was histological and ultrastructural investigation of the cellular and skeletal characteristics of DSS affected and healthy *Siderastrea siderea* and *Agaricia agaricites.* The greater resolution possible with transmission (TEM) and scanning (SEM) electron microscopy can reveal microbial activity and initial tissue changes not resolvable utilizing histology. Preliminary results indicate that DSS affected tissue has less integrity, with increasing cellular degradation and vacuolization. The zooxanthellae population was in decline, characterized by abnormal or necrotic cells with internal organelle disruption and debris. A high concentration of electron dense inclusions, believed to be zymogen granules based on morphology and staining properties, was concentrated in the calicodermis and adjacent gastrodermal layer. Numerous fungal cells, dimensionally and morphologically consistent with the genus *Aspergillus,* were observed directly beneath the tissue in close proximity to the calicodermis in all of the DSS affected samples. Skeletal changes observed included darkened areas of skeleton both directly beneath dark spots in the tissue and some distance beneath the coral surface. Further histological and ultrastructural analyses are currently being performed.

## 7.189

**Characterization of Microbial Communities Associated with Black Band Diseased Corals by Targeting the 16S rRNA and DsrAB Genes**

Raju SEKAR[1], Longin KACZMARSKY[1], **Laurie RICHARDSON*[1]**

[1]Department of Biological Sciences, Florida International University, Miami, FL

Black band disease (BBD) is a polymicrobial disease affecting both scleractinian and gorgonian corals on a worldwide basis. The causative agent for BBD has not yet been identified although several bacteria and cyanobacteria have been proposed as pathogens. We have been using 16S rRNA gene analysis to characterize microbial communities associated with healthy surface mucupolysaccharide (SML) and BBD microbial mats of various coral hosts such as *Sidereastrea siderea*, *Diploria strigosa* and *D. clivosa* collected from Bahamas, Florida Keys and St. Croix. Our earlier studies showed that the microorganisms associated with BBD were very different with higher microbial diversity compared to those in the SML. Seven clone libraries constructed from BBD samples of *S. siderea* from these regions showed the α-proteobacteria to be abundant in all the clone libraries followed by the γ- and δ-proteobacteria, bacteroidetes and firmicutes. The clone libraries constructed using BBD samples of the second coral host *D. strigosa,* showed a very different pattern of microbial communities. The clone libraries were dominated by ε-proteobacteria and α-proteobacteria followed by γ-proteobacteria, firmicutes and δ-proteobacteria. A clone library constructed from the third, host *D. clivosa,* showed that the α-proteobacteria were dominant followed by firmicutes, cytophaga-flavobacterium, and γ-proteobacteria. The microbial diversity varied highly with coral hosts and regions. Many sequences of bacteria involved in the sulfur cycle were observed in the clone libraries. Earlier studies discussed the involvement of sulfate-reducing bacteria (SRB) and sulfide-oxidizing bacteria (SOB) in BBD pathogenesis. We are currently analyzing BBD samples from various host species by targeting the dissimilative sulfite-reductase (DsrAB) gene to assess the diversity of SRB and SOB, and are using fluorescent in situ hybridization (FISH) to determine the abundance and distribution of these bacteria in BBD.

## 7.190

**Molecular Analysis Of Bacteria Associated With Healthy And Yellow-Band Diseased Montastraea Faveolata**

**Joel THURMOND*[1]**, Weil ERNESTO[2], Kim RITCHIE[1]

[1]Mote Marine Laboratory, Sarasota, FL, [2]University of Puerto Rico, Mayaguez

Caribbean Yellow Band Disease (YBD) is a blotching and band disease that affects three species in the major reef-building coral genus *Montastraea* in the wider Caribbean. The microbial community associated with corals is dynamic and adapts to varying states of health, stress and disease. Although *Vibrios* are implicated in disease in this coral, assessment of microbial community shifts from healthy to diseased states have not been addressed using culture independent methods. In this study we used both denaturing gradient gel electrophoresis (DGGE) and terminal restriction fragment length polymorphisms (T-RFLP) to assess the microbial community structure of healthy and diseased *Montastraea faveolata* colonies. Genomic DNA was extracted from the surface mucus and tissue of five YBD colonies, five healthy regions of the same diseased colonies, and five entirely healthy colonies collected from a coral reef in Puerto Rico. The T-RFLP method was performed using restriction enzymes *Cfo*-I, *Msp*-I and *Rsa*-I and elucidates community structure differences between healthy and YBD-diseased corals. In addition, a nested PCR-DGGE method was performed using primers specific to different bacterial groups. Analyses indicate the PCR-DGGE method is able to reveal specific profiles within the microbial community. In one example, a sulfate-reducing bacterial population shows increasing diversity from the healthy to diseased state.

## 7.191

**A survey of Vibrios associated with healthy and Yellow Band Diseased Montastraea faveolata**

**Ross CUNNING*[1]**, Joel THURMOND[1], Garriet SMITH[2], Ernesto WEIL[3], Kim RITCHIE[1]

[1]Mote Marine Laboratory, Sarasota, FL, [2]University of South Carolina at Aiken, Sarasota, FL, [3]University of Puerto Rico, Mayaguez

Bacteria of the genus *Vibrio* have been implicated in coral bleaching as well as coral diseases, including Caribbean Yellow Band Disease (YBD). Four *Vibrio* species have been previously identified as causative agents of YBD through a series of infection and reisolation experiments. The mechanisms of pathogenesis and the dynamics of the *Vibrio* community, as a whole, during YBD infection are poorly understood. In order to establish a more comprehensive understanding of the dynamics of *Vibrios* in coral health and disease, a survey of *Vibrio* species associated with healthy corals and YBD-infected corals was conducted using both a culture-based approach and *Vibrio*-specific DGGE analysis. Fragments were collected from YBD lesions of five colonies of *Montastraea faveolata*, five healthy regions of the same diseased colonies, and from five entirely healthy colonies. In the culture-based approach, YBD samples were serially diluted and plated onto TCBS agar to differentially select for *Vibrio* species. Colonies were subcultured using GASWA media and 364 isolates were identified by 16S rDNA sequence analysis. Sequences were aligned using CLUSTAL X and dendograms using neighbor-joining method were constructed for each sample. Phylogenetic analysis of *Vibrio* spp. community composition among healthy and diseased coral states illustrated a shift from *V. fortis* dominating in healthy corals to *V. harveyi/alginolyticus* dominating in diseased corals. There was a similar shift to *Photobacterium rosenbergii* as corals progressed to diseased states. Bacteria similar to 3 of 4 *Vibrios* implicated in YBD were isolated for future studies.

## 7.192

**Apoptosis in White Band Disease Of *acropora Palmata* And *a. Cervicornis***

**Eric BORNEMAN*[1]**, Amy SATER[1]

[1]Biology and Biochemistry, University of Houston, Houston, TX

There are a number of coral diseases with gross signs manifested by a loss of coral tissue leaving an area of white skeleton where denuded coral tissue has been lost, collectively known as white syndromes, and where the etiologies remain uncertain. White band disease (WBD), putatively believed to only affect Caribbean acroporids, was the first white syndrome of corals that profoundly impacted coral reefs throughout the Caribbean. Until the early 1980s, Caribbean reefs were dominated notably by the two major hermatypic species of *Acropora*. Outbreaks of WBD have been the principal cause of mortality in these species throughout the Caribbean region in the past two decades and have resulted in local extirpations and the loss of approximately 95% of the populations. In 2006, the Caribbean acroporids were the first corals to receive protection under the U.S. Endangered Species act.

Despite thirty years of research and the continued presence of WBD on existing remnant stands and isolated colonies, only tentative causal links have been proposed and no pathogen has been conclusively identified. Using samples spanning thirteen years and by sampling varying populations throughout the Caribbean, WBD colonies have an indicative molecular signature of apoptosis as the mode of coral tissue death. Colonies may or may not have abnormal biotic components associated with them and these can vary in space and time. The signature of apoptosis in WBD of Caribbean acroporids is in agreement with gross signs and diagnoses of similar disease reported in Pacific acroporids, as well as in other species. Truly healthy corals have a very low baseline level of apoptotic cells and gross signs from field observations do not necessarily allow for accurate assessments of coral health. Caribbean WBD appears to be a suite of diseases with many potential causes manifested by similar gross signs of disease.

## 7.193

**Inoculation Of Vibrio Spp. Onto Montastraea Faveolata Fragments To Determine Potential Pathogenicity**

**Ernesto WEIL*[1]**, Kim RITCHIE[2], Garriet SMITH[3]

[1]University of Puerto Rico, Mayaguez, [2]Mote Marine Laboratory, Sarasota, FL, [3]University of South Carolina at Aiken, Aiken, SC

Vibrio strains previously isolated from yellow band diseased Montastraea faveolata in Puerto Rico were combined into phylogenetically similar groups (P1, similar to V. campbelli; P2, similar to V. splendidus and P3, similar to Photobacterium rosenbergii). Bacterial groups were inoculated onto healthy Montastraea faveolata colony fragments that were aerated in individual plastic containers exposed to two temperature regimes (28ºC and 31ºC). Ten fragments of the same clone were divided into two groups and five fragments from each group were maintained at either 28ºC or 31ºC. Three fragments were inoculated with bacterial groups P1, P2, or P3, and two were used as delivery medium or water/container controls. Corals were monitored for ten days. After Day 1, two fragments inoculated with P1 and maintained at 31ºC showed signs of yellowing tissue similar to initial stages of yellow band disease. Three fragments inoculated with P2 and held at 28ºC showed similar signs of paling to yellowing tissue. Two additional fragments showed signs at Day 2 (P1 and P2 at 28ºC). At Day 5, two more P1 inoculated fragments showed disease signs (one at 31ºC and one at 28ºC). These preliminary results indicate that more than one type of Vibrio sp. may be able to initiate signs of disease and/or bleaching.

## 7.194

**Incidence and Etiology of Diseases Affecting Massive *Porites* in Negros Oriental, Philippines**

Satoshi YAMAZAKI[1], **JB TANANGONAN*[1]**

[1]Dept.of Environmental Management, Kinki University (Japan), Nara, Japan

Field observations of diseases affecting massive *Porites* in coral reefs near the southern coast of Negros Oriental, Philippines were conducted in February 2006 and in September 2007. Corals found to have disease symptoms were marked with floats to identify for latter observation. A total of 103 *Porites* colonies were observed and 82% were found to have *Porites* ulcerative white spot (PUWS), 15% have tumors, 2% have white syndrome, and 1% showed "pigmentation response" ("pink line disease"). More than 50% of the colonies were found to have PUWS in an early stage that were not serious enough to cause mortality of the coral colony. Corals found to have tumors affected less than 40% of the total surface area of the colony. The polyps in the tumor appear to show a relatively disorderly pattern as compared to unaffected portion of the colony. Observation by stereoscopic microscope showed that the corallites in the tumor are undeveloped. PUWS were found to have differing degrees of progression. Some colonies completely recovered after 35 days, while no change was observed in others. In some colonies, PUWS were observed to have spread rapidly but recovery was also fast. There appears to be a repeated pattern of infection and recovery.

## 7.195

**How Quickly Does *gorgonia Ventalina* Mount A Cellular Response To Elicitors?**

**Courtney COUCH*[1]**, C. Drew HARVELL[1], Esther PETERS[2], Laura MYDLARZ[3]

[1]Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY, [2]Tetra Tech, Inc., Fairfax, VA, [3]Department of Biology, University of Texas at Arlington, Arlington, TX

In fighting infectious microorganisms, corals rely on innate immune defenses. One of these primary defenses is the wandering phagocytic cells called granular amoebocytes. The Caribbean sea fan coral, *Gorgonia ventalina*, is a tractable system to study this cellular response because granular amoebocytes aggregate during exposure to the fungal pathogen *Aspergillus sydowii* and thermal stress, and can be quantified. In the lab, live *A. sydowii* was a successful elicitor of amoebocyte aggregation and revealed a time course peaking at 48 hours. After 48 hours, the response also showed a relaxation period between 72 to 168 hours. However, the induction of a coral cellular response in a field setting is still unclear. Therefore, a number of alternatives to live *A. sydowii* were tested to effectively stimulate an amoebocyte response in the field. In addition, field experiments are planned to examine the magnitude and time course of this cellular response in nature. Finally, one important unanswered question is: What is the coral's cellular threshold to disease? Therefore, field experiments are planned to measure amoebocyte levels in sea fans exposed to multiple inductions overtime. Consequently, this research could provide valuable information towards the study of host-pathogen interactions and disease progression.

## 7.196

**Coral Molecular Responses to Disease**

**David ANDERSON*[1]**, Sandra GILCHRIST[1], Megan PEDERSEN[1]

[1]Natural Sciences, New College of Florida, Sarasota, FL

Reports of coral disease incidences have rapidly increased over the past three decades. Studies on coral disease published to date have largely focused on ecological surveys and the identification of causative agents. However, the mechanisms controlling coral "immune-like" responses and resistance to disease are not well understood. In this study we hypothesized that there are specific molecular responses to disease manifested by corals during periods of infection and exposure. During July of 2007 in Cayos Cochinos, Honduras, surface layer mucus samples were collected from diseased and healthy corals of the species *Diploria strigosa* and *Siderastrea siderea*, putatively affected by White Plague Disease, Dark Spot Syndrome, and Black Band Disease. From condensed mucus samples preserved in RNA*later* (Ambion) we isolated coral RNA to analyze gene expression profiles by Differential Display Reverse Transcriptase PCR. PCR products were analyzed by 2 % agarose gel electrophoresis, and DNA bands that were differentially associated with diseased and healthy states were isolated, cloned, and sequenced. Sequences statistically similar to known coral and cnidarian genes were used to design Real-Time PCR probes to compare differential gene expression quantitatively. The putative molecular "immune-like" responses identified in this study will contribute to better understanding mechanisms associated with coral resistance and susceptibility to disease.

## 7.197

**Release Of Antifungal Activities From Immune Challenged Sea Fans**

**Nancy DOUGLAS*[1]**, Steve LOWES[2], C. Drew HARVELL[1]

[1]Cornell University, Ithaca, NY, [2]Advion BioSciences, Ithaca, NY

Sea fans offer an excellent system for studying innate immunity in corals because of their abundance, distribution, and ease of experimental manipulation. In addition, sea fans have a relatively well characterized susceptibility to harmful fungal infections that has been the basis for several disease ecology studies. The objectives of this study were to establish if sea fans respond to immune challenge by releasing potential protective compounds into the surrounding seawater and to begin to characterize the released activity. Antifungal, antibacterial and chitinolytic activity were assayed in the water surrounding sea fan pieces before and after immune stimulation. Sea fans were found to transiently release significant antimicrobial and chitinolytic activity between 1 and 48 hours after induction. Induced samples are being subjected to chromatographic separation followed by SDS-PAGE analysis and Mass Spectrometry (MS) to isolate and characterize active fractions. Preliminary analysis suggests that sea fans appear to release a mixture of various molecular weight protective compounds as an initial response to acute immune challenge. Further fractionation and analysis of these activities will identify individual compounds and their mode of action.

## 7.198

**The Role Of Nitric Oxide in The Immune Defenses Of The Sea Fan *gorgonia Ventalina***

**Joyce STUCKEY*[1]**, Nancy DOUGLAS[2], Courtney SALTONSTALL[2], Catherine HARVELL[3,4]

[1]Zoology, Cornell University, Freeville, NY, [2]Ecology and Evolutionary Biology, Cornell University, Ithaca, NY, [3]Zoology, Cornell University, Ithaca, NY, [4]Ecology and Evolutionary Biology, Cornell University, Ithaca

Coral disease outbreaks have increased and are linked with climate warming. One mechanism for increased disease in a stressed coral is through immune compromise. A centerpiece of innate invertebrate immunity in non-cnidarians is nitric oxide (NO), leading us to investigate its role in corals. In this study, the production of NO by nitric oxide synthase (NOS), a well studied component of vertebrate innate immunity, was measured to determine its role in the immune defenses of the sea fan *Gorgonia ventalina*. The NO production was measured using two methods: (1) the Griess reagent which causes a colorimetric change in the presence of NO that is quantified by a spectrophotometer and (2) confocal microscopy which allows for measurement of the fluorescence produced from the binding of a dye to NO. Both the constitutive NO production as well as production induced by several elicitors was measured. In the sea fans, NO production had great variability among individuals for both constitutive and induced levels. Identifying a more robust elicitor for NO production will help in future experiments to more clearly elucidate the role of NO in the immune response of sea fans.

## 7.199

**Antibacterial Chemical Defenses in Corals: Widespread But Selective Resistance To Bacterial Pathogens**

**Deborah GOCHFELD*[1,2]**, Greta S. AEBY[3], Katerina PAPPAS[1]

[1]National Center for Natural Products Research, University of Mississippi, University, MS, [2]Environmental Toxicology Research Program, University of Mississippi, University, [3]Hawaii Institute of Marine Biology, Kaneohe, HI

One potential mechanism of resistance to disease in corals is the production of antibacterial chemical defenses that protect corals from bacterial pathogens. In an effort to determine whether corals produce antibacterial chemical defenses, we have tested aqueous extracts from Caribbean and Pacific corals in bacterial growth assays using a series of test strains including known coral pathogens, potential marine pathogens found in human waste and bacteria previously identified from the surfaces of corals. Extracts from all three species of Hawaiian corals exhibited high levels of antibacterial activity. This activity varied at the coral colony, population and species level, and the activity was highly selective against different bacterial strains, rather than broad-spectrum in nature. In addition, some extracts were stimulatory to certain bacteria. Caribbean corals also exhibited widespread antibacterial activity against the strains tested, and these were also highly selective in their activity against different bacterial strains. Extracts from several Caribbean species, however, stimulated the growth of Caribbean coral pathogens, providing evidence for a correlation between coral chemical defenses and disease incidence. Antibacterial chemical defenses clearly have the potential to provide corals with protection from bacterial pathogens. The high degree of selectivity observed is necessary so that the coral can maintain its naturally associated microbial community, yet still ward off potentially harmful bacteria. Differences in levels or types of antibacterial chemical defenses may represent a mechanism by which variability in resistance or susceptibility to pathogens might be realized and may provide insight into patterns of disease incidence and prevalence on coral reefs.

## 7.200

**Optimization Of Bacterial Challenge Protocols For Study Of *montipora* White Syndrome**

**Teresa LEWIS*[1]**, Megan COLVIN[1], Ashley SMITH[1], Greta AEBY[1], Thierry WORK[2], Jo-Ann LEONG[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii at Manoa, Kaneohe, HI, [2]USGS-BRD-NWHC, Honolulu, HI

Laboratory studies characterizing coral bacterial pathogens provide an essential foundation for moving coral disease from descriptive nomenclature (i.e., white syndromes) into identification of putative etiological agents. While a number of methods have been published to test Koch's Postulate's, none have been applied for coral disease research in Hawaii. *Montipora* white syndrome is a disease recently described in Hawaii involving tissue loss. Developing a model for disease transmission studies using methods described by others has led to some interesting observations, the most prominent being the need to verify methods for each species of coral under study to account for differences in physiology and adaptability to stress. "Model" bacteria isolated from *M. capitata* associated with healthy (*Alteromonas* sp.) and diseased coral mucus (*Vibrio parahaemolyticus*) were used in pilot studies to optimize methods for future bacterial challenge experiments. Growth curves in Glycerol Artificial Seawater (GASW) and sterile filtered seawater (FSW) established both bacteria capable of growing to log phase in GASW but not FSW. Corals were fragmented and recovered in water tables with flow-through conditions for one week, then placed in triplicate in static aquaria containing FSW and provided aeration. Log phase *Alteromonas* or *Vibrio* cultures were inoculated into the water or directly onto exposed surfaces of corals and after two hours the water level was raised. Corals were monitored for two weeks, photographed, and sampled periodically. At the end of the study no signs of disease at gross or microscopic levels were observed. Analysis of mucus plated onto GASW agar at the conclusion of experiments showed significant elevation of colonization of *Alteromonas* or *Vibrio* without any disease signs. This study highlights the need for stringent validation of bacterial challenge models for coral disease and continued refinement of methods.

Funding: NOAA/HCRI-RP grant #NOA06NOS4260200

## 7.201

**Parrotfish As Vectors Of Coral Disease - Evaluation By Comparison Of Bacterial Populations**

**Christopher SHERIDAN*[1]**, John C BYTHELL[2], Reia GUPPY[2], Randi D ROTJAN[3]

[1]School of Marine Science and Technology, Newcastle University, Newcastle, United Kingdom, [2]School of Biology, Newcastle University, Newcastle Upon Tyne, United Kingdom, [3]Department of Organismc and Evolutionary Biology, Harvard University, Cambridge, MA

The role of parrotfish as bio-eroders and grazers is well described, but examination of bacterial communities associated with parrotfish-inflicted lesions and parrotfish jaws suggest that they may also act as vectors of coral pathogens. The microbiological and genetic analyses of these microbial communities suggested a potential exchange of micro-organisms between parrotfish jaws and bites taken from live coral. However, the defence mechanisms of corals seemed sufficient to prevent both the penetration of these microbes within their tissues, and the resulting disease causation. Mucus secretion in particular appeared to be the predominant defence response to injury and possibly to the presence of foreign organisms.

## 7.202

**Spatio-Temporal Transmission Patterns Of Black Band Disease (Bbd) in A Coral Community**

**Assaf ZVULONI*[1,2]**, Yael ARTZY-RANDRUP[3], Lewi STONE[3], Esti KRAMARSKY-WINTER[1], Roy BARKAN[4], Ariel KUSHMARO[5], Yossi LOYA[1]

[1]Department of Zoology, Tel-Aviv University, Tel-Aviv, Israel, [2]The Interuniversity Institute for Marine Sciences of Eilat, Eilat, Israel, [3]Biomathematics Unit, Department of Zoology, Tel-Aviv University, Tel-Aviv, Israel, [4]Department of Geophysics and Planetary Sciences, Tel-Aviv University, Tel-Aviv, Israel, [5]Department of Biotechnology Engineering, Ben-Gurion University of the Negev, Be'er-Sheva, Israel

Transmission mechanisms of black band disease (BBD) in open marine systems are poorly understood although this disease is considered as a widespread and destructive coral infectious disease. The major objective of the study was to assess transmission mechanisms of BBD in an open marine community from the spatio-temporal patterns of the disease. Susceptible and infected corals were mapped over an area of 10x10 m in Eilat (Israel, Red Sea) and the distribution of the disease was examined monthly throughout almost two full disease cycles (June 2006 – December 2007). We found that the prevalence of the disease is strongly associated with high water temperature. Infected corals start showing aggregated distributions (among susceptible corals) on small spatial scales of up to 1.9 m in July, when water temperatures rise and the disease prevalence increases. Additionally, newly infected corals clearly develop in proximity to previously infected corals. This provides, what we believe to be first evidence, that local transmission, often not by direct contact alone, is likely to be an important factor in the spread of the disease within the studied site. We suggest that loose infectious material released into the water originating from infected corals may be a significant mechanism of transmission of the disease. Although potential vectors with limited mobility (i.e., snails, fireworms) were not observed to be common in the studied site, we can not refute the possibility that vector mediation mechanism also contributes to disease aggregation. Another novel finding of this spatio-temporal analysis is that the number of corals that survived the first disease season and became re-infected during the second season is much higher than expected by random processes. This points to the possibility that those corals are 'winter reservoirs' of the disease in this reef.

## 7.203

**Spatial and temporal variability in Caribbean coral and octocoral diseases.**

Ernesto WEIL[1], **Aldo CROQUER*[1]**

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Coral reef diseases have become a major threat to Caribbean coral reefs in recent years. A nested ANOVA design was used to assess the status and spatial and temporal variability in the number, distribution and prevalence of major coral reef diseases in the wider Caribbean since 2005 as part of the GEF-World bank Coral Reef Targeted Research and Capacity Building project. Using a modified CARICOMP protocol, five permanent band transects (20m²) were surveyed yearly during the summer-fall in each of three depth intervals (0-4, 5-10 and >15m) in each of three reefs in each of six geographic localities (Bermuda, Grand Cayman, Puerto Rico, Panamá, Curacao and Grenada). Preliminary results indicate high variability in the number and prevalence of the different diseases at the genera and community levels at different spatial scales and over time. At the genera level, significant differences in disease prevalence were found across reefs and among countries, but not across habitats and regions. At the community level, significant differences in disease prevalence was only found across reefs (high variability in other spatial scales). Montastraea was affected by more diseases with WP-II and YBD prevalence ranging between 4 and 35%. Agaricia, Colpophyllia and Diploria were affected by WP-II (0.5-16%), black band (0.4-5%) and ciliates (0.2-12%), Siderastrea and Stephanocoenia by dark spots in Curacao (19%) and Grenada (9%). Aspergillosis mainly affected Gorgonia ventalina (0.2-8%) and other conditions affected other common and widespread octocorals (1-14%). Strong dependency between the frequency of particular diseases and regions (?2 = 426.25), countries (?2 = 1030.8), reef sites (?2 = 1704.2) and habitats (?2 = 161.9) was found. Furthermore, a strong dependency between disease prevalence and the genus they affect (?2 = 1168.6) was present. Overall, the prevalence of diseases in coral reef communities seems to be persistent but highly variable spatially.

## 7.204

**Host Range And Infection Intensity Of The Ectoparasite *neobenedenia Melleni* (Maccallum 1927) On Caribbean Coral Reef Fishes**

**Paul SIKKEL*[1]**, Donna NEMETH[2], Amber MCCAMMON[2], Ernest WILLIAMS[3], Lillian TUTTLE[1]

[1]Biology, Centre College, Danville, KY, [2]Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [3]Marine Science, University of Puerto Rico, Lajas, Puerto Rico

The nature of parasite-host interactions on coral reefs and how they are affected by environmental change is poorly understood. Among the parasites whose abundance is most likely affected by changing environmental conditions are monogenean flatworms. One monogenean in particular, *Neobenedenia melleni* (MacCallum 1927) is an abundant and highly damaging parasite in captive reef fishes. Unlike most monogeneans, which infect a narrow range of hosts, this parasite occurs almost worldwide on a long and complex list of fish species, families, and orders. However, it has rarely been found on wild hosts. Thus, data on patterns of infestation among free-living fishes are sorely needed. As a step toward a better understanding of the dynamics of Caribbean ectoparasites and their fish hosts in general, and Caribbean *N. melleni* in particular, we are conducting a comprehensive assessment of *N. melleni* loads among reef fishes in the Virgin Islands and Puerto Rico. Thus far, we have used non-lethal techniques to sample over 300 individuals, representing 35 species from 18 families. Among these, infections were limited to diurnally active fishes from 5 families, with infections being rare in all but two. All three Caribbean species of surgeonfish (Acanthuridae) were infected, with blue tang (*A. coeruleus*) having the highest levels of infection of any species we have sampled. All three species of boxfishes (Ostraciidae) we sampled were also infected, but at significantly lower levels than blue tang. Our findings thus far suggest that *N. melleni* in the Caribbean infects diurnally active fish at night while they are resting, and infects a narrower range of hosts in the field than in captivity.

## 7.205

**Differences in The Susceptibility To Black Band Disease (Bbd) Between Two Species Of *diploria* On The Reefs Of Bermuda**

**Kristin KUEHL*[1]**, Ross JONES[2], Laurie RICHARDSON[1]

[1]Florida International University, Miami, FL, [2]Bermuda Institute of Ocean Sciences, St. George, Bermuda

Throughout the wider Caribbean, *Diploria* spp. are susceptible to black band disease (BBD). On the reefs of Bermuda, however, *D. labyrinthiformis* demonstrates an apparent resistance to BBD. For example, in surveys along five × 30 m transects at 26 long-term monitoring sites across the Bermuda platform conducted in 2004, 2005 and 2006, BBD prevalence averaged 0.62% (n=45,000) in *D. strigosa*, and only 0.01% (n=21,000) in *D. labyrinthiformis*. Why *D. labyrinthiformis* is seldom observed to be infected with BBD in Bermuda is unknown. We are currently examining whether there are differences between the two species in (1) the BBD pathogen(s), (2) the microbes normally present in the surface mucopolysaccharide layer (SML), (3) the antibiotic properties of the SML, and (4) the physical characteristics that might prevent pathogen entry into host tissue. Ongoing work includes inoculating healthy *D. labyrinthiformis* colonies with BBD collected from an infected *D. strigosa*, characterization of the microbial communities normally present in the SML of healthy colonies, and the apparently healthy region of diseased colonies, using LH-PCR molecular profiling, and inoculating water column bacteria onto marine agar plates treated with SML of both *Diploria* species. Differences in the ability of the species to prevent pathogen(s) from colonizing healthy tissue was tested by examining the rate at which they could clear themselves of foreign objects. In these experiments, 2 g of finely graded (< 250 µm) oven dried marine sediment was directly applied to the surface of the colonies. After one hour, *D. labyrinthiformis* was able to clear 72% of the sediment, which was significantly more than the 39% cleared by *D. strigosa*. These early results suggest that differences in SML properties between the two *Diploria* species may make *D. labyrinthiformis* more efficient at physically expelling the BBD pathogen(s).

## 7.206

**Reduced Fecundity in Yellow Band Diseased Colonies Of The Caribbean Reef-Building Species Montastraea Faveolata.**

**Ernesto WEIL*[1]**, Aldo CROQUER[1], Isabel URREIZTIETA[1]

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Significant losses of live coral tissue and colonies caused by diseases compromise the survivorship and recovery of coral populations. Sexual reproduction is critical to the long-term maintenance of coral populations, however, little is known about the effect diseases have at this level. The ongoing Yellow Band Disease epizootic in the Caribbean is devastating three of the four Montastraea species, the main reef-building genus in the region. The impact of YBD on the fecundity (eggs/polyp) of M. faveolata was investigated by coring diseased, transition and healthy tissue areas of five YBD colonies and five healthy-looking colonies. Cores were also taken from healthy-looking surviving patches of different sizes within disease-free colonies to test effect of reduction in effective reproductive area on fecundity. Samples were processed and analyzed using well tested coral histological methods. Significant decreases in fecundity (99% fewer eggs) ($F = 22.6$, $p<0.05$; $F = 22.9$, $p<0.05$) were found in mesenteries and polyps from YBD infected tissues compared to controls. Fecundity in transition areas was significantly lower (50%) than in healthy areas. Furthermore, healthy-looking areas of infected colonies had 23% lower fecundity than controls indicating a potential systemic (colony-level) effect of YBD. Disruption of continuous reproductive live tissues after partial mortality significantly reduced fecundity by increasing the "border effect" and reducing minimum threshold reproductive area. Both large and small patches showed significant lower number of eggs at both, mesentery (64%) and polyp (84%) levels compared to controls. Edge polyps in these patches had 97% reduction in number of eggs (0.96 ± SE 0.4 eggs) compared to controls (29.4 ± SE 2.3 eggs). YBD significanlty reduced reproductive output of M. faveolata which could have short-term effects on population's recovery and fitness and long-term evolutionary consequences on this important Caribbean reef-builder.

Key words: Yellow Band Disease, reproduction, Caribbean, Montastraea faveolata

## 7.207

**Ecological Immunity Of Diseased And Healthy Montastrea Faveolata Through The 2005 Bleaching Event**

**Laura D. MYDLARZ*[1]**, Ernesto WEIL[2], Courtney S. COUCH[3], Nancy L. DOUGLAS[3], C. Drew HARVELL[3]

[1]Department of Biology, University of Texas at Arlington, Arlington, TX, [2]Marine Science, University of Puerto Rico, Mayagüez, Puerto Rico, [3]Ecology and Evolutionary Biology, Cornell University, Ithaca, NY

One prominent hypothesis regarding climate stress and scleractinian corals is that thermal stress will compromise immunity. The ultimate test of this hypothesis is to track how immunity of both healthy and diseased colonies varies with massive thermal stress in nature. Bleached, healthy and Yellow Band Diseased (YBD) colonies of *Montastrea faveolata* were marked and followed in the field through the 2005 bleaching event and activities of known immune proteins such as prophenoloxidase, lysozyme, chitinase and anti-bacterial activity were monitored. Mortality and infection rate was high: all colonies except one either died or became infected by the end of the two year observation. Tissue with YBD did not expel all their zooxanthellae, even when healthy parts of these colonies bleached. Interestingly, the levels of all the immune proteins in diseased tissue were statistically the same during the 2005 bleaching event and in the subsequent year. Some immune proteins were induced systemically throughout infected colonies, like lysozyme and antibacterial activity which was systemically higher in diseased corals in both healthy and diseased tissue of YBD corals, compared to healthy coral colonies. Both lysozyme and antibacterial activity showed a trend for suppression of activity in bleached corals, while prophenoloxidase showed an opposite trend with highly elevated levels in the bleached corals collected in 2005. These results demonstrate that some components of immunity respond to natural temperature stress as predicted and are suppressed, while others are actually activated by elevated temperatures, suggesting a general stress response or resilience to a changing environment.

## 7.208

**On The White Plague Disease in Corals, With Remarks On The Interactions Between Disease, Environment And Host**

**Santiago HERRERA*[1]**, Juan SANCHEZ[1]

[1]Ciencias Biologicas, Universidad de los Andes, Bogota, Colombia

Coral Reefs are one of the most important ecosystems in the ocean and therefore in the planet. However a highly significant decline during the past decades is threatening their survival. Infectious diseases are one of the biggest factors that contribute to this phenomenon. Among the most common, widespread and virulent coral diseases is the White Plague Disease. Here I review the literature available to date about (i) the history and status of WPD, (ii) the factors that might account for WP epizootic events, and (iii) immunologic interactions between the pathogen and the coral. The WPD is caused by the bacterial pathogen *Auratimonas coralicida* and has the widest host range of all coral diseases that had been detected so far in the Caribbean, with 43 scleractinian species from 24 genera and two hydrocoral species. Three different types of the disease have been described to date, but it seems like they all are produced by the same pathogen. The differences in the rate of the coral tissue destruction, which are the basis to distinguish the three types of WPD, are likely the product of heterogeneous local environmental conditions that trigger the pathogenesis. Some of the best studied factors that promote the disease development, by producing stress in the coral and enhancing the virulence of the pathogen, are: the increasing seawater temperature, human and terrestrial contaminants, and the spatial distribution of the coral populations. Corals do not posses an adaptive-immune system, as mammals do, but they do posses other defence mechanisms against pathogens. Primitive, but efficient cellular and humoral immune response mechanisms, accompanied by a microbial-flora, are their main ways of protection. The future of the coral reefs is unknown. Several measures, including reducing contaminants production, anti-global-warming actions and more research in marine diseases, are fundamental in order to preserve these important ecosystems.

## 7.209

**Phage Therapy Of Coral Disease**

**Ilil ATAD*[1]**, Rotem EFRONY[1], Eugene ROSENBERG[1]

[1]Department of Molecular Microbiology and Biotechnology, Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel

At present there are no known procedures for preventing or treating infectious diseases of corals. In this study, the use of phage therapy of coral disease has been investigated. A lytic bacteriophage (phage BA3) was isolated for the bacterial pathogen, *Thalosomonas loyaeana* that is the causative agent of the white plague-like disease of *Favia favus* on the Eilat coral reef. Phage BA3 was characterized as dsDNA lytic phage belonging to the Podoviridea family. The genome of phage BA3 was sequenced and it contains 37,313 bp (40.9% G+C content) with 47 ORFs.

By using this pathogen-specific phage in controlled aquaria experiments, it was demonstrated that the disease could be controlled by addition of the phage. The data indicate that initially the phages bind to the pathogen in seawater and are then brought to the coral surface where they multiply and lyse the pathogen. The phages remained associated with the coral and could prevent subsequent infections. Additionally, it was shown that addition of the phages one day after the infection also prevented the disease, whereas applying the phage 2 or 3 days after infection failed. Phages also prevented the transmission of the disease from sick coral to healthy corals. Subsequent infection of healthy phage-treated corals (37d after initial phage therapy) did not cause the disease, even though no additional phages were added. Corals treated with phage retained the phages for weeks after they were inoculated. The data presented suggest that phage therapy has the potential to control the spread of infectious coral diseases.

## 8.210

**Quorum Sensing Inhibitory Activities From Coral-Associated Bacteria**

**Stephanie HALBIG*[1]**, Max TEPLITSKI[1], Kim RITCHIE[2]

[1]Soil and Water Science, University of Florida, Gainesville, FL, [2]Mote Marine Lab, Sarasota, FL

Many symbionts and pathogens rely on a cell-to-cell communication mechanism called "quorum sensing" (QS) to structure multicellular communities and coordinate their interactions with eukaryotic hosts. Interactions that are influenced by QS between coral associated commensal bacteria and a coral pathogen were investigated in this study. A collection of coral-associated bacteria, including those from zooxanthellae cultures, was screened for the ability to inhibit a model QS reporter, *Chromobacterium violaceum* to investigate potential roles for QS in the interactions between normal coral microflora and opportunistic pathogens. Six isolates showing the greatest degree of inhibition were chosen and identified by 16S sequencing as *Planococcus* spp, *Photobacterium* spp., *Marinobacter salsuginis*, *Agrobacterium stellulatum*, *Vibrio* spp., and *Caryophanon* spp. The range of QS inhibition was tested with a suite of reporters carrying receptors for different QS signals. Isolates in co-culture were able to inhibit reporter activity by 75% - 100%. Inhibition of surface spreading in *S. marcescens* by the isolates was tested. *Marinobacter salsuginis* and *Agrobacterium* spp. from zooxanthellae, and *Photobacterium* spp., *Planococcus* spp., and *Caryophanon* spp. from coral mucus all showed inhibition of surface spreading in at least one of the *S. marcescens* strains tested. The mechanism by which surface motility is inhibited was confirmed in experiments with a mutant of *S. marcescens* that carries a reporter gene insertion in the surfactant gene that is involved in surface colonization. The role of QS in surface spreading of PDL100 was investigated using a "quorum-quenching" approach. A plasmid borne QS signal lactonase aiiA was conjugated into PDL100 to generate a functional QS mutant and spreading behavior was monitored. Our results indicate that native coral-associated bacteria are capable of inhibiting QS that may aid in the defense against pathogen colonization.

## 8.211

**Bacterial Diversity Associated With The Corals Of Gulf Of Mannar**

**Shunmugiah Thevar Karutha PANDIAN*[1]**, Paramasivam NithyANAND[1]

[1]department Of Biotechnology, Alagappa University, Karaikudi 630 003, India

Coral microbiology is an emerging field, driven largely by a desire to understand, and ultimately prevent, the worldwide destruction of coral reefs. Coral microbiology is still in infancy in India and molecular cataloguing of bacterial diversity associated with Indian corals is not well established. As a preface, we attempted to divulge the bacterial diversity associated with the coral Acropora digitifera, a predominant coral species of the Gulf of Mannar region. Samples of coral mucus and coral tissues were collected form Acropora digitifera from Hare Island. Bacteria were isolated from both coral mucus and coral tissue by serially diluting the sample and plating them on different media to isolate total heterotrophic bacteria, Pseudomonas .sp and Vibrio. sp. As expected, the total bacterial count was highest in coral mucus followed by coral tissue, sediment and seawater. The isolated bacteria were identified by biochemical tests as well as by molecular typing. 16S rRNA genes were successfully amplified from the genome of the isolates using universal eubacterial 16S rRNA primers. The different phylotypes obtained through ARDRA were selected for 16S rRNA gene sequencing. 16S rRNA gene sequencing is underway and the same is expected to reveal the different bacteria associated with the coral Acropora digitifera. Isolation of Enterobacter cloacae, a member of coliform group indicates that there is evidence of anthropogenic pressure in the coral reef ecosystem and warrants constant monitoring of total and fecal coliforms in the coral reef ecosystem. Preliminary knowledge about the number and different types of Vibrio. sp associated with healthy corals is of utmost importance because it helps in identifying pathogenic Vibrios. sp which are responsible for mass coral bleaching. The outcome of this study is very important to evolve appropriate strategies for conservation of coral reef ecosystem of the Gulf of Mannar.

## 8.212

**Are You Interested in The Invisible? Tools For Coral Reef Microbiology**

**Forest ROHWER*[1]**, Mark HATAY[1], Linda WEGLEY[1], Neilan KUNTZ[1], Olga PANTOS[1]

[1]Biology, San Diego State University, San Diego, CA

In the last decade, there has been an increasing awareness that microbes and viruses are important components of coral reef ecosystems. Novel tools are needed for coral reef microbiology, some of which will be highlighted here. SPIDERS is a syringe pump system that can be used to deliver treatments, such as varying levels of inorganic and organic nutrients, pesticides, herbicides, etc., both on land and underwater. Using SPIDERS, a researcher can determine how different stressors change the coral holobiont under field conditions. The SUPERSUCKERS system can be used by a diver to remove the mucus from the surface of a coral without introducing contaminants from the surrounding water column. These samples can then be assayed in FAM, a simple, field deployable system for rapid quantification of microbes. We have also developed a field kit for collecting and processing water samples for dissolved organic carbon, nutrient, and isotope measurements. With these tools it is relatively easy for coral reef scientists to collect and start assaying the invisible, microbial components on coral reefs.

## 8.213

**Histopathological Analysis Of Hyaline, Fibrillar Lesions in The Caribbean Staghorn Coral, *acropora Cervicornis***

**Erin HODEL*[1,2]**, Esther PETERS[3]

[1]CSA International, Inc., Stuart, FL, [2]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, [3]Tetra Tech, Inc., Fairfax, VA

Tissue and cellular parameters definitive of healthy, stressed, or diseased states are not well understood for any coral species. The histology of the Caribbean staghorn coral, *Acropora cervicornis*, was examined after field collection and after 4 weeks of exposure in laboratory aquaria to high levels of sedimentation (200 mg cm-2 day) and phosphate (4 µM). Histopathological analysis revealed small- to large-sized lesions consisting of strands of proteinaceous, hyaline, fibrillar material surrounded by or underlying gastrovascular canal-lining tissue in the skeleton of both experimental and field-collected specimens; however, lesions were larger in experimental specimens. Staining properties of the strands varied within each lesion, indicating regions with different biochemistry. With Harris's hematoxylin and eosin, lesions were mostly eosinophilic but graded into basophilic portions along the strands. The strands were mostly positive for the periodic acid-Schiff reaction, indicating neutral or acidic properties and suggesting a mucopolysaccharide origin. Gomori's methanamine silver procedure positively stains fungi black and was used after filaments resembling fungal hyphae were discovered within the lesions and calicodermis of several specimens. Filaments and clustered bodies containing black- and blue-staining granules were revealed that might have been of fungal origin. The lesions were usually bordered by calicodermis and observed in areas where skeleton had been prior to decalcification. In some cases, the calicodermis was hypertrophied near the lesions, which is consistent with organic matrix formation and enhanced skeletal deposition. Therefore, these lesions may have been a result of augmented organic matrix formation in order to "wall off" invading fungi or other organisms with aragonite. Such lesions in coral tissues might indicate a defensive or immune response toward potentially invasive organisms to protect coral tissues; however, more observations are needed to link them with compromised health status.

## 8.214

**Bacterial Diversity Associated With Tropical Azooxanthellate Hexacorals And Octocorals**

**Lory Z. SANTIAGO-VÁZQUEZ*[1]**, Wolfram M. BRÜCK[2], Thomas B. BRÜCK[3], Angela P. DUQUE-ALARCÓN[4], Peter J. MCCARTHY[5], Russell G. KERR[6]

[1]Biotechnology, University of Houston, Clear Lake, Houston, TX, [2]Centre of Applied Marine Biotechnology, Letterkenny Institute of Technology, CAMBio, Letterkenny, Ireland, [3]Corporate Research and Development, Süd-Chemie AG, München, Germany, [4]Center of Excellence in Biomedical and Marine Biotechnology, Department of Chem. and Biochem., Florida Atlantic University, Boca Raton, FL, [5]Center for Ocean Exploration, Harbor Branch Oceanographic Institution, Ft. Pierce, FL, [6]Department of Chemistry, University of Prince Edward Island, Charlottetown, PE, Canada

There is limited information on the microbial communities associated with azooxanthellate soft corals. Most of these organisms inhabit inaccessible deep or cold water environments. However, some tropical azooxanthellate hexacorals and octocorals grow at moderate depths (40-100m) reached by SCUBA. This study examined the bacterial symbionts of some of these corals, the hexacoral *Cirrhipathes lutkeni* and the octocorals *Leptogorgia minimata*, *Swiftia exertia*, and *Iciligorgia schrammi*. For this purpose, we used fluorescence in situ hybridization (FISH) and traditional plate culture.

FISH counts for the hexacoral *C. lutkeni* showed a predominance of γ- and α-Proteobacteria, and Actinobacteria. FISH counts for the three octocorals showed a concentration of α-, β-, and γ-Proteobacteria, however, Actinobacteria were present in low amounts. When examining the bacterial diversity using plate culture, it was found that these cultures were highly selective for γ-Proteobacteria. The next two most prominent groups present were α-Proteobacteria and Firmicutes. The predominance of γ-Proteobacteria observed correlates well with the bacterial populations of other soft corals. Some γ-Proteobacteria are symbiotic in nature and thus may be important for coral health. This study provides further insight into the microbial ecology of these unique organisms.

## 8.215

**Bacterial Community Associated With Tissue And Skeleton Of Three Scleractinian Species: *galaxea Fascicularis*, *pavona Cactus* And *turbinaria Reniformis***

**Pascale TREMBLAY*[1,2]**, Markus G. WEINBAUER[3], Christian NOZAIS[1], Cécile ROTTIER[2], Christine FERRIER-PAGÈS[2]

[1]Département de Biologie, Chimie et Géographie, Université du Québec à Rimouski, Rimouski, QC, Canada, [2]Centre Scientifique de Monaco, Monaco, Monaco, [3]Microbial Ecology and Biogeochemistry Group, Laboratoire d'Océanographie de Villefranche, CNRS-UPMC, UMR 7093, Villefranche-sur-Mer, France

A study was performed, to assess the bacterial community composition and richness of the tissue and skeleton of three scleractinian coral species *Galaxea fascicularis*, *Pavona cactus* and *Turbinaria reniformis*. The main question was to assess if this bacterial diversity was species specific. For this purpose, corals were incubated all together in the same environment and bacterial diversity analyzed using denaturing gradient gel electrophoresis (DGGE) on nested PCR amplified fragments of the 16S rRNA gene. The multidimensional scaling (MDS) and cluster analyses showed that the bacterial community in the tissue was species-specific, conversely to the community associated to the skeleton, which was more homogenous between species. Results concerning tissue indeed showed that *P. cactus* was different from *G. fascicularis* (richness and Shannon $p < 0.0001$) and from *T. reniformis* (Shannon Index $p = 0.0335$) and *G. fascicularis* was different of *T. reniformis* (richness $p = 0.0190$). The Shannon Index and richness parameter were not significantly different between tissue and skeleton, except for *P. cactus* ($p = 0.0023$ and 0.0038 respectively). Mucus excretion was significantly different ($p < 0.0001$) for the three species, with a higher excretion in *G. fascicularis* (178.2 ± 17.4 nmol C mg protein-1 h-1) than in *P. cactus* (48.4 ± 3.3) and *T. reniformis* (18.4 ± 1.4). The mucus of *G. fascicuaris* and *P. cactus* also mainly contains galactose and glucose compared to the mucus of *T. reniformis* that contains glucose and xylose. This different excretion and composition can partly explain the observed differences in bacterial diversity.

## 8.216

**Bacterial Quorum Sensing Signals And Settlement Of Coral Larvae**

**Cory KREDIET*[1]**, Kim RITCHIE[2], Mikhail MATZ[3], Max TEPLITSKI[4]

[1]School of Natural Resources and Environment, University of Florida, Gainesville, FL, [2]Marine Microbiology, Mote Marine Laboratory, Sarasota, FL, [3]Section of Integrative Biology, University of Texas, Austin, TX, [4]Soil and Water Science, University of Florida, Gainesville, FL

The settlement cue perceived by coral larvae is currently unknown. Several research groups demonstrated that coral larvae prefer to settle on substrates that are colonized by coralline algae or by mats (biofilms) formed by coralline algae and associated microbes. Formation and function of microbial biofilms involves quorum sensing (QS) signals (acyl homoserine lactones, AHLs). Both bacteria and eukaryotes produce vitamin signals with newly discovered functions in QS and host-microbial interactions. While the chemical characterization of the settlement cue is ongoing elsewhere, we tested a hypothesis that known signals commonly associated with microbial biofilms may function as settlement cues for larvae of stony corals. These settlement experiments involved C4-homoserine lactone, 3-oxo-C12-homoserine lactone, lumichrome and riboflavin, each compound is known to function in bacterial cell-to-cell communication. Acyl homoserine lactones (AHL) and a riboflavin derivative lumichrome are also involved in interactions between bacteria and their eukaryotic hosts. These molecules have also been shown to contribute to settlement or metamorphosis of marine organisms. Presence of AHLs, lumichrome and riboflavin in coral-associated microbes and in coralline algae was investigated. Their role in settlement was investigated using two complementary approaches. First, transgenic microbial biofilms expressing AHL-lactonase were constructed to test the consequences of AHL hydrolysis in larval settlement. Chemicals were also impregnated onto C18-bonded silica resin to simulate biologically-relevant release rates of the compounds into the medium during the settlement experiment. Two settlement experiments were carried out to date with larvae of *Acropora palmata* and *Montastraea faveolata*. A strong correlation between the treatments and settlement rates has yet to be elucidated. Although optimization of techniques and larval rearing is ongoing, sub-optimal larval and settlement conditions may have affected the outcome of the experiments.

## 8.217

**Efficient Isolation Of Bacteria That Induce Settlement And Metamorphosis Of *acropora* Larvae**

**Kanae MATSUSHIMA*[1]**, Masayuki HATTA[2]

[1]Graduate School of Humanities and Sciences, Ochanomizu University, Tokyo, Japan, [2]Marine and Coastal Biology Center, Ochanomizu University, Tokyo, Japan

Biofilms on submarine substrata can act as efficient inducers for settlement and metamorphosis of *Acropora* larvae. Indeed, bacteria that induce metamorphosis have been identified from biofilms; one strain of *Pseudoalteromonas* and three of *Alteromonas*. Since micro-environments on substrata are very diverse, there could be more bacteria species capable of inducing metamorphosis. Then we tried screening of such bacteria by a new method. Each bacteria source was swabbed from a 1cm2 surface of tiles submerged in a reef for 3 months, and suspended in sterilized seawater (SSW). Membrane filters were soaked in each suspension and incubated on agar media. For passage, the bacteria-grown filter (mixed culture filter; MCF) was broken into pieces in SSW. We tested each MCF for the activity to induce metamorphosis. Out of 32 MCF lineages from 16 sources, metamorphosis-inducing batches were obtained in 11 from 8. Although individual batches varied in their activities, every lineage contained one or more batches giving 100% metamorphosis. Some lineages retained their activities through passages. Next, a total of 230 independent strains were isolated from 12 active MCFs, and 19 isolates turned out to induce metamorphosis, including 17 giving 100% metamorphosis. According to 16SrDNA sequencing analyses, 17 isolates, except 2 that failed to be identified, fell into 7 species in 4 genera; *Pseudoalteromonas*, *Alteromonas*, *Vibrio* and one in alpha-proteobacteria. Our original culture method using MCFs enabled us to get metamorphosis-inducing bacteria very efficiently, compared with the conventional isolation method (1/80 and 3/500 isolates). This study reveals that inducer bacteria spread over in wide taxa. In addition, we found two *Pseudoalteromonas* species that inhibit metamorphosis. These findings may suggest very high diversity of bacteria concerned with the metamorphosis decision of *Acropora* larvae.

## 8.218

**Bacterial Communities Associated With The Surface Mucopolysaccharide Layer And Tissues Of Healthy And Diseased Montastrea Faveolata**

**Wes JOHNSON*[1]**, Reney HENDERSON[2], Garriet SMITH[3], Ernesto WEIL[4], Karen NELSON[5], Pamela MORRIS[1,6]

[1]Marine Biomedicine and Environmental Sciences Center, Medical University of South Carolina, Charleston, SC, [2]Department of Biology, Howard University, Washington, DC, [3]Department of Biology and Geology, University of South Carolina Aiken, Aiken, SC, [4]Department of Marine Sciences, University of Puerto Rico Mayaguez, Mayaguez, Puerto Rico, [5]The J. Craig Venter Institute, Rockville, MD, [6]Department of Cell Biology and Anatomy, Medical University of South Carolina, Charleston

Corals naturally form associations with complex assemblages of microorganisms that are thought to play vital roles in coral ecology. Detailed exploration of the composition and structure of these communities can improve our understanding of the potential roles of these communities and their interactions with their host. Our objectives were to (1) assess the composition of the bacterial communities associated with *Montastrea faveolata*, (2) compare the communities of healthy and diseased colonies of *M. faveolata*, and (3) characterize the assemblages from the surface mucopolysaccharide layer (SML) and coral tissue. Samples were collected from La Parguera, Puerto Rico in March 2006. SML and tissues were collected from three healthy and three diseased colonies. Community DNA was isolated and clone libraries of 16S rDNA genes were constructed by amplifying nearly complete 16S rDNA sequences and inserting them into cloning vectors. Clones were sequenced at the J. Craig Venter Institute (Rockville, MD). Comparisons of community structure were also performed using denaturing gradient gel electrophoresis (DGGE). Results from clone libraries showed tissues were dominated by sphingobacteria, while SML communities were composed mostly of α-proteobacteria. Diseased tissues had fewer Clostridium sequences than did healthy tissues. SML samples also showed differences between healthy and diseased colonies, with healthy colonies containing numerous sequences of *Lactococcus lactis*, which were not observed in diseased samples. DGGE showed differences between SML communities of healthy and diseased colonies that were not observed between healthy and diseased tissues. These data indicate shifts in the structure of *M. faveolata* bacterial assemblages related to host health, and suggests that SML and tissue communities are affected differently in diseased corals. We are currently generating and sequencing metagenomic libraries to further elucidate the composition and functional potential within these communities.

## 8.219

**Role Of The Coral Surface Microbiota in Disease: An in Situ Test Using The Gorgonia-Aspergillus Pathosystem**

**Emily BRODERICK*[1]**, Karen BUSHAW-NEWTON[1], Walker TIMME[1], Jessica WARD[2], Kiho KIM[1]

[1]Biology, American University, Washington, DC, [2]Scripps Institution of Oceanography, San Diego, CA

Surface mucopolysaccharide layer (SML) of corals are known to have a variety of functions including serving as a protective layer against UV light damage and desiccation. The SML is also an energy rich environment that supports host-specific microbial communities. Studies have shown that the microbial communities shift, in both richness and abundance, in response to environmental perturbations and pathogens. Thus, analogous to the role of human gut microbiota, the coral surface microbiota may play a mutualistic role in the health of the coral host. Indeed, the "coral-microbiota-disease" hypothesis predicts that the coral surface microbiota is an important aspect of disease resistance. More specifically, perturbation of the surface microbiota increases disease susceptibility. Here, we report on *in situ* experiments to test whether the structure of the coral surface microbiota is mutable in the Caribbean sea fan, *Gorgonia ventalina*. We tested the effects of light reduction, nutrient enrichment, antibiotic wash, and pathogen (*Aspergillus sydowii*) exposure on the microbiota as characterized using DGGE. Results so far indicate that the structure of coral surface microbiota is mutable and that some bacterial stains were present in untreated control corals and remained throughout all treatments. In addition to the on-going work to characterize the structure of the microbiota, it is also important to understand how an intact microbiota confers disease resistance.

## 8.220

**Discoloration Of Coral Larval Cultures Caused By Pseudomonas Sp.?**

**Iliana BAUMS*[1]**

[1]Biology, The Pennsylvania State University, University Park, PA

Rearing of coral larvae from mass-spawning events is a common and important approach to coral research and conservation. Yet, larval rearing in captivity is often associated with high mortality rates. Larval cultures of the Caribbean mass-spawners, Acropora, Montastraea and Agaricia predictably crash after two to three days. This crash appears associated with the break down of unfertilized eggs. A pink discoloration of Montastraea faveolata larvae as well as of tygon tubing and other plastic ware used for culturing was observed during multiple years and at two locations. Brown (1974) described a similar phenomenon in embryos of bivalve mollusks and identified antibiotic sensitive Pseudomonas sp. as the likely origin. It is hypothesized that a related bacterial strain causes infections in coral larval cultures. Disinfection of culture equipment with a 10% bleach solution prevented a spread in 2007, however delivery of antibiotics sometimes promotes pink discoloration. Thus, the hypothesized target is an antiobiotic resistant strain of Pseudomonas sp. Initial sequencing of a bacterial 16s RNA library extracted from pink gametes yielded diverse sequences related to Bacteroidetes, Clostridium and Vibrio but did not produce a Pseudomonas relative. Sequencing efforts are ongoing. Meanwhile, simple disinfection procedures may alleviate problems with bacterial infections in coral culturing efforts.

## 8.221

**Patterns Of Antibiotic Resistance in Microbial Isolates From Pseudopterogorgia Americana**

**Katherine WILLIAMS*[1,2]**, Maria VIZCAINO[1,2], Jennifer DELANEY[3,4], Garriet SMITH[5], Karen NELSON[6], Pamela MORRIS[1,2]

[1]Marine Biology and Environmental Science, Medical University of South Carolina, Charleston, SC, [2]Hollings Marine Laboratory, Charleston, [3]Hollings Marine Laboratory, Charleston, SC, [4]Grice Marine Laboratory, The College of Charleston, Charleston, [5]Biology and Geology, University of South Carolina - Aiken, Aiken, SC, [6]J Craig Venter Institute, Rockville, MD

The coral surface mucopolysaccharide layer (SML) is home to myriad microbial species that compete for habitat and nutrients, produce and resist anti-microbial compounds, and likely play a role in coral health. This study examined differences in patterns of antibiotic resistance and susceptibility profiles exhibited by bacteria isolated from healthy and diseased colonies of *Pseudopterogorgia americana*. Mucus samples were taken from healthy and diseased colonies off of the southern coast of Puerto Rico in March 2006. SML was spread-plated onto glycerol-artificial seawater (GASW) agar plates and incubated, and colonies were purified by successive streaking. Isolates from one healthy and one diseased *P. americana* colony were resuspended in GASW, introduced into 96-well plates containing 26 different antibiotics, and incubated overnight. Resistance was indicated by greater than 20% of control turbidity at the minimal inhibitory concentration (MIC) of antibiotic. The percentage of instances of resistance out of the total number of possible instances (number of antibiotics multiplied by number of isolates) was 47% in the healthy-coral subset and 25% in diseased; of the four drugs which inhibited growth in all of the isolates, three were cell wall synthesis-inhibiting antibiotics. These results suggest that the microbial community of the healthy coral may be more stable than that of the diseased, and reflects changes in both microbial community structure and the chemical ecology in these communities.

## 8.222

**$\delta^{13}C$ and $\delta^{15}N$ values for branching coral reefs at the Berau Marine Conservation Area in East Kalimantan, Indonesia**

**Handoko Adi SUSANTO*[1]**, Masaaki YONEDA[2], Hiroko KOIKE[1]

[1]Department of Environmental Changes, Graduate School of Social and Cultural Studies, Kyushu University, Fukuoka-shi, Japan, [2]Japan Wildlife Research Center, Tokyo, Japan

To understand □13C and □15Nvalues between zooxanthellae and coral tissue, branching coral reefs *Porites spp., Seriotophora sp.* and *Stylophora sp.* were collected from the Berau Marine Conservation Area (MCA), East Kalimantan, Indonesia. The study was also intended to examine the affect of sedimentation from the Berau River mouth to the coral reef conditions. Zooxanthellae was separated using sonication method, and coral tissue was obtained by decalcification method from their coral skeleton. Carbon and nitrogen isotope values showed that most of the coral tissues had higher □15N values than those of zooxanthellae. It indicates that zooxanthellae must be the main source of nutrient for the coral tissue. Samples collected from three localities, designated as the nearest (Locality 1), medium distance (Locality 2) and the farthest (Locality 3) from the Berau river mouth, indicated that □13C valuesof the zooxanthellae and the coral tissue had no significant different among localities, but □15N values were statistically significant. The highest □15N value found from locality 2 could be due to the anthropogenic impact from Derawan Island (48 ha) which is inhabited by about 1500 people. The higher □15N values in locality 1 were an indication of the affect of sedimentation from the Berau River that served as nutrient sources compare with locality 3 which is mainly marine condition.

## 8.223

**Seasonal Changes in Bacterial Communities Associated With Acropora Palmata Surface Mucus And Surrounding Water Column**

**Kim RITCHIE*[1]**, Jonathan ONUFRYK[1], Erich BARTELS[2], Joel THURMOND[1]

[1]Mote Marine Laboratory, Sarasota, FL, [2]Mote Marine Laboratory, Summerland Key, FL

The Caribbean Elkhorn coral, *Acropora palmata,* is an important primary producer and shallow water framework builder in the Florida Reef Tract. This coral species is extremely sensitive to various stressors, including disease, elevated temperatures, and storm damage. The severe population declines of *A. palmata* due to secondary responses to these stressors (disease and bleaching) have changed the composition, structure, and function of the Florida Keys coral reef ecosystem. In order to address temporal shifts in coral sensitivity and microbial community dynamics in surface mucus and the surrounding water column, both *A. palmata* and sea water was sampled monthly from 2005 through 2007 at three sites at Looe Key Reef in the lower Florida Keys. Assays performed included mucus inhibition of pathogenic tester strains, vibrio ratios estimated from dilutions inoculated onto TCBS plates, and shifts in antibiotic producing bacteria associated with coral surfaces. Although there were not significant or consistent trends in antibiotic qualities or antibiotic producing bacteria on coral surfaces, results show a general trend towards an increase in *Vibrio* spp. in the water column and on coral surfaces as temperatures increase. Continued monthly to quarterly monitoring of corals will provide much needed information on microbial community dynamics of this sensitive species.

## 8.224

**Realistic measure of the supply of bacteria from the water column to a coral**

**Michael SWEET*[1]**

[1]School of biology, Newcastle University, Newcastle upon tyne, United Kingdom

This study investigates the controls on bacterial community development and organisation on the surface mucus layer (SML) of reef corals. Various factors may influence the SML bacterial community of corals, including production of antimicrobial chemicals, supply of bacteria from the water column, environmental conditions and mucus composition and production rates. Mucus production is particularly important as it represents both the availability of Carbon and Nitrogen and the dynamics of the SML as a physical barrier, entrapment surface and growth medium. Although the SML of corals is believed to be a highly dynamic layer, it appears to support a distinct resident bacterial community rather than one resulting from passive settlement and entrapment of water-borne bacteria. Comparisons between the bacterial species diversity found in the surrounding water column and coral mucus show very little overlap. Previous studies have investigated supply of bacteria from the water column using discreet (Niskin bottle) samples, which do not adequately represent either the diurnal and longer-term temporal variation in the water column or the spatial scale and position of corals at the benthos. To investigate the water column supply in this study, continuous and composite (periodic) in situ sampling was undertaken using modern sample methods. A peristaltic pump sampler and PTFE tubing was utilised to sample continuously direct into Sterivex GP filter units stored on ice. The use of a peristaltic pump system enabled the sample inlet to be precisely positioned and flow rates to be controlled to approximate the natural delivery rate from the water column due to tidal and wind-driven currents. The bacterial 16S rRNA gene diversity was routinely monitored using polymerase chain reaction (PCR)/ denaturing gradient gel electrophoresis (DGGE) techniques, along with selective clone libraries and sequence analysis.

## 8.225

**Transitions in *Vibrio* spp. populations correlate with human impact in the Northern Line Islands**

**Robert SCHMIEDER*[1]**, Tracy MCDOLE[1], Elizabeth DINSDALE[1], Matthew HAYNES[1], Forest ROHWER[1], Robert EDWARDS[2]

[1]Department of Biology, San Diego State University, San Diego, CA, [2]Department of Computer Science, San Diego State University, San Diego, CA

The initial microbiological survey of the Northern Line Islands showed most cultured Vibrio species were found on Kiritimati, fewer on Tabuaeran and Palmyra, and least on Kingman. These islands are situated in a North/South gradient (from 0-6oN), where Kiritimati is the most southerly and largest and Kingman is the most northerly and smallest. These islands also display a gradient of human activity where Kiritimati has the most human activity and Kingman is unpopulated and protected from fishing. Tabuaeran and Palmyra are intermediates in all variables. In contrast to the culturing results, a culture-independent survey by metagenomics – randomly sequencing environmental DNA from these islands – showed a relatively consistent distribution of *Vibrio* spp. at each island. Neither the culturing nor the metagenomics could accurately identify the exact species present, so a multi-locus sequencing approach (MLSA) was used to analyze the water samples at each island. This analysis demonstrated that there is a consistent background of *Vibrio* spp. present everywhere and detectable by metagenomics, and supplemental strains present at the specific locations where *Vibrios* were readily cultured, i.e. on Kiritimati. To determine whether the changes in *Vibrio* population were biogeographic or human influenced, both culture-dependent and culture-independent surveys were conducted around Kiritimati Island were conducted. By studying Kiritimati only, latitudinal and island size effect was removed, but variation in human activity still remained. These surveys recapitulated the results of the previous analyses, and furthermore demonstrated a clear correlation between human population, *Vibrio* counts, and *Vibrio* spp., but no correlation with other prevailing factors (latitude, temperature, island size etc).

## 8.226

**Bacterial Growth On Coral Mucus**

**Gil SHARON*[1]**, Eugene ROSENBERG[1]

[1]Department of Molecular Microbiology and Biotechnology, Tel Aviv University, Tel Aviv, Israel

Coral mucus-degrading bacteria were isolated by an enrichment culture procedure. The isolates were able to grow as pure cultures on 10% sterilized mucus in seawater, yielding 108 CFU per ml. The isolates, mostly *Vibrio* strains, were classified by classical and molecular methods. When the 10% sterilized mucus was supplemented with glucose and then inoculated with the mucus-degrading bacteria there was a 2-fold increase in CFU per ml, whereas supplementation with NH4NO3 or K2HPO4 did not increase cell yield. The indigenous bacterial population of coral mucus increased from 103 to 108 CFU per ml when incubated at 30°C for 11 h, changing from a heterogeneous community to a *Vibrio*-dominated population. Factors which regulate the abundance and diversity of coral mucus bacteria are presented.

## 8.227

**Effect Of Temperature And Light Stress On Bacterial Communities in Aiptasia Pulchella**

**Nick JACHOWSKI*[1]**, Joel THURMOND[2], Kim RITCHIE[2]

[1]Stanford University, Stanford, CA, [2]Mote Marine Laboratory, Sarasota, FL

Populations of hard corals worldwide are declining due to mortality caused by bleaching and disease. In some cases, bacteria have been shown to be the cause of bleaching and disease. Corals naturally have microbial communities in their surface mucus that help to inhibit potentially malignant microbes from harming coral health. However, under conditions of environmental stress such as increased temperature, the beneficial microbial communities can break down, leading to an overgrowth of opportunistic, malignant microbes. In this study, *Aiptasia pulchella*, a model system for cnidarian-symbiosis, was subjected to different temperature and light regimes and the microbial communities were examined by terminal restriction fragment length polymorphisms (TRFLP) analysis. The six treatments used in the two-week-long experiment were: light (control), dark, cold-shocked and light, cold-shocked and dark, 3-(3,4-dichlorophenyl)-1,1-dimethylurea (DCMU) and light, heated and light. The cold-shocked treatments showed the greatest loss of zooxanthellae. The results of this study will further the understanding of the dynamics between environmental conditions and microbial communities in cnidarian symbioses.

## 8.228

**Coral Mucus Production By *acropora Cervicornis* And Its Utilization By Heterotrophic Bacteria**

**Ryota NAKAJIMA*[1]**, Kassim ZALEHA[2], Rahim AZMAN[3], Ross OTHMAN[3], Tatsuki TODA[1]

[1]Soka University, Tokyo, Japan, [2]KUSTEM, Terengganu, Malaysia, [3]UKM, Selangor, Malaysia

*In situ* mucus production by hard coral of *Acropora cervicornis* was measured quantitatively and the degradation of mucus by heterotrophic bacteria was investigated at Bidong Island, Malaysia. Mucus release rates for *A. cervicornis* were varied from 0.03 to 0.25 mg C $cm^{-2}$ $day^{-1}$ with an average of 0.09±0.09 mg C $cm^{-2}$ $day^{-1}$. We found approximately 70 % of the released mucus consisted of dissolved component and the remaining 30 % was particulate matter. Concentrations of inorganic nutrients in the mucus were relatively higher than that of the surrounding seawater. Phosphate concentrations were more than 100-fold higher in the coral mucus compared to the surrounding seawater. In the mucus degradation experiment, seawater-mucus mixtures were incubated and compared with control runs for 24 hours. The bacterial densities in the control runs stilly increased from $3.4\times10^5$ cells $ml^{-1}$ to $6.6\times10^5$ cells $ml^{-1}$ in the incubation period. On the other hand, the bacterial densities in the seawater-mucus mixtures considerably increased from $7.1\times10^5$ cells $ml^{-1}$ to $87.9\times10^5$ cells $ml^{-1}$. In the control runs, there were no substantial changes in the concentrations of dissolved and particulate organic carbon in the incubation media. However, concentrations of both dissolved and particulate organic carbon in the mucus mixtures were fairly decreased, which suggests that the heterotrophic bacteria consumed and degraded of organic matter in the coral mucus.

## 8.229

**Carbonate And Silicate Reef Sands From The Northern Red Sea Provide Different Micro-Habitats For Specific Bacterial Communities**

**Barbara PFITZNER*[1,2]**, Sandra SCHÖTTNER[1,2], Alban RAMETTE[2], Antje BOETIUS[2], Christian WILD[3]

[1]Coral Reef Ecology Working Group(CORE) GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-University, Munich, Germany, Munich, Germany, [2]Microbial Habitat Group, Max Planck Institute for Marine Microbiology, Bremen, Germany, Bremen, Germany, [3]Coral Reef Ecology Working Group(CORE) GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-University, Munich, Germany, München, Germany

In coral reefs of the Northern Red Sea the seafloor can be covered by either biogenous carbonate or terrigenous silicate sands. Often, both kinds of reef sands occur in direct vicinity to each other, thereby experiencing identical environmental conditions. However, previous research showed that natural organic matter is degraded much faster in carbonate compared to silicate reef sands of similar grain size. One possible reason for this finding may be that reef sands of different mineralogy may also host different microbial communities. This study presents the first data from comparative investigations on microbial community structure in carbonate and silicate sands associated with a shallow fringing reef off Aqaba, Jordan. Using ARISA, a high-resolution molecular fingerprinting tool targeting differences in the 16S-ITS region, bacterial diversity and specificity were analyzed in correlation to the sand mineralogy in a seasonal and vertical resolution. The results revealed significant differences in bacterial community structure between the two sand types at all investigated sediment depths, which suggests specific sand-microbe associations due to variations in micro-habitat structure. This finding is of particular importance concerning the microbial community composition in the sediment surface, which is directly exposed to and influenced by the input of organic matter from the overlying water column. It also became evident, that seasonal changes are reflected in the bacterial community patterns of the two reef sands, emphasizing the high dynamics of reef-sand bacteria. Overall, it can be concluded that coral-reef sands of different mineralogy favor very specific microbial colonization patterns, also over sediment depth and time, and therefore represent unique habitats for associated microbes. Further work will include the identification and quantification of sand-associated bacteria and the correlation of obtained diversity patterns with environmental parameters and biogeochemical data.

## 8.230

**Metabolic Profiling Of Microbial Communities Within The Surface Mucopolysaccharide Layer Of Corals**

**Kathy KILGORE*[1,2]**, Scott GRAVES[1], Roy YANONG[1], Craig WATSON[1], Ilze BERZINS[3]

[1]University of Florida, Tropical Aquaculture Laboratory, Ruskin, FL, [2]The Florida Aquarium, Tampa, [3]The Florida Aquarium, Tampa, FL

As part of a larger project involving coral reef restoration in the Florida Keys using colonies derived from aquacultured fragments, we attempted to characterize the metabolic diversity of the surface microbiota of seven species of Atlantic Scleractinia using Biolog® EcoPlates™. One of the overall goals of the project was to determine if survival and growth of reintroduced fragments was affected by various culture techniques (open ocean "control" site, land-based flow-through system, and greenhouse recirculating system). Further, preliminary data involving the identification of individual bacterial strains suggested that a shift in the coral surface microbial community occurs during times of disease. Therefore, we addressed two separate questions with the metabolic profiling methodology: 1) Do surface microbial communities shift during times of disease; and 2) will these populations also shift depending upon their culture conditions?

Samples of the surface mucopolysaccharide layer (SML) from two fragments of each species from the two land-based facilities were obtained after a six-month period in culture (December 2006). These samples were obtained by direct suction with a syringe and used to inoculate the EcoPlates™. Turbidity and tetrazolium peak data were collected for each sample every 12-24 hours for a 192-hour period. At that same time, those fragments that passed a health certification process were then transplanted to the field site with the "control" fragments. Subsequent SML samples from all three groups were obtained in May, August, and December 2007.

Microbial community analyses at the 72-hour time point using a Jaccard Index revealed similarities in the metabolic profiles of the coral SML at the two land-based culture sites as well as in comparing those to samples from the open ocean site. In contrast, comparison of healthy to diseased samples revealed differences in the metabolic profiles obtained.

## 8.231

**Characterizing Uncultured Coral-Associated Bacteria in Genotypically Distinct Colonies of *Acropora palmata* Using Universal 16S rDNA Primers**

**Pascal MEGE*[1]**, W. Owen MCMILLAN[2], María Gloria DOMÍNGUEZ-BELLO[1], Edwin HERNANDEZ DELGADO[1], Tomas HRBEK[1]

[1]Department of Biology, University of Puerto Rico - Río Piedras, San Juan, Puerto Rico, [2]Department of Genetics, North Carolina State University, San Juan, NC

Over the last three decades, Caribbean Elkhorn coral *Acropora palmata* and Staghorn coral *Acropora cervicornis* have suffered a considerable loss in numbers, resulting in their recent listing under the US Endangered Species Act. This reduction has been mainly attributed to White Band disease outbreaks. Because coral disease etiology is poorly understood, previous efforts have focused on better understanding the coral associated-bacteria that may act as a barrier to pathogens.

The aim of this study was to characterize the bacterial communities associated with five healthy and genetically distinct colonies from the same reef near Mona Island, Puerto Rico. Genotype identities were confirmed using six microsatellite markers. Utilizing universal bacterial 16S rDNA primers in PCR, 669 sequences were isolated from the five colonies (ranging from 94 to 158 sequences per sample). Sequence comparisons to the closest known bacteria using BLAST analysis confirm the species-specificity of the bacterial community structure as was previously reported for *A. palmata* and many other corals. 54% of our sequences matched the uncultured bacterium AY323179 with 98% similarity or more, a sequence originally isolated from Elkhorn coral (unpublished). Two additional observations were particularly remarkable: (1) the main taxa found in this study coincide with previous observations made for *A. palmata* (e.g. the majority of the sequences are Proteobacteria), but the ribotypes identified were mostly unknown; (2) Although species-specificity of the bacterial community structure was evident, there still was intra-specific variation between colonies, possibly as a result of their own genotypic variation.

Future work will explore the extent of within-species variation, and focus on its implication for coral defense mechanisms and possible contributions to conservation.

## 8.232

**Metamorphosis Decision Of *acropora* Larvae in Response To Mixtures Of Exclusive Cues From Environments**

**Masayuki HATTA*[1]**, Ayaka HORIKOSHI[1], Chie SASAKI[1], Yoshimi FURUTA[1]

[1]Marine and Coastal Biology Center, Ochanomizu University, Tokyo, Japan

Planula larvae of acroporids require positive cues from environments for the initiation of metamorphosis and settlement, and some calcareous algae and bacteria have been identified as metamorphosis inducers on the substrata indeed. We also isolated 3 novel bacteria strains that induce metamorphosis of acroporids, and they were identified as 2 independent species in the genus *Alteromonas*. Planulae may sense particular products by those bacteria and convert the external cues to internal signals that trigger metamorphosis and settlement. A neuropeptide GLWamide induces metamorphosis of acroporids as we have reported, so it is a candidate for internal cues as the "Go" sign. On the other hand, there would be also bacteria inhibiting settlement of planulae on substrata where various bacteria grow in nature. We screened bacteria that inhibit metamorphosis induction by GLWamide, and isolated two strains. One strain transiently inhibited the metamorphosis induction by simultaneous application with GLWa. The active material(s) appeared to be heat labile and larger than 5kDa. The other strain revealed a persistent inhibitory activity though it required 6hrs-pretreatments prior to the GLWa administration. Curious but a heat treatment enhanced the activity and split the active material(s) to two fractions of over and below 5kDa. The both strains turned out to belong to the genus *Pseudoalteromonas*. Another neuropeptide, RFamide, can transiently inhibit GLWamide-induced metamorphosis, and it is one of candidates for the corresponding internal signal molecules as the "Stop" sign. There would be a number of different positive and negative metamorphic cues in each small area of the substrata for larvae of acroporids in natural environments. There should be ecological strategies for larvae to make decisions on metamorphosis in response to the complicated situations that exclusive positive and negative cues are simultaneously displayed.

## 8.233

**The Impact Of Ph On Coral Bacterial Community**

Maoz FINE[1], Ehud BANIN[2], **Dalit MERON*[2]**

[1]faculty of life sciences, Bar Ilan University, Ramat GAN, Israel, [2]faculty of life sciences, Bar Ilan University, Ramat Gan, Israel

Rising concentrations of atmospheric carbon dioxide is acidifying the world's oceans. Surface seawater pH is already 0.1 units lower than pre-industrial values and is predicted to decrease by up to 0.4 units by the end of the century. This drastic change in pH may result in dramatic changes in the physiology of corals and other ocean organisms, in particular organisms that build their skeletons/shells from calcium carbonate. In a recent paper (Fine and Tchernov, Science 2007) our group reported that a decrease in pH (8.2 to 7.4) led to physiology alterations in the coral *Oculina patagonica* and *Madracis pharensis*, leading to complete dissolution of their skeleton. Interestingly the corals returned to calcify when returned, after a year, to ambient pH. This physiological change may lead to shifts in the holobiont members. (zooxanthellae, bacteria etc.). One such shift may involve coral associated microbial communities which in turn may affect the coral health. In the present study we examined interactions between the coral *Acropora eurystoma* and its microbial community following exposure to different pH treatments (7.3, 7.6 , 8.2) for 10 weeks. The changes in bacterial community in the coral mucus, tissue and skeleton were analyzed by DGGE, 16s rRNA clone library followed by sequencing, molecular and classical microbiology methodologies. Our preliminary results show changes in bacterial community between the treatments. These changes in bacterial communities and their impact on the coral will be presented.

## 8.234

**Functional Diversity of Microbial Communities Associated with the Mucus of Scleractinians around Moorea (French Polynesia)**

**Ophélie LADRIÈRE*[1]**, Laetitia THEUNIS[1], Annick WILMOTTE[2], Mathieu POULICEK[1]

[1]Unit of Marine Ecology, Laboratory of Animal Ecology and Ecotoxicology, University of Liège, Liège, Belgium, [2]Unit of Cyanobacteria, Centre for Protein Engineering, University of Liège, Liège, Benin

Mucus production by scleractinians appears as an antifouling mechanism which prevents settlement of other organisms and accumulation of sediments on their surface. This Surface Muccopolysaccharide Layer (SML) harbours dense populations of bacteria which play a paramount role in scleractinians nutrition, metabolism and good health maintenance. However, environmental disturbances can alter these microbiocenoses. Characterization of bacterial communities was carried out using a set of simple techniques that enable us to describe the state and functions of whole microbial communities associated with different hard coral species. Multi-comparisons have been performed on bacterial communities from open water, interstitial water, sedimentary interface and macro algae as well as between healthy and bleached colonies, and patches associated or not with Pomacentridae fishes.

The functional study included measurements of bacterial biomass, respiration, oxydative and hydrolytic metabolisms. Non-Fungiidae corals and sedimentary interface have a quite similar bacterial biomass but open water, interstitial water and macro-algae are characterized by higher bacterial biomass. Bacterial respiration potential is similar on corals and at the sedimentary interface, but it is higher in interstitial water and lower in open water and for bacterial community associated with macro-algae. Hydrolytic activities are highest in SML.

Bleached corals and patches associated with Pomacentridae fishes show more abundant bacteria, with higher respiration rate and higher hydrolytic activity than corals without fishes and healthy ones. In addition, bacteria of bleached corals display a higher division percentage, a higher growth rate and a lower turn-over time

We confirmed that bleaching events or the presence of sedentary fishes modify the bacterial communities structure and affect relationships between coral, endosymbiotic algae, SML-associated microbial community and associated organisms. Such results highlight that SML-bacterial communities are modified by bleaching and raise the question of a potential protection of fishes against pathogens.

## 8.235

**Prokaryotic Diversity Associated With Brazilian Corals**

**Monica LINS-DE-BARROS*[1]**, Ricardo P. VIEIRA[2], Ricardo COUTINHO[1], Maysa B.M. CLEMENTINO[3], Alexander M. CARDOSO[2], Aline TURQUE[2], Cynthia B. SILVEIRA[2], Vívian A. MONTEIRO[2], Orlando B. MARTINS[2]

[1]Instituto de Pesquisas do Mar Almirante Paulo Moreira (IEAPM), Arraial do Cabo, Brazil, [2]Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil, [3]Instituto Nacional de Controle de Qualidade em Saúde (FIOCRUZ), Rio de Janeiro, Brazil

Reef-building corals associate with a diverse array of microorganisms. Best known are dinoflagellates in the genus *Symbiodinium* ("zooxanthellae"), but studies indicate that individual coral colonies also host diverse assemblages of Bacteria and Archaea, some of which seem to have species-specific associations. The diversity of microbial associates has important evolutionary and ecological implications. Recent studies report the influence of these microorganisms as agents of coral diseases, such as coral bleaching. The present study aims to determine the diversity of the prokaryotic community structure associated with two Brazilian coral species, *Siderastrea stellata* and *Mussismilia hispida*. These species are characterized by different physiological responses to bleaching, the former being considered more resistant. Samples of colonies of both species were colleted from Tartaruga beach, in Búzios, Rio de Janeiro, Brazil (22o45`S; 41o54`W). Mitochondrial DNA sequences of the COI gene were determined for the two species and submitted to GenBank. The diversity of Bacteria and Archaea communities was analyzed using 16S ribosomal RNA surveys. Preliminary results indicated similar Archaea communities between the two coral species, including representatives from the marine Crenarchaeota, which are also reported as associates on tissue and mucus of other corals species. Further surveys, already in progress, aim to determine the bacterial community associated with these two coral species, which appear to form more species-specific associations with reef-building corals. Microorganism of bleach and unbleached corals are being also analyzed to detect agents potentially responsible to coral bleaching. This study represents the first report on Archaea diversity associated with Brazilian coral species.

## 8.236

**Coral Associated Microbial Community Diversity: Differences Between Impacted And Non-Impacted Reefs in Se Sulawesi, Indonesia.**

Corinne WHITBY[1], Boyd MCKEW[1], **Leanne HEPBURN*[1]**

[1]Biological Sciences, University of Essex, Colchester, United Kingdom

Microorganisms are of fundamental importance in reef systems through their role in carbon/nitrogen cycling, possible roles in nutrition and possible causal agents of coral disease. However, there is a paucity of information on the temporal and spatial changes in relation to habitat quality for the microbial populations associated with Indo-Pacific reefs. Coral mucus samples were collected from *Acropora* spp. and *Porites* spp. from both a non-impacted and an impacted reef, which was light-limited with a high sediment loading. Differences in bacterial community structure were characterised by denaturing gradient gel electrophoresis (DGGE) analysis of PCR-amplified 16S rRNA genes. Both coral species harboured diverse microbial communities, which were distinct from the surrounding seawater. Whilst greater similarities were observed between bacterial communities associated with coral colonies of the same species, DGGE profiles of communities from the two different sites were clearly distinct. These results suggest that whilst each coral species harbours a distinct bacterial community, environmental conditions also play a role in determining the bacterial community structure. This study contributes to the understanding of microbial communities associated with corals and the factors that may cause changes in microbial diversity, which may ultimately have implications on coral health.

## 8.237

**Coral-Bacterial Associations Vary Under Environmental And Experimental Conditions**

**Tracy AINSWORTH*[1]**, Ove HOEGH-GULDBERG[2]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, University of Queensland, Brisbane, Australia

The coral holobiont model proposes coral bacterial communities, in addition to symbiotic dinoflagellates, are an integral component of reef building corals. Documenting the natural diversity of bacterial communities within and closely associated to coral tissues provides information on the role and interaction of bacteria within the coral holobiont. Here investigate bacterial associations with coral tissues in both normal environmental and experimental conditions. This study aims to determine how these important interactions can vary as a result of experimental handling (collection, fragmentation and maintenance in aquaria) and under thermal stress conditions. A gamma-proteobacteria bacterial symbiosis is evident within the gastrodermis of various tropical coral species in the form of an aggregation of rod-shaped bacteria. *In situ* bacterial community dynamics are also found to vary due to handling stress and maintenance in experimental conditions. Both thermally stressed and experimentally maintained corals showed a shift of *in situ* bacterial communities, however complete bacterial colonisation of the tissues only occurred during thermal bleaching and breakdown of the coral-dinoflagellate endosymbiosis. This study demonstrates that natural bacterial community dynamics are rapidly altered during experimental conditions. This is an important consideration for the use of experimental studies that investigate the role of coral-bacterial associations on coral reefs.

## 8.238

**Coral Mucus As A Source Of Bacteria With Antimicrobial Activity**

**Maya SHNIT-ORLAND*[1]**, Ariel KUSHMARO[2]

[1]Environmental engineering, Ben Gurion University of the Negev, Beer-Sheva, Israel, [2]Biotechnology engineering, Ben Gurion University of the Negev, Beer-Sheva, Israel

In the oligotrophic marine environment there are ecological niches rich in nutrients and diverse in bacterial populations. One such niche is the coral surface mucus layer. Interactions amongst microorganisms found in coral mucus may be symbiotic or competitive; competing over space and food. It has been hypothesized that the microbial communities found on the coral surface may play a role in the coral defense, possibly through the production of antimicrobial substances. To find potentially active compounds produced by coral-mucus bacteria, over 200 selected microorganisms isolated from mucus layer of a number of scleractinian coral species were grown using agar plating technique. Screening for antimicrobial substances was performed using overlay and drop techniques, and antibacterial activity was tested against indicator microorganisms. Results indicated that approximately 25% of the mucus-associated bacteria demonstrated bioactivity. Isolates related to the genus *Vibrio* and *Pseudoalteromonas* demonstrated high activity against both gram positive and gram negative bacteria. Isolates related to the genus *Shewanella* demonstrated activity against gram positive bacteria. Gram positive bacteria (*Bacillus*, *Planomicrobium*) demonstrated lower activity, primarily against gram positive bacteria. These results demonstrate the existence of microorganisms with antimicrobial activity on the coral surface, indicating that they may play a role in protecting the coral host against pathogens. Further isolation and characterization of these active substances may lead to novel substances for use in medical and biotechnological applications.

## 8.239

**Changes in Coral-Surface Bacterial Communities Following Bleaching Induced Coral Mortality And Their Implications For Ecosystem Function.**

**Ron JOHNSTONE*[1]**, Mark DAVEY[1], Anna EDLUND[2], Sara SJÖLING[2]

[1]Centre for Marine Studies, University of Queensland, St Lucia, Australia, [2]School of Life Sciences, Södertörn University College, Huddinge, Sweden

The processing and remineralisation of carbon and nutrients by prokaryotes is critical to the development and sustainability of coral reef ecosystems - underpinning productivity at all trophic levels. Both the structure and function of coral associated bacterial communities can alter following a disturbance. This study investigated the differences in the primary colonization and early succession of bacteria on coral skeletons over time after coral mortality. Bacterial populations were characterised using denaturing gradient gel electrophoresis (DGGE) and terminal-restriction fragment length polymorphism (T-RFLP) analysis of the 16S rRNA gene. This determined there were significant differences in surface bacterial populations between live and dead coral and a clear succession of bacteria on dead coral surfaces over a period of 6 months after coral mortality. Sequencing of DNA fragments from DGGE additionally allowed identification of specific individuals. By assessing these changes in light of concurrent community metabolism studies there is clear indication that the changes observed in bacterial populations from living to dead coral may have significant consequences for biogeochemical process.

## 8.240

**Phenotypic characterization of a coral white pox pathogen, Serratia marcescens**

**Cory KREDIET*[1]**, Kim RITCHIE[2], Erin LIPP[3], Max TEPLITSKI[4]

[1]School of Natural Resources and Environment, University of Florida, Gainesville, FL, [2]Marine Microbiology, Mote Marine Laboratory, Sarasota, FL, [3]Environmental Health Science, University of Georgia, Athens, GA, [4]Soil and Water Science, University of Florida, Gainesville, FL

The surface mucopolysaccharide layer (SML) secreted by corals is a rich environment where bacteria proliferate, with population levels often being several orders of magnitude higher than in the surrounding waters. Colonization of coral SML and bacterial growth on coral mucus most likely requires specific regulatory genes and catabolic enzymes. However, the activities that are required for SML colonization by bacterial pathogens and commensals are not yet known. *Serratia marcescens* is an opportunistic pathogen that causes white pox disease of the elkhorn coral, *Acropora palmata.* To characterize mechanisms of SML colonization by the *S. marcescens* White Pox pathogen, its ability for carbohydrate catabolism was characterized. A complement of enzymatic activities induced by growth on coral mucus was identified using defined chromogenic (*p*-Nitrophenyl) substrates. N-Acetyl-B-D-Galactosaminadase, a-D-galactopyranosidase, a-D-glucopyranosidase, B-D-glucopyranosidase and a-L-fucopyranosidase were induced after two hours of *S. marcescens* incubation with coral mucus, while B-D-galactopyranosidase, a-L-arabinopyranosidase and B-D-fucopyranosidase were induced after eighteen hours of incubation. The characterization of glycosidases induced by growth on coral mucus demonstrates that *Serratia marcescens* relies on specific catabolic genes for its colonization of *Acroporid* SML. Induction of these specific enzymes also provides insight into the types of bonds found in coral mucus. A Biolog EcoPlate was used to characterize the ability of several isolates of *S. marcescens* to catabolize model carbon sources. The ability to utilize fourteen substrates was common to the isolates of *S. marcescens* isolated from humans, plant soft rots, channel water, and a White Pox lesion. The coral pathogenic *S. marcescens* was able to utilize no additional substrates while the known pathogenic isolates were capable of metabolizing 13 additional carbon sources. The repertoire of carbohydrate degrading enzymes in the coral pathogen is likely to be distinct from that of the human and plant pathogenic isolates.

## 8.241

**Free living Symbiodinium sp. existence in the rocky reef of the Pacific Coast of Colombia**

**Pedro CASTRO*[1]**, Juan A. SANCHEZ[2]

[1]Ciencias Biologicas, Universidad de los Andes, Bogota, Colombia, [2]Laboratorio de Biologia Molecular Marina, Departamento de Ciencias Biologicas, Universidad de los Andes, Bogota, Colombia

The major climate changes occurring in the Colombian pacific coast are producing dramatic transformations in the coral reef ecosystems. The free living dynoflagellate Symbiodinium sp. is a great biological indicator of the resilience of the reef. The hypothesis of the adaptive bleaching explains how the coral expels the less convenient symbionts and up-takes, from the water column, the better adapted ones to the actual conditions of the reef. Some studies have proven the actual existence of this free-living symbionts in the Indopacific ocean, the Caribbean sea, the Chinese sea and in the Australian great barrier.

The Gorgona Island is a continental-oceanic land mass located at 56 km of the Colombian Pacific coast. It possesses a perfect environment for the coral reef development. The coral reefs in Gorgona have been highly affected by the negative action of commercial fisheries and natives, plus the climatic phenomena such as the ENSO. These harmful environmental and human-induced factors almost resulted in the total loss of the coral ecosystem. Today a no-take Marine Protected Area has been established by the government to help to protect the marine Island Biodiversity. The main goal of this study was to isolate free-living zooxanthella from the water column taken from the surroundings of the Gorgona Island. The samples were cultured in a specific-Symbiodinium F/2 media, and subsequently analyzed using a number of molecular tools. Here we present ecological and molecular evidence demonstrating the existence of demersal free-living Symbiodinium populations in Pacific reefs. Different cultures were identified according to the nuclear internal transcribed spacer (ITS2) and posterior banding pattern (fingerprinting) with the Denaturing Gradient Gel Electrophoresis, DGGE. It is suggestive that predictions on coral-zooxanthellae symbiosis aclimatation/adaptation and reef resilience could significantly improve by including the occurrence of free-living zooxanthellae and their potential dispersers as part of the reef ecosystem

## 8.242

**Microbial Community Profile Of Coral Mucus From Recovering *porites* Ulcerative White Spot Disease**

**Miahnie Joy PUEBLOS*[1]**, Wolfgang REICHARDT[1]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines

The genus *Porites* has been reported as a dominant host to most of the diseases found in the Philippines, *Porites* Ulcerative White Spot Disease (PUWSD), of which is most prevalent. This study aims at observing changes in the microbial community in the mucus of both healthy and recovering colonies of *Porites cylindrica* using a molecular tool like Fluorescent *in situ* Hybridization (FISH) and a culture-dependent method such as plate counts. Mucus used for FISH was sampled from a coral colony via suction with the use of a sterile syringe while mucus used for plate counts was harvested by "milking," which involves exposing colonies to open air to induce the production of mucus and gentle spraying of sterile salt water. Preliminary observations under FISH, showed an increase and decrease of Vibrio species profile during the recovery period. In the plate count assay, mucus from healthy *Porites* sp. was incorporated into glycerol artificial seawater agar, to test against potentially invasive microbes found in the ambient water column, fish mariculture water and bacterial strains such as presumptive *Vibrio* isolated from PUWS. Plate counts on mucus-incorporated saltwater-glycerol agar media versus the presumptive *Vibrio* showed antibacterial properties that may possibly explain the recovery phenomenon observed in *Porites* corals affected by PUWSD. Both tools used in this study showed the possible role of *Vibrio* in PUWSD. Further studies should demonstrate how extensive this role is and show whether it is the causative or the recovery agent.

## 8.243

**Anti-Microbial And Antibiotic Resistance Of *vibrio Coralliilyticus* And Sister Phylotypes**

**Maria VIZCAINO*[1,2]**, Gregory S. MATTHEWS[3,4], Nikole E. KIME[1,2], Katherine WILLIAMS[1,2], Peter D.R. MOELLER[1,2], Pamela J. MORRIS[1,2]

[1]Marine Biomedicine and Environmental Sciences Center, Medical University of South Carolina, Charleston, SC, [2]Hollings Marine Laboratory, Charleston, [3]Hollings Marine Laboratory, Charleston, SC, [4]Grice Marine Laboratory, College of Charleston, Charleston

Vibrio coralliilyticus ATCC BAA-450, a temperature-dependent coral pathogen first isolated from the Indian Ocean and Red Sea, induces bleaching in Pocillopora damicornis at temperatures greater than 24.5°C. Currently, our research group is having the genome of this coral pathogen sequenced and is examining it's proteome at 24°C and 27°C. In addition to these two approaches, we are comparing the anti-microbial and antibiotic resistance and susceptibility profiles of this V. coralliilyticus strain and the sister phylotypes isolated from the southern coast of Puerto Rico. First, five bacterial isolates, obtained from the surface mucopolysaccharide layer of visually-diseased Pseudopterogorgia americana, showed 16S rDNA homology to V. coralliilyticus. Genomic profiling (REP-PCR) demonstrated that one isolate had a similar profile to ATCC BAA-450, while the other four were different (but similar to one another). Second, we examined whether bacteria isolated from healthy and diseased P. americana colonies were able to inhibit V. coralliilyticus grown at 24°C and 27°C. We observed that twelve (12/140) isolates inhibited V. coralliilyticus at 24°C, while only five strains inhibited growth at 27°C. Next, four of the sister phylotypes were screened against coral isolates that exhibited bioactivity in prior anti-microbial tests. Similarly to the ATCC strain, four of the sister phylotypes showed a high level of resistance to the anti-microbial activity of the coral isolates. This observed resistance increased at 27°C. Lastly, V. coralliilyticus ATCC BAA-450 and the four sister phylotypes were screened against 26 known antibiotics; and they all exhibited similar resistance and susceptibility profiles. To summarize, both V. coralliilyticus and Caribbean phylotypes showed similar levels of resistance in our anti-microbial (temperature-dependent) and antibiotic assays. This study will further contribute to our understanding of the pathogenicity of V. coralliilyticus and the similarity with sister phylotypes in a broader ecological context.

## 9.244

**Coral Recruitment At Sites With And Without Cyanobacteria Blooms On Midway Atoll, Nw Hawaiian Islands**

**Wendy A. COVER*[1]**, Donald C. POTTS[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA

Sufficient coral recruitment is essential for recovery of degraded reefs, but interactions with cyanobacteria may interfere with coral recruitment processes. We aimed to determine if coral recruitment is impeded locally by the seasonal presence of cyanobacteria on Midway Atoll (NW Hawaiian Islands). There are two primary sites within the lagoon that are impacted by seasonal blooms of the cyanobacterium *Hormothamnion enteromorphioides*. These sites were degraded by the dumping of scrap metal in the 1970's. We investigated coral recruitment patterns using settlement tiles at six sites in the backreef: two in the degraded areas, two in adjacent undisturbed areas, and two in farther, unimpacted sites. Tiles were in place for 13 months through July 2007. Coral recruits on all 60 tile sets will be counted and identified to genus level. Further insights into the role of cyanobacteria in these degraded areas will inform future management decisions.

## 9.245

**A Comparison Of Defensive Metabolite Production in Healthy And Diseased Sponges**

**Deborah GOCHFELD*[1,2]**, Haidy KAMEL[3]

[1]National Center for Natural Products Research, University of Mississippi, University, MS, [2]Environmental Toxicology Research Program, University of Mississippi, University, [3]Dept. of Pharmacognosy, University of Mississippi, University, MS

Sponges on Caribbean reefs represent tremendous biomass and biodiversity and perform numerous critical ecological roles. Thus, the health of sponges on reefs is important to the overall condition of these coral reef communities. In recent years, newly emerging diseases of sponges have been reported with increasing frequency. *Aplysina* Red Band Syndrome (ARBS) is a recently described disease affecting Caribbean rope sponges. Although the etiologic agent for ARBS has not yet been characterized, it is believed to be a filamentous cyanobacterium, which forms a red band that progresses along the sponge, leaving necrotic tissue behind. ARBS currently affects approximately 10% of *Aplysina cauliformis* on certain Caribbean reefs, and it is not clear whether this patchy distribution is due to mechanisms of pathogen transmission or differential resistance on the part of individual sponges. Some sponges produce antimicrobial chemical defenses that may protect them from pathogens. To investigate whether differences in chemical defenses may explain why some individual sponges are susceptible to ARBS and others are not, we compared chemical profiles from healthy and diseased sponges. Quantitative and qualitative differences in chemical constituents were found in tissues from healthy and diseased sponges. Both healthy and diseased sponges were feeding deterrent, thus, these compounds may represent antimicrobial chemical defenses that inhibit pathogenesis, inducible defenses in response to pathogenesis, or compounds of microbial origin from the pathogen itself or from other opportunistic microorganisms. Once potential sponge pathogens have been isolated, we will evaluate the antimicrobial activity of extracts and specific marker compounds.

## 9.246

**Taxonomy And Distribution Of Some Sponges Of Cebu, Philippines With Notes On Their Biomedical Properties**

**Ma. Belinda LONGAKIT*[1]**, Michelle KELLY[2], Filipina SOTTO[3]

[1]Extension Services Office, Cebu State College of Science and Technology, Cebu City, Philippines, [2]National Center for Aquatic Biodiversity and Biosecurity, National Institute of Water and Atmospheric (NIWA) Research, Ltd., Auckland, New Zealand, [3]Biology, University of San Carlos, Cebu City, Philippines

Twenty-nine species of sponges from Cebu were evaluated for their biomedical potential based on published literature. This is a preliminary step in establishing aquaculture of these sponges possibly to augment their future need. Fourteen species were cited as containing a variety of new and known bioactive compounds. These belong to 14 genera, 11 families and 6 orders. An assessment of the fourteen sponge species based on the number of compounds present, range of their bioactivity and their presence in the different stations around Cebu revealed that Hyrtios erecta (Keller, 1889) has the most number of compounds with bioactivity ranging from anti-microbial and anti-fungal to receptor-interaction-based to cytotoxic. It is widely distributed in Cebu thus, it is best recommended for aquaculture in the island. Biemna fortis (Topsent, 1897) and Plakortis lita de Laubenfels, 1954 are also good candidates for culture. Of the fourteen species, nine were present in San Francisco, Cebu station making it the most favorable place to conduct future aquaculture experiments of these sponges.

## 9.247

**Is There A Trade-Off Between Chemical Defense And Reproduction in Reef Sponges?**

**Wai LEONG*[1]**, Joseph PAWLIK[1]

[1]University of North Carolina at Wilmington, Wilmington, NC

As benthic sessile organisms, sponges need to invest in life functions such as growth and reproduction. Additionally, some sponges may produce defensive compounds in order to deter predation. As these processes are energetically demanding, species that produce defensive metabolites are expected to allocate fewer resources to growth and yearly reproduction. A trade-off has already been found between defense and tissue regeneration. To investigate if a trade-off also exists between defense and reproduction, monthly samples will be collected from five individuals (n=5) of defended (Amphimedon compressa, Aplysina fulva and Aplysina cauliformis) and undefended (Callyspongia armigera, Iotrochota birotulata and Niphates erecta) species from November 2007 to October 2008. Samples will be collected every two weeks during the months when the sponges are reproducing. The female reproductive propagules (ROI = % area of propagules / % area of slide) will be quantified using light microscopy. If total reproduction during the year is lower for defended species, it would provide support for the hypothesis that there is a trade-off between chemical defense and reproduction in reef sponges.

## 9.248

**Chemistry And Ecology Of A Coral Encrusting Marine Sponge, Terpios Spp., From Guam**

**Ingeborg IPING PETTERSON*[1]**

[1]Marine Lab, University of Guam, Mangilao, Guam

Comparisons of past studies on an unidentified encrusting marine sponge, *Terpios spp*., from Guam reveal conflicting results as to its substrate preference. Terpios spp. has been documented as growing on a diversity of substrates, and it is believed that it is able to encrust live coral tissue through the use of cytotoxic chemicals produced by the sponge or its associated bacteria.

We aim to gain insight on the substrate preference and growth of *Terpios spp*., as well as characterize its chemistry in terms of interesting biologically active compounds. Extractions were performed of *Terpios spp*. encrusting coral rubble, live Crustose Coraline Algae (CCA), and live coral. The 1 cm region of *Terpios spp*. directly bordering living CCA (attacking front) and the attacking front on live coral were also and extracted. All samples were lyophilized prior to extraction, and were characterized using High Performance Liquid Chromatography (HPLC) to determine any relative differences among samples from different substrates, as well as to identify the presence of any cytotoxic compounds. An as yet unidentified compound was found to be present in extracts from the attacking front on live coral at concentrations at least ten fold of that in other samples. This may be evidence of qualitative chemicals used by *Terpios spp* to specifically target, compete with and overtake its living coral substrate. Also, inoculation experiments using living and dead coral tissue showed that *Terpios spp.* more rapidly attaches and spreads on living coral tissue than dead coral.

## 9.249

**Feeding Preference, Growth Rate, And Secondary Chemical Substance Of The Nudibranch, *Jorunna Funebris*, Associated With The Blue Sponge, *Xestospongia* sp.**

**Voranop VIYAKARN*[1]**, Nalinee RASSAMETHUMMATHIKUL[1], Udomsak DARUMAS[1], Suchana CHAVANICH[1]

[1]Marine Science, Chulalongkorn University, Bangkok, Thailand

The feeding preference and growth rates of the nudibranch, *Jorunna funebris,* fed on the blue sponge, *Xestospongia* sp. were conducted. In addition, the relationship between the secondary chemical substances found in the nudibranch and its food source were investigated. The results showed that *Jorunna* was a prey-specific nudibranch fed only on *Xestospongia* sp. The growth rate experiments showed that the small size class (2 cm in length) of *Jorunna* had the highest daily weight gained (8.8%) while the medium size class (5 cm in length) had the highest daily length gained (3.6%). Moreover, the 12 and 24- hour feeding rate experiments showed that *Jorunna* fed both during the day and night. The chemical analysis showed that there was a relationship between the secondary chemical substance, renieramycin M, found in *Jorunna* and the chemical substance found in its sponge food source. When *Jorunna* was starved and was not allowed to feed on *Xestospongia,* the content of renieramycin M in the foot muscle of *Jorunna* decreased significantly. Recently, Thai scientists also found that the renieramycins from *Jorunna* can exhibit potent cytotoxic activity against cancer cells.

## 9.250

**Implications Of Inter-And Intra-Species Variation in Secondary Metabolite Chemistry Of The Genus Pseudopterogorgia**

**Maia MUKHERJEE*[1]**, Lyndon WEST[2], Howard LASKER[3]

[1]Odum School of Ecology, University of Georgia, Athens, GA, [2]Pharmaceutical and Biomedical Sciences, University of Georgia College of Pharmacy, Athens, GA, [3]Geology, University at Buffalo, Buffalo, NY

We have generated gas chromatography-mass spectrometry (GC-MS), high pressure liquid chromatography (HPLC), and nuclear magnetic resonance (NMR) data which serves as "finger-prints" to be applied as a complementary tool for identification of species within the genus Pseudopterogorgia. While the presence and absence of compounds will be useful in identification, the structural relationships among the compounds can delineate not only chemical, but also evolutionary relationships. Secondary compounds vary among species and the biosynthetic pathways producing the compounds are homologous traits which can be used for phylogenetic inference. Indeed some of the most intricate accounts of microevolution have been based on the evolution of secondary metabolites and chemical defense (Berenbaum 1990). Efforts to generate chemical fingerprints of samples of the genus Pseudopterogorgia have lead to the development of libraries that can be used for the rapid identification of Pseudopterogorgia spp. collected from the northern Bahamas and the Florida Keys. Additionally we have evaluated the variation in secondary metabolites amongst Pseudopterogorgia elisabethae collected from different locations, different depths along the same reef tract and at different times of the year. Pseudopterogorgia elisabethae is currently commercially harvested for the pharmacologically active compounds the pseudopterosins, and information about chemical variation across geographic, depth and seasonal gradients may prove useful for future management decisions regarding their harvest.

## 9.251

**Metabolic Response To Nutrient Enrichment in A Brazilian Coastal Benthic Community**

**Beatriz FLEURY*[1]**, Elaine PETRONILHO[2], Flávia COSTA[1], Renata PEDERNEIRAS[1], Angelo PINTO[2], Friedrich HERMS[3], Joel CREED[1]

[1]Departamento de Ecologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil, [2]Departamento de Química Orgânica, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil, [3]Departamento de Oceanografia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

The effects of anthropogenic activities on marine coasts have become a worldwide concern. One of the major stresses comes from the discharge of excessive nutrients from sewage into coastal waters, which leads to eutrophication. At the moment, there is no report in the Brazilian literature on the use of lipids from benthic organisms as markers for contamination of marine environments by organic pollutants. Therefore, a manipulative field experiment was conducted to investigate the impact of nutrient enrichment on the metabolisms of *Palythoa caribaeorum* (Zoanthidea), *Mussismilia hispida* (Scleractinia) and *Desmapsamma anchorata* (Porifera) at Ilha Grande Bay, Rio de Janeiro State. A randomized design comprised the fixation of fertilizer around the colonies along the coast. After 1 month, the lipids of these organisms were extracted with organic solvents, separately. The triacylglycerols were converted to fatty acids methyl esters by saponification and esterification. The FAMEs were analyzed by HRGC/MS, and showed predominance of palmitic, stearic, arachidic, arachidonic and EPA acids in *P. caribaeorum*; the same fatty acids and also behenic acid were found in *M. hispida*, and mainly 5,9-hexacosadienoic acid in *D. anchorata*. Monohydroxylated sterols were also identified in all organisms. The preliminary data on impact of the nutrient enrichment seem to show little difference in the capacity of synthesis of these metabolites in *Palythoa, Mussismilia and Desmapsamma.* However, future studies are important to confirm these results. These studies may help the development of strategies for appropriate management of the water quality in this environment.

## 9.252

**Antifouling Herbicides (Diuron And Irgarol 1051) Contamination On Coral Reefs And Adjacent Environments Around The Ryukyu Archipelago, Southwestern Japan**

**Sheikh ALI*[1]**, Taema IMO[1,2], Tomihiko HIGUCHI[1], Alrum ARMID[1], Hiroyuki FUJIMURA[3], Tanri FAHMIATI[1], Yuushi SHINODA[1], Akamatsu AYA[1], Toshihiko MIYAGI[4], Yasuharu UECHI[5], Tohru YOKOTA[5], Shigeki YASUMURA[6], Tamotsu OOMORI[3]

[1]Department of Chemistry, University of the Ryukyus, Japan, Nishihara, Japan, [2]Department of Chemistry, National University of Samoa, Apia, Samoa, [3]Department of Chemistry, Graduate School of Engineering and Science, University of the Ryukyus, Japan, Nishihara, Japan, [4]Okinawa Prefectural Institute of Health and Environment, Ozato, Japan, [5]Okinawa Prefectural Enterprise Bureau, Naha, Japan, [6]WWF Japan, Tokyo, Japan

The coral reefs around the Ryukyu Archipelago faced various threats in recent decades mainly caused by global environmental changes, anthropogenic activities such as marine pollution and biological survival competition. Diuron and Irgarol 1051 are recent herbicidal compounds, inhibitor of photosynthesis, used in antifouling paints. Diuron has been approved as an alternative compound for TBT as well as in agricultural activities in Japan. Large amounts of Diuron are used in the Okinawa Prefecture compared to other Prefectures in Japan. Due to toxic nature of Diuron, several European countries have restricted the use of Diuron in antifouling paints. We measured the concentration of Diuron in water and sediment samples collected around the Ryukyu Islands. The Diuron concentration ranged from not detected to 20ng/L in water and also from not detected to 10µg/kg in sediments. Irgarol 1051 residues are in the process of analysis. Spatial distribution and temporal variations were also observed. However, little is known on the occurrence and the impacts of Diuron and Irgarol 1051 in the coral reef ecosystem. Environmental behaviour and eco-toxicological impacts of Diuron and Irgarol 1051 on the carbon metabolism of corals will also be discussed in this paper.

## 9.254

**The Effects Of Dispersant (Corexit 9500), Physically And Chemically Dispersed Oil On The Symbiotic Soft Coral Xenia Elongata**

**Carys MITCHELMORE*[1]**, Michael TEASDALE[2], Denise YOST[2], Eileen BEARD[2], Joel BAKER[2], Walter HATCH[3]

[1]Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, [2]University of Maryland Center for Environmental Science, Solomons, MD, [3]St Mary's College of Maryland, St Mary's City, MD

Following an oil spill near a coral reef various response options may be considered. One option to prevent oil spills from impacting shorelines and mangrove systems is to use chemical dispersants. The tropical soft coral *Xenia elongata* were exposed for 8 hours to either physically-dispersed (dissolved PAHs) or chemically-dispersed (dissolved/colloidal/particulate PAHs and dispersant) oil fractions using weathered Arabian light crude and the dispersant Corexit 9500. The concentrations of oil used were driven by the dispersant-only toxicity limits (8 hour LC50 <50 ppm). Oil exposures also consisted of filtered (via 0.7 micron glass fiber filters) versus non-filtered preparations to investigate in more detail the route of exposure (dissolved, colloidal versus particulate fractions). We determined acute toxicity and assessed a variety of sublethal biomarker endpoints, including recovery and delayed responses after 30 days removal into clean seawater. Pulsing rate, pulsing intensity and rigidity were sensitive endpoints for the soft coral. Corals after 8 hours exhibited decreased pulsing rates and intensity in the dispersant and oil-dispersant exposures. Delayed mortality was observed in the oil-dispersant unfiltered exposure and at the end of the 30-days experiment growth rate was significantly reduced in the dispersant, filtered and non-filtered oil-dispersant exposures. Decreased dissolved oxygen content in the exposures were observed in the dispersant and oil-dispersant doses. Bioaccumulation of PAHs was from both the dissolved and colloidal fractions. Overall this study highlights that long-term and delayed responses of corals to dispersant and dispersed-oil occurs in the soft coral and that careful consideration should be given when applying dispersant near coral reefs.

## 9.255

**Analysis Of The Zoanthid *palythoa Caribaeorum* (Cnidaria, Anthozoa) As A Bioaccumulator Of Heavy Metals**

**Diego COSTA*[1]**, Carlos PEREZ[2]

[1]Zoology Department, Federal University of Pernambuco, Recife, Brazil, [2]Biology department, University Federal of Pernambuco, Recife, Brazil

The genus *Palythoa* is characterized to incorporate sediment in the layer mesogleal during his growth, acting as a sustentation structure. The zoanthid *Palythoa caribaeorum* is one of the species more abundant in Brazilian coast, being found from the south of Brazil to Florida. This study was developed during the dry and wet seasons, among the years of 2005 and 2006, in two beaches of the south coast of the Pernambuco, Brazil. The beach of Suape possesses an extensive reef and it is the most important harbor area for Pernambuco. The second area was the beach of Gamela located to 50km off Suape localizate in a Unit of Environmental Conservation (APA). The aim of this job was to compare the concentration of heavy metals of *P. caribaeorum* with the sediment and with two known bioaccumulators, the seaweed *Padina gymnospora* and seegrass *Halodule wrightii* among the two beaches. The analyzed metals were Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn. Suape and Gamela didn't present significant differences in relation to concentration of heavy metals and they possess characteristics of environments not much polluted. *P. caribaeorum*, *P. gymnospora* and *H. wrightii* had similar concentration to the sediment for all the metals in the two beaches. However, Nickel presented a greater significative concentration in the zoanthid than in the other organisms and than the sediment. This metal will be analyzed isolate in a future study. One of the explanations for the low concentration of metals in the zoanthids, may be the big size of particles of sediments that the animal accumulates in its tissues that hinder the quelant capacity of the heavy metals. For this reason, the species *P. caribaeorum* would not an efficient bioindicator of accumulation of heavy metals.

## 10.256

**Effects of Alternate Coral Reef States On Attraction, Settlement And Subsequent Survival Of Marine Invertebrate And Fish Larvae**

**David LECCHINI*[1]**, Pascal DUMAS[1], Suzanne MILLS[2], Eric PARMENTIER[3], Bernard BANAIGS[4], Dominique PONTON[1]

[1]IRD, UR 128 CoReUs, Noumea, New Caledonia, [2]EPHE, Perpignan, France, [3]University of Liege, Liege, Belgium, [4]INSERM University of Perpignan, Perpignan, France

Biodiversity is declining, and habitat degradation is now commonplace. Coral ecosystem degradation is usually characterized by coral mortality from natural and anthropogenic stressors. This decrease in coral cover causes a substantial increase in macroalgal cover which, in turn, limits the recovery of coral populations and thus modifies fish and invertebrate communities. Thus, areas experiencing perturbations often exhibit declines in adult populations, leading to a higher rate of species loss than in pristine habitats, and the persistence of species in the area becomes reliant on the rescue effects of recruitment. Yet, we do not know if the decline of marine organisms is due to increased mortality of adult reef organisms or due to a decrease in the degraded reef's recruitment potential, which could decline if 1) its properties have changed sufficiently to decrease its inherent attractiveness to planktonic larvae; 2) larval ability to locate preferred microhabitats has decreased; or 3) newly settled individuals' ability to survive to recruitment has decreased.

We will test the effects of alternate reef states on the attraction, settlement, and subsequent survival of marine invertebrate and fish larvae. We will present the first results acquired in French Polynesia (ANR Project and CRISP Program). For example, a series of laboratory, in situ and biochemical experiments was conducted to test how marine larvae respond to water-borne chemical cues originating from different reef states (degraded vs un-degraded habitat). This was followed by testing if the auditory signals originating from different reef states impact the selection of reef state by fish and invertebrates larvae.

## 10.257

**Abundance, distribution and taxonomic composition of juvenile scleractinian corals in coral frameworks at the Islas del Rosario archipelago, Colombian Caribbean**

**Tomás LÓPEZ*[1]**, Raúl NAVAS-CAMACHO[1], Diego L. GIL-AGUDELO[1]

[1]INVEMAR, Santa Marta, Colombia

This study aimed to evaluate the juvenile coral community structure in Islas del Rosario, one of the most important coral reefs in Colombia that nowadays is showing signs of deterioration. Census of abundance and taxonomical identification of juvenile corals were carried out in eight zones with coral frameworks, assesing two depths using sampling bands of 30m2. Depth, reproductive strategies, non-juvenile coral community structure and mortality rates of juvenile corals were factors included in this study in order to analyze their relation with the juvenile community found. A total of 2622 juvenile corals, belonging to 18 taxa, were recorded, of which Agaricia spp. and Porites astreoides, being brooders or planulators, were the most abundant. Those taxa including massive species, generally spawners, showed low abundance, being infrequent at juvenile stage. Taxa richness and density of juvenile corals were considered low. Depth did not significantly affect juvenile coral densities; even though, it did influence the community structure since patterns of zonation of the communities sampled, were found in accordance with this factor. Positive correlation between juvenile and non-juvenile densities was found according to depth and reproductive strategy. Coral juvenile structure could be indicating a phase shift in the coral communities of Islas del Rosario Archipelago, in which massive long-living corals which presented lower juvenile densities, seem to be replaced by corals with short-living strategies which showed numerous juveniles. Mortality found could be reflecting that previous events to recruitment determine in a broader way the coral community structure in the Archipelago.

## 10.258

**Coral Recruitment On Reefs With Intact Fish Communities: Early Results & Hypotheses**

Daniel BRUMBAUGH[1,2], **Katherine HOLMES*[1]**, Robert STENECK[3], Suzanne ARNOLD[3], Douglas MCCAULEY[4], Hillary YOUNG[5]

[1]Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, [2]National MPA Center, NOAA, Santa Cruz, [3]Darling Marine Center, University of Maine, Walpole, ME, [4]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [5]Department of Biological Sciences, Stanford University, Stanford, CA

Although coral recruitment is a key component of reef resilience, relatively little is known about how recruitment interacts with other ecological processes that also contribute to ecosystem-level resilience. In particular, the types and intensities of couplings between fish communities and coral recruitment remain particularly unclear, largely because of the limited research on reefs with intact fish communities. To help fill this gap, we have initiated studies of recruitment and related processes on Palmyra Atoll in the northern Line Islands of the central Pacific. Due to its isolation and history free from substantial human populations (with the exception of occupation during World War II), Palmyra Atoll supports fish communities that are considered to be relatively intact and pristine. Terracotta settlement tiles (n=180), situated at three locations and three depth zones across back and forereefs around the atoll show significant spatial heterogeneity in background levels of coral recruitment. A four-month experiment, in which additional tiles (n=66) were placed inside cages that excluded large fish, showed a transient increase in recruitment on caged tiles, followed by low survivorship across all treatments. Further observations and analysis suggest the substantial direct and indirect roles of grazing by parrotfishes and surgeonfishes in structuring benthic communities dynamics. For example, a grazing tolerant crustose coralline alga, *Porolithon onkodes*, dominates upper reef surfaces, and the balance between *Porolithon* growth and grazing injury appears to influence the dynamics of recruitment. These preliminary results illustrate some of the complex interactions between fish, algae, and corals in early community succession in intact reef communities.

## 10.259

**Contrasting Effects of Benthic Algae on Coral Recruits in an Upwelling Reef from the Colombian Caribbean**

**Dagoberto VENERA-PONTON*[1]**, Guillermo DIAZ-PULIDO[2], Laurence MCCOOK[3], Alejandro RANGEL-CAMPO[1]

[1]Instituto de Investigaciones Tropicales-INTROPIC, Universidad del Magdalena, Santa Marta, Colombia, [2]Centre for Marine Studies and ARC Centre of Excellence for Coral Reef Studies, University of Queensland, Brisbane, Australia, [3]Great Barrier Reef Marine Park Authority-GBRMPA, Townsville, Australia

Reef degradation generally involves the replacement of hard corals cover by benthic algae. A successful recovery of coral populations will depend on the competitive ability of corals to settle, recruit, growth and survive on habitats dominated by benthic algae. Most studies on coral-algal interactions and on the impacts of algae on the recovery of coral populations have focused on the roles of algae on coral settlement and adult performance; however, there is very little known about the effects on the survival of coral recruits, a critical step in the resilience of coral reefs. Here we present the results of an experiment investigating 1) whether coral recruits actually compete for space with the surrounding benthic algae; 2) the effects of benthic algae on the growth and survival of coral recruits, and 3) the roles of algae on parrotfish predation on coral recruits. The study used recruits of the coral Porites astreoides and was carried out in the Tayrona National Natural Park in the Colombian Caribbean during two contrasting climatic and oceanographic seasons (upwelling and non-upwelling). We found that the growth of recruits of the coral P. astreoides was significantly increased when the surrounding algae were removed while a weak algal colonization occurred when the coral recruits were damaged. These results were consistent among the upwelling and non-upwelling seasons and constitutes an unequivocal proof for competition between algae and coral recruits. The coral recruits were bitten by parrotfishes only when the surrounding algae were removed and it was also consistent among the two seasons. This suggests that benthic algae may actually protect coral recruits from parrotfish damage. Our results illustrate the complexities of the effects of coral reef algae on the early life history stages of corals.

## 10.261

**Influence Of *palythoa Caribaeorum* (Anthozoa, Cnidaria) Patches On Reef Fish Community in Subtropical Rocky Shores**

José P. MENDONÇA-NETO[1], **Laís C. T. CHAVES*[2]**, Carlos E. L. FERREIRA[3], Cassiano MONTEIRO-NETO[1], Renato C. PEREIRA[1]

[1]Departamento de Biologia Marinha, Universidade Federal Fluminense, Niteroi, Brazil, [2]Departamento de Oceanografia, Universidade Federal de Pernambuco, Recife, Brazil, [3]Departamento de Biologia Marinha, Universidade Federal Fluminense, Niterói, Brazil

This work aimed to test the influence of the *Palythoa caribeorum*, a Zoanthid widely distributed in the Atlantic, on the fish community of Arraial do Cabo rocky reefs, Southeastern Brazil. Abundance, diversity and vertical distribution of reef fish inside (ID) and outside (OD) previously chosen *P. caribaeorum* dominance patches were compared among two different sites. Replicated visual stationary censuses were conducted through different bathymetric zones: shallow (~0-3m); intermediate (~3-6m) and bottom (~6-9m). Sites were revisited during one year period effort (SEP06/ OCT07). A total of 180 censuses were conducted; 30 censuses on each bathymetric reef zone. Percentage cover of *P. caribaeorum* and other benthic organisms were obtained analyzing random points from replicated photo-quadrats (n = 30). This work resulted in 45 species belonging to 25 families. The ten most abundant fishes for both sites comprised together 65% of all fishes recorded during this study. Despite sites presented similar components on reef fish community, they differed in abundance (ANOVA, p=0.003) and richness (ANOVA, p=***), where OD patches presented higher values. We also recognized two major benthic communities occupying the same depth zones: the algal community, in which turf algae was dominant and the zoanthid community, which was dominated by *P. caribaeorum*. In overall view, differences between fish community among patches could be attributed to particular species for swimming ability and ontogeny. Results seem not to indicate direct effects of *P. caribaeorum* on reef fish community, despite some evidence that these areas might play a important role in space limitation by structuring neighboring benthic community and consequently, fish community.

## 10.262

**Reproductive fitness consequences of parrotfish predation on a tropical reef-building coral: small damage, large consequence**

**Randi ROTJAN*[1]**, Sara LEWIS[2]

[1]Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, [2]Department of Biology, Tufts University, Medford, MA

The trophic role of Caribbean parrotfish on coral reefs is controversial: while parrotfish are classically known for their role as important reef herbivores, they are also significant corallivores that selectively graze species of important reef-building corals in the *Montastraea annularis* species complex. While the benefits of parrotfish herbivory for coral reef resilience and conservation have been extensively documented, the consequences of parrotfish grazing for coral reproductive fitness have not been previously examined. We examined colonies of *Montastraea annularis* corals that had been recently grazed (within 2 weeks of sampling) by parrotfishes in order to examine whether grazing was positively associated with coral reproductive effort. We measured gonad number, egg number and size, and proportional reproductive allocation for grazed and intact *Montastraea annularis* colonies 2-5 days prior to their annual spawning time. We found that parrotfish selectively grazed coral tissue areas with high total reproductive effort (number of gonads), providing the first evidence that parrotfish selectively target specific tissue areas within a single coral colony. Our data suggest that the removal of polyps with high reproductive effort has direct adverse affects for coral colony fitness, with additional indirect implications for colony growth and survival. However, nearby *M. annularis* colonies showing high reproductive effort were not grazed by parrotfishes, suggesting that some colonies are defended against grazing. We conclude that chronic grazing by parrotfishes has negative fitness consequences for these reef-building corals, and that these previously underappreciated impacts have the potential to adversely affect reef ecosystems.

## 10.263

**Evolutionary Ecology Of Sponge-Cyanobacteria Symbioses**

**Robert THACKER*[1]**, Patrick ERWIN[2]

[1]Department of Biology, University of Alabama at Birmingham, Birmingham, AL, [2]Center for Marine Science, University of North Carolina at Wilmington, Wilmington, NC

Symbioses between sponges and cyanobacteria are common on coral reefs, with cyanobacterial symbionts including filamentous *Oscillatoria spongeliae* and unicellular *Synechococcus spongiarum*. We investigated the filamentous symbionts associated with two recently described species from Caribbean Panama, *Haliclona walentinae* and *Xestospongia bocatorensis*, and the unicellular symbionts associated with *Aplysina fulva* and *Neopetrosia subtriangularis*. We shaded *A. fulva* and *N. subtriangularis* to examine the effects of reduced light availability on symbiont load and host growth. We estimated the photosynthetic capacities of cyanobacterial symbionts of all four host sponges by measuring changes in dissolved oxygen concentrations in light and dark conditions. We also amplified and sequenced cyanobacterial 16S ribosomal RNA genes from each host. Six weeks of shading reduced symbiont load in *A. fulva* and *N. subtriangularis* by over 40%. In *A. fulva*, control sponges exhibited twice the growth of shaded sponges. In *N. subtriangularis*, no significant difference in growth was observed between control and shaded sponges. We observed no significant differences in respiration among the sponges tested; however, *Haliclona walentinae* and *Xestospongia bocatorensis* exhibited higher oxygen production than *A. fulva* and *N. subtriangularis*. A phylogeny of cyanobacterial 16S ribosomal RNA genes recovered from each sponge species confirmed that the symbionts of *Haliclona walentinae* and *Xestospongia bocatorensis* are part of the *O. spongeliae* clade and that each sponge hosts a unique ribotype of this vertically transmitted symbiont. The cyanobacteria hosted by *A. fulva* and *N. subtriangularis* are part of the *S. spongiarum* clade, which shows less host specificity despite evidence of vertical transmission. Ecological interactions between sponges and their cyanobacterial symbionts vary among host species, spaning a range of interactions from commensalisms to facultative and obligate mutualisms.

## 10.264

**Growth strategy of a dominant reef-building coral in the southern Caribbean: *Agaricia tenuifolia***

**Silvia CACERES*[1]**, Juan Armando SANCHEZ[2]

[1]Biologia, universidad de los Andes, Bogota, Colombia, [2]Biologia, Universidad de los Andes, Bogota, Colombia

Shifts have occurred in the coral community structure at Caribbean reefs, particularly regarding dominance, which are not yet understood completely. The branching scleractinian coral, *Agaricia tenuifolia* (thin leaf lettuce coral), is the dominant coral species in shallow reefs at many Southern and Western Caribbean reefs. To estimate the population fluctuation and growth strategy colonies of *A. tenuifolia* in the Southern Caribbean (Cartagena, Colombia) were followed over a year and a half using photograph censuses and *in situ* growth measurements. A size class model was generated in order to estimate colonial growth rate and clonal processes (e.g., fission and fusion events). Overall population abundance was stable over the monitored period, but differed between locations. The largest size class was directly responsible to the dominant abundance of *A. tenuifolia*. Mortality patterns were not correlated to colonial size classes and were variable in space and time. Fusion was also an important process in *A. tenuifolia* but not as common as fission. Colonial growth rate was correlated to the colony size class, the interaction between the location and the size class, the aggregation of multiple colonies and possibly multiple genets. Clonal strategies, as bet hedges, allowed species like *A. tenuifolia* to avoid the vulnerability to survive and compete that is often associated with early post-settlement larvae. The *A. tenuifolia* population showed a dynamic life pattern with variable rates for clonal processes that play an important descriptive role of the population together with the size distribution frequency. *A. tenuifolia* is normally extracted as a souvenir in the Southern Caribbean. Quantifying the changes in the population structure and size frequency is important to manage this resource as it is necessary to perform long-term observations and coral extraction experiments.

## 10.265

**Zoantharia Habitat Preference Depending On Host Sponge Morphology**

**Alberto ACOSTA*[1], Javier MONTENEGRO*[2]**

[1]Biology, Pontificia Universidad Javeriana, Bogota, Colombia, [2]Pontificia Universidad Javeriana, Bogota, Colombia

Population's habitat preference is hard to estimate for some species due to their complex life histories, spatial and temporal variation in resource selection criteria by organisms, and difficulty in habitat delimitation. Some symbiotic genera of zoantharian (Hexacorallia) can serve as optimal models to evaluate habitat preference, not only because their habitat (host sponge) could be easily delimited, but also because the habitat selected by larvae will have an effect in the fitness of the adult colony. According to this, we studied the *Parazoanthus* and *Epizoanthus* genera in order to demonstrate whether their habitat preference is related to sponge (host) morphology. The presence/absence of zoanthids in a total of 1,068 sponges was recorded in San Andres Island (Caribbean). The sponge shape was categorized as: cup, tubular, encrusting, globular and branching, and the mechanic resistance (MR) as: compressible, elastic, and fragile. Habitat preference was evaluated using the most important indices and Bonferroni confidence intervals. 109 zoantharian colonies were associated to sponges (10.2%) of which 85 and 24 were *Parazoanthus* (8.0%) and *Epizoanthus* (2.2%) respectively. The colony frequency of both genera was significantly dependent of the sponge shape and MR ($p<0.01$). The niche amplitude index (Shannon-Hulbert) indicated that sponges are not used uniformly by the symbionts. All indices suggested that zoanthids prefer branching and encrusting sponges, and also fragile and compressible MR. However, the Bonferroni confidence interval indicated that *Parazoanthus* use branching shape and compressible MR but prefers encrusting and fragile sponges, while *Epizoanthus* showed the opposite pattern. These results indicated that sponge morphology may be an important issue for Zoantharia larvae habitat selection. On the other hand, habitat use suggested a potential interspecific competition (host shape-MR) between both genera, while the differential habitat preference revealed a possible outcome of coexistence competition.

## 10.267

**Coral Recruitment Around Southern Taiwan**

**YI-TING JHENG*[1]**, Tung-Yung FAN[2]

[1]Institute of Marine Biodiversity and Evolution, National Dong Hwa University, Taiwan, Pingtung, Taiwan, [2]National Museum of Marine Biology and Aquarium, Taiwan, Pingtung, Taiwan

Coral recruitment plays an important role in determining population and community dynamics of coral reefs as well as the recovery of coral reefs following damage. In this study, the variability of coral recruitment in coral reefs around southern Taiwan was examined in order to test the effects of spatial variation and substratum orientation on coral recruitment. Twenty settlement tiles (10?0?.7 cm) were fixed on the substratum at 5-9 m depths at each of 13 sites scattered haphazardly along 65.9 km of the shore of southern Taiwan. The tiles were replaced and examined for the presence of coral recruits at 6 month intervals over 1 year. The preliminary results show that the mean recruitment rate ranged from 3.7 to 10.8 recruits tile-1 with the highest recruitment of 39 recruits on 1 tile during April-September 2007. The proportion of recruits on the lower surface of the tiles (89.4%) was higher than on either the upper surface (3.7%) or the sides (6.9%). In addition, the proportion of recruits settling on the 2.5 cm wide perimeter of the lower surface of the tiles (74.7%) was higher than on the inner area portion of the lower surface (25.3%). The coral recruitment rates reported here are higher than document in previous studies in Taiwan. They suggest suggests that recruitment processes plays an important role in maintaining the coral abundance in this location.

## 10.268

**Bioecological Study of Eightband butterflyfish (Chaetodon octofasciatus, Bloch 1787) to Detect Condition of Coral Reef Ecosystem in East Petondan Island, Seribu Islands, Indonesia**

**Hawis MADDUPPA*[1]**, Neviaty PUTRI ZAMANI[1], Unggul AKTANI[2]

[1]Marine Science and Technology, Bogor Agricultural University (IPB), Bogor, Indonesia, [2]Aquatic Living Resources Management, Bogor Agricultural University (IPB), Bogor, Indonesia

Monitoring the changes of coral reefs is an important task considering many of the world's coral reefs have been destroyed or degraded. Certain members of an easily identifiable conspicuous family of fish, Chaetodontidae, have been considered to be reliable indicators of reef health (Hourigan *et al.* 1988; Ohman *et al.* 1998, Berumen *et al.* 2005). The present study was conducted in East Petondan Island, belonging to Kepulauan Seribu, north of Jakarta. Data of *Chaetodon octofasciatus* are based on field observation using SCUBA diving on the reef slope (3 and 10 meter). Food and feeding habit analysis were conducted in the laboratory. The percent coverage of living corals was estimated on the reef slope at all sites by 50 m line transects. By using belt transects according to Brock (1982) and English et al. (1997), the abundance of *C. octofasciatus* and the occurrence of each coral genus were counted and recorded. Feeding rates were calculated by observing randomly selected species at the study area. Ivlev's electivity index was used to measure feeding selectivity, comparing the utilization of food with respect to its availability. The feeding bites seem to be larger in rich reef corals with high percentage of live coral**.** The feeding rates in south, west and north site which show a high percentage of live coral are highest compared to the east site which show a low percentage of live coral. The fish stomach contains more than 90% coral nematocysts which indicated *C. octofasciatus* as an obligate coralivore. The highest number of *Chaetodon octofasciatus* was found in a habitat dominated by *Acropora* spp. So this species can be considered as an indicator for the condition of the coral reef ecosystem which is dominated by branching *Acopora* spp.

## 10.269

**Variation in Coral And Macroalgae Recruitment At The Coral Beach Nature Reserve, Eilat, Northern Red Sea: A Case Of Competition For Settling Space?**

**David ZAKAI*[1]**, Zvy DUBINSKY[2], Noga STAMBLER[2]

[1]Israel Nature & National Parks Protection Authority, Eilat, Israel, [2]Faculty of Life Sciences, Bar-Ilan University, Ramat-Gan, Israel, Ramat-Gan, Israel

The interaction between coral and seaweed recruitment is important to the understanding of the dynamics and potential causes for the decline of coral reefs. During a period of 4 years, we monitored the abundance and size of stony coral juveniles, and algal biomass recruitment, simultaneously to the same artificial substrates at sites within the Coral Beach Nature Reserve of Eilat, northern Red Sea. Variation was assessed on a) 3 spatial: between racks, sites, and plate faces, and b) 2 temporal: between seasons and years scales.

Coral recruitment was significantly lower in summer, when algal chlorophyll was most abundant. However, most corals recruited during spring, when algal chlorophyll was low. Algae preferentially settled on the upper well-illuminated faces, whereas corals were more abundant and grew larger on the lower, shaded sides. The numbers of coral recruits were negatively correlated with algal biomass on the upper plate surfaces. This study also showed that chlorophyll a biomass larger than 1 æg/0.01 m2 may reduce coral recruitment and size. Our results might indicate interference of macroalgal proliferation with coral recruitment.

## 10.270

**Some sponges don't bleach**

**Christine SCHÖNBERG*[1]**, Ryota SUWA[2], Michio HIDAKA[2], William Kok Weng LOH[3]

[1]Dept. of Animal Biodiversity and Evolution, Carl von Ossietzky University, Faculty 5, Biology and Environmental Sciences, Oldenburg, Germany, [2]Department of Marine and Environmental Science, University of the Ryukyus, Graduate School of Engineering and Science, Okinawa, Japan, [3]Marine Biology Australia, PO Box 6112, St. Lucia, QLD 4067, Australia; and CMS, QLD Uni, Australia, St. Lucia, Brisbane, Australia

Symbiotic coral reef organisms are under increasing environmntal pressure. Related studies are mostly concerned with reef builders. That bioeroding sponges contain dinoflagellate symbionts (zooxanthellae) is less well known. However, it may be possible to learn from this symbiosis, which appears to be comparatively robust and has never been observed to fail in nature. In this context *Cliona orientalis* Thiele, 1900 was studied. It is a common Indo-Pacific bioeroding sponge, which can attack live coral, is a representative of the *Cliona viridis* (Schmidt, 1870) species complex, which occurs in all warm and temperate seas, and plays an important role in benthic calcium carbonate cycling. Our data showed that the sponge-zooxanthella symbiosis is younger than other known invertebrate-zooxanthella associations. Only subclade G-type *Symbiodinium* was found in these bioeroding sponges taken from locations thousands of kilometers apart. The symbionts appear to be transferred maternally to form a very close relationship with the sponge, e.g. supporting its growth. Approaches to experimentally bleach *C. orientalis* failed, and we could not detect clear evidence of heat or light stress during experiments. The stability of the symbiosis is partly related to the stress resistance of G-type *Symbiodinium*, and partly to protection by the host. The symbionts can be shifted within the sponge and are transported away from the source of stress. This behaviour, the sponge's endolithic life style and its three-dimensionality provide very efficient shelter. Additional protection may be obtained from a bright yellow pigment that appears when the sponge is exposed to adverse conditions. Overall, the sponge-zooxanthella symbiosis is extraordinarily strong, and we have noted significant increases in sponge abundances in disturbed habitats where coral mortality was high.

## 10.271

**Probing Into Hard Substrates – Growth Habits Of Bioeroding Sponges**

**Christine SCHÖNBERG*[1]**, Lydia BEUCK[2]

[1]Animal Biodiversity and Evolution, Carl von Ossietzky University, Faculty 5, Biology and Environmental Science, Oldenburg, Germany, [2]Institute for Palaeontology, University of Erlangen, Erlangen, Germany

Traditionally, bioeroders have been studied by medical radiographic and cast techniques. These methods have significantly improved over the last 10 years and presently allow viewing in three dimensions and as animation, thus enabling studies in unprecedented detail. The application of anaglyph technique on three-dimensional images and animations further enhances the spatial visualisation, permitting even the interpretation of dense and interwoven trace assemblages often present in long-term exposed calcareous substrates. We show a few examples of erosion caused by bioeroding sponges in various samples from the Australian Great Barrier Reef and Atlantic and Mediterranean cold-water corals. While cast techniques display features 'in negative', micro-computed tomography allows the investigator to view the material as if the substrate were transparent. Traces of different species can easily be recognised, precisely pictured and displayed, especially supported by the application of the anaglyph technique. As an example, the two bioeroding sponges *Cliona orientalis* Thiele, 1900 and *Cliona celata* Grant, 1826 develop very different patterns of destruction, with the former eroding very uniformly and densely, while the latter has larger canal diameters in the centre and thins out towards the margins. We further show images of erosion obtained from cold-water reefs, with sponges such as *Aka, Pione* and *Alectona* displaying aspects of their co-existence and interspecific interactions.

## 10.272

**Impact of the invasive native algae Caulerpa sertularioides on coral reef communities in Culebra Bay, Costa Rica (Eastern Pacific)**

**Cindy FERNÁNDEZ*[1]**, Juan José ALVARADO[1], Jorge CORTÉS[1]

[1]Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica, San José, Costa Rica

The green algae Caulerpa sertularioides is spreading in the seasonal upwelling region of the northern Pacific coast of Costa Rica (Culebra Bay). It seems that this macroalgae is the cause, and not the consequence, of coral degradation of the reef ecosystem. The spread of C. sertularioides negatively affected the growth rate of the branching corals such as Pocillopora elegans and Psammocora stellata. Coral growth declined mainly due to accumulation of sediments, abrasion and overgrowth of the algal fronds. This last impact did not seem to effect the survival of P. elegans due to the presence of symbiont crabs (Trapezia spp.) that constantly cropped the algae. Intensity of the algal impact on the corals varied with areal cover and density of the algal fronds, which were dependent on the amount of nutrients and the water temperature. Algal cover and frond density were highest during seasonal upwelling, while coral growth was highest in the non-upwelling season when algal cover and frond density decreased. The propagation of C. sertularioides also caused modifications in the structure of other components of the benthic community as its presence affected the abundances of invertebrates such as nudibranchs and polychaetes and displaced other algal species.

## 10.273

**Effect Of Hurricane John (2006) On Invertebrates Associated With Coral in Bahía De La Paz, Gulf Of California**

Luis HERNANDEZ[1], **Eduardo BALART*[1]**

[1]CIBNOR, La Paz, Mexico

Every quarter for the past four years, surveys of 10 m × 1 m sample areas at six sites at a coral reef community, with five replicates, were undertaken near Bahía de La Paz. This study describes the effect of Hurricane John (level II, 216 km/h winds) on the assemblage of invertebrates on the reef and documents the conditions prior and previous to the hurricane. Physical damage to the coral reef included fragmentation of coral branches and changing the sandy gravel bottom with surviving coral fragments. Prior to the hurricane (July 2006), the surveys averaged 50 species (3093 specimens). After the hurricane (October 2006), the surveys located only 39 species (2018 specimens). Similarity Index for these two months was 83.1%. After the hurricane, 13 species were lost, but three species were new for this area. The most affected group was echinoderms, with the disappearance of six species. Two of the new species were crabs. One year after Hurricane John (October 2007), the community had recovered 38% (five) of its lost species. These were three echinoderms and two mollusks.

## 10.274

**Factors Influencing Coral Recruitment Patterns in The Sulu Sea Marine Corridors**

**Jeneen GARCIA*[1]**, Porfirio ALINO[2]

[1]Institute of Environmental & Marine Sciences, Silliman University, Dumaguete City, Philippines, [2]Marine Science Institute, University of the Philippines, Quezon City, Philippines

Coral recruitment studies provide crucial information on a reef's capacity to recover from disturbances in the form of catastrophic events, such as storms and mass mortality from coral bleaching, or destructive fishing. The Sulu Sea has been identified as the apex of a "coral triangle", yet little is known on coral recruitment in this area. This study aimed to determine the abundance and composition of coral recruits in the three major marine corridors of the Sulu Sea, and determine patterns in coral recruitment in relation to each corridor's physical and biological features. Terracotta tiles were deployed along 50-m transects in the Cagayan Ridge (Jessie Beazley reefs, Tubbataha atolls, Cagayancillo islands), Balabac Strait, and Verde Island Passage in October 2006. The tiles were retrieved in April and May 2007 and subjected to stereoscopic analysis. Initial results show high recruit density in embayments and island fronts, while diversity is greater in the Balabac Strait, which is a convergence point of the Sulu and South China Seas. These results, however, varied with the density and composition of corresponding adult coral communities. This shows that currents greatly determine recruitment patterns, but other factors may come into play to alter the composition and density of corresponding adult communities. These insights are significant to the Sulu Sulawesi Seascape marine conservation strategy in the design of a marine protected areas network. Recommendations on how to maintain and improve the connectedness of these corridors are derived.

## 10.275

**Herbivory Is The Primary Promoter Of Coral Health On Bonaire, Netherlands Antilles**

**Joost DEN HAAN*[1]**, Ramon DE LEON[2], Emily MCGRATH[3], Rudi ROIJACKERS[4], Marten SCHEFFER[4], Robert STENECK[5]

[1]Earth System Science & Climate Change, Wageningen University, Wageningen, Netherlands, [2]Bonaire National Marine Park, Kralendijk, Netherlands Antilles, [3]CIEE, Benton, PA, [4]Wageningen University, Wageningen, Netherlands, [5]University of Maine, Walpole, MA

A massive region-wide decline of corals across almost the entire Caribbean basin has been reported, with the average hard coral cover of reefs being reduced by 80%, from approximately 50% to 10% cover in only three decades. The amount of substratum currently occupied by macroalgae apparently exceeds the amount that can be controlled by herbivores, with the result that substantial stands of macroalgae developed and persisted. Many coral reefs in the Caribbean seem to have turned into this alternative equilibrium, however, there are still some locations in the Caribbean where the coral reefs are not algal-dominated. The island of Bonaire (Netherlands Antilles) has the highest abundance of live coral and the lowest abundance of macroalgae resulting in the highest index of reef health in the Caribbean. From September 2007 until January 2008 the western coast of Bonaire was studied for coral cover, algal biomass, juvenile coral recruitment and herbivore biomass to study the interrelationships between coral health – macroalgae – herbivores. There seems to be a strong negative correlation between the biomass of macroalgae and the biomass of herbivores (parrotfishes and surgeonfishes) resulting in increased recruitment possibilities for young corals increasing the reef's resilience. This makes reefs less susceptible to both man-made and natural disturbances, e.g. the impact of hurricanes. It is recommended that parrotfishes and surgeonfishes remain highly protected as they serve a major purpose in maintaining the coral reefs as healthy as they are today. For other regions in the Caribbean, to increase their reef's resilience it is recommended management plans are made to protect herbivory, especially parrotfishes and surgeonfishes.

## 10.276

**Anthropogenic Influence On Macroalgal Nutrient Dynamics -Implications For Potential Bottom-Up Effects On Secondary Production in The Western Indian Ocean**

**Gustaf LILLIESKÖLD SJÖÖ*[1]**, Erik MÖRK[1]

[1]Systems Ecology, Stockholm University, Stockholm, Sweden

The circulation and retention of nutrients determine the trophic status in coastal ecosystems. Benthic producers, such as macroalgae, greatly influence these processes, as they bind nutrients and transfer energy to higher levels in the food web. Due to different morphological properties, different macroalgal types have different uptake and binding potential. Furthermore, morphological and physiological traits determine nutritional value and susceptibility to grazing by herbivores, thus controlling subsequent bottom-up transfer in the system. Temporal changes in composition and nutritional status of the macroalgal communities can therefore indicate the amount of energy bound within the system, as well as the rate of nutrient turnover and production potential at higher trophic levels. The present study investigates changes in macroalgal biomass, diversity, composition of functional groups and gross nutrient binding, within and between seasons. The study was conducted in Kenya, during two dry seasons 2006/2007, at sites with varying levels of nutrient loading and herbivore abundance. Both grazing and available nutrients proved to affect the properties of the macroalgal community, with the highest nutrient turnover at a fished site where both herbivore abundance and nutrient loading is relatively low. The reduced grazing pressure increased biomass of ephemeral macroalgae, with a high growth-rate and tissue turnover. At sites where herbivores are more abundant, the algal community is dominated by fleshy brown macroalgae with lower nutrient capture ability and tissue turnover. Overall it seems that sites under moderate anthropogenic influence have the highest macroalgal productivity and nutrient circulation, resulting in a possibly higher energy transfer between trophic levels. In turn, such areas may sustain a larger production of macroalgal grazers and subsequent extraction over time.

## 10.277

**Top-Down And Bottom-Up Regulation Of Coral Reef Macroalgal Communities in A Gradient Of Anthropogenic Influence Off The Kenyan Coast**

**Erik MÖRK*[1]**, Gustaf LILLIESKÖLD SJÖÖ[1], Nils KAUTSKY[1], Tim MCCLANAHAN[2]

[1]Systems Ecology, Stockholm University, Stockholm, Sweden, [2]Marine Programs, Wildlife Conservation Society, Mombasa, Kenya

Humans affect the herbivore abundances and nutrient loading in coral reef communities through artisanal fisheries and effluents from populated areas. Such anthropogenic activities influence the top-down and bottom-up forces regulating macroalgal community structure and function. In turn, an altered community structure can result in trophic cascades, as macroalgae are the most important benthic producers in the coral reef ecosystem. In areas where traditional fishing methods are common and still practiced by the majority of the local coastal communities, anthropogenic influences have been observed to decrease with increasing distance from settlements. This is mainly due to limitation of travel as regular visits to remote fishing grounds is time consuming and sometimes dangerous. This case study was conducted in the southernmost part of Kenya, where a chain of islands with increasing distance (up to 10 km) from a fishing community was used as a model system. Increasing herbivore abundance, and decreasing nutrient loading, has been established along the gradient, making the system a suitable area for testing distance related effects on macroalgal community structure. In general, the study showed a decrease in macroalgal cover, diversity and biomass, with increasing distance from the fishing community. Composition and relative abundance of algal functional groups also changed along the island chain. Furthermore, the dominant type of grazers (i.e. fish or sea urchins) proved to influence macroalgal abundance and composition. In conclusion, even a traditional fishing community can greatly influence coral/macroalgal dominance regimes, within accessible distance.

## 10.278

**Defining Fundamental Niche Dimensions Of Corals: Synergistic Effects Of Colony Size, Light And Flow**

**Mia HOOGENBOOM*[1]**, Sean CONNOLLY[1]

[1]School of Tropical and Marine Biology, ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

The 'fundamental niche' is the range of conditions under which an organism can survive and reproduce in the absence of biotic interactions. Niche measurements are often based on statistical relationships between species presence and environmental variables, or inferred from measured responses (e.g. growth rates) along hypothesized niche axes. In this study, we use novel, process-based models of how irradiance and gas diffusion influence photosynthesis and respiration, to predict niche dimensions for three coral species (Acropora nasuta, Montipora foliosa and Leptoria phrygia). We use a combination of mathematical modeling, laboratory experiments and field observations to establish the link between energy acquisition and the dominant environmental gradients on reefs – light intensity and water flow velocity. The model predicts that, due to its higher photosynthetic capacity, the branching coral A. nasuta has a positive energy balance over a wider range of conditions than both a massive (L. phrygia) and a foliose species (M. foliosa). Moreover, colony size influences niche width, with larger colonies of all three species achieving a positive energy balance over a broader range of conditions than small colonies. Comparison of model predictions with field data demonstrates that observed tissue biomass and reproductive output are strongly correlated with model predictions of energy acquisition, despite the many additional sources of colony-level variation in energy acquisition that occur under field conditions. These results show how interactions between light and flow determine organism performance along environmental gradients on coral reefs. In addition, this study demonstrates the utility of process-based models for quantifying how physiology influences ecology, and for predicting the ecological consequences of varying environmental conditions.

## 10.279

**Density Effects On Grouping Behavior And Habitat Associations Of Recruit Reef Fishes in Hawaii: Contrasts Between Years And Among Species**

**Edward DEMARTINI*[1]**, Todd ANDERSON[2], Alan FRIEDLANDER[3], Jim BEETS[4]

[1]NMFS, NOAA, Aiea, HI, [2]Biology, San Diego State University, San Diego, CA, [3]NOS, NOAA, Waimanalo, HI, [4]Marine Science, University of Hawaii at Hilo, Hilo, HI

We used in situ surveys of recruit reef fishes (≤ 5 cm TL) to explore the possible effects of recruit density on habitat associations and on the incidence and degree of association among conspecific and heterospecific recruits. Surveys were conducted in 2006 and 2007 at wave-protected fringing reefs on the Big Island of Hawaii (in the Main Hawaiian Islands) and at protected back reefs on Midway Atoll, Northwestern Hawaiian Islands, 2000 km upchain of Hawaii Island. Recruit densities differed almost 3-fold between 2006 (13 fish/100 m2) and 2007 (34 fish/100 m2) and were especially pronounced for small (≤ 2 cm TL), recently settled individuals. Both the incidence of groups (≥ 2 fish individuals within 10 cm radius) and the median number of individuals present in groups were greater in 2007 when recruit densities were higher. Electivity of recruits for rugose coral substrata differed between sites and years for some, but not all species. Electivity for rugose corals also varied positively with recruit density for taxa such as *Chlorurus* spp (Scaridae) that associate disproportionately with corals like *Porites compressa* and erect *Montipora* spp. We suggest that habitat electivity and grouping behavior are sensitive to annual and other variations in settler density for some species and that rugose coral habitat is especially important for strong year-classes of these species. Recruit density, grouping, and habitat electivity thus might interact to importantly influence year-class strength and related population dynamics.

## 10.280

**Substratum Utilization And Space Competition With Reef Corals By The Caribbean Excavating Sponge *cliona Delitrix***

**Andia CHAVES-FONNEGRA*[1]**, Sven ZEA[1]

[1]Departamento de Biología and Centro de Estudios en Ciencias del Mar -CECIMAR-, Universidad Nacional de Colombia, INVEMAR, Cerro Punta de Betín, Santa Marta, Colombia, Santa Marta, Colombia

The Caribbean sponge *Cliona delitrix* is a strong reef bioeroder, amply encrusting and deeply excavating corals. To interpret current trends of reef space occupation, sponge presence and abundance was recorded in relation to the degree of reef development and coral health status at the W shallow fore-reef terrace of San Andrés Island, SW Caribbean, Colombia. To establish the circumstances and the speed at which this sponge advances laterally into live coral, and the corals retreat, 44 sponge-colonized coral colonies were marked and followed for 13 months. Steel nails driven at the sponge-coral frontier were used to measure advance and retreat. *C. delitrix* prefers elevated portions of the substratum built by massive corals, and currently inhabits 6 % to 9 % of colonies in sites in which it is locally abundant. This sponge is disproportionately common in *Siderastrea siderea*, a massive coral locally more susceptible to be colonized. *C. delitrix* colonizing live corals was always surrounded by a few mm to several cm-wide band of dead or dying coral tissue, which was being undermined by excavating tissue fronts and filaments. *C. delitrix* was responsible for coral tissue death only when they were in close proximity, being both organisms in direct competition for space. At greater distances, coral death was independent of sponge advance, being indirectly dependent on other conditions that tended to accelerate it. Biting by the long-spined sea urchin Diadema antillarum allowed the sponge to advance slightly faster than when the death band was covered by algae or other organisms. Current mortality and bioerosion threats to massive corals from *C. delitrix* could initially change the relative proportions of different coral species and, in the long term, favor foliose and branching corals.

## 10.281

**The Effect Of Predatory Disturbance On Spatial Arrangement in *cryptocentrus Singapurensis* (Herre, 1936)**

Rebecca SHELL[1], **Craig SYMS*[2]**

[1]College of Science and Math, Montclair State University, Montclair, NJ, [2]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

Disturbance events of all types influence the availability of resources such as prey and habitat availability, and can drastically affect community structure and spatial arrangement. The goby *Cryptocentrus singapurensis* does not venture far from burrows shared with, and maintained by, alpheid shrimps. This study examines how physical parameters determine goby distribution, and to what extent natural and artificial levels of disturbance have on the goby community and its trophic dependents. *C. singapurensis* burrows were mapped in six quadrats on a sand flat in Pioneer Bay, Orpheus Island, Queensland. Quadrats were artificially disturbed at increasing levels, mimicking the predatory methods of rays, a natural predator. Post-disturbance comparisons show no significant alteration in spatial arrangement at any level: goby burrows tend towards random distributions at smaller scales and overdispersal at distances greater than 1m. This pattern is not correlated with grain size or prey availability. Microfaunal gastropod abundance was significantly lower 5cm away from goby burrows, but prey abundance did not explain community spatial arrangement at scales larger than 50cm. A larger investigation may indicate large-scale spatial patterns undetected by this small-scale study. Any such investigations should attempt to isolate predation patterns by locating experimental disturbance events in ecologically desirable areas.

## 10.282

**The Role Of The Ecological Factors Interacting in The Colombian Coral Reef Algal Community**

**Martha DÍAZ-RUIZ*[1]**, Guillermo DIAZ-PULIDO[2,3], Alejandro RANGEL-CAMPO[4], Lenin FLOREZ-LEIVA[5], Dagoberto VENERA-PONTÓN[6]

[1]BEM, INVEMAR, Santa Marta, Colombia, [2]Centre for Marine Studies, University of Queensland, Australia, Australia, [3]Centre for Marine Studies, University of Queensland, Queensland, Australia, [4]Programa de Biologia, Universidad del Magdalena, Santa Marta, Colombia, [5]Departamento de Oceanografía, Universidad de Concepción, Concepción, Chile, [6]INTROPIC, Universidad del Magdalena, Santa Marta, Colombia

Macroalgae are one of the most diverse and complex groups in coral reef habitats, contributing to the maintenance of reef health and to reef degradation. This last process is evident in ecological phase shifts where abundant reef-building corals are replaced by abundant fleshy macroalgae; however, a macroalgal-dominant state may be very persistent. The main causes are involved with coral disturbances and human related impacts (herbivory reduction, increases in sedimentation and increased nutrients), that together can play critical roles in regulating algal abundance. Despite the knowledge available about the independent effects of such processes, there is limited information about how they all interact, or on the relative contribution each factor plays in algal dynamics. We experimentally and simultaneously manipulated sedimentation, herbivores, and algal propagule density, and explored the effects on community structure of benthic algae in two Colombian coral reefs. The results indicate that propagule density had little effect on the abundance and species composition of macroalgae. The locality, sedimentation and herbivory modelled the community structure. These results help to identify critical ecological processes that contribute to the understanding and managing of coral and algal phase shifts. In the same way, it is clear that algae are playing an important role in reef degradation; so many factors contributing to the deterioration of coral reefs as overfishing and sedimentation require the implementation and monitoring of appropriate environmental policies

## 10.283

**Spatio-Temporal Patterns in Coral Settlement On An Exposed Shoreline in Hawaii: The Influence Of Current, Proximity To A River Source And Sediment Discharge Levels.**

**Eric BROWN*[1]**, Alan FRIEDLANDER[2], Curt STORLAZZI[3], Carl BERG[4]

[1]Kalaupapa NHP, U.S. National Park Service, Kalaupapa, HI, [2]Biogeography Branch and the Oceanic Institute, NOAA/National Ocean Service/National Centers for Coastal and Ocean Science, Waimanalo, HI, [3]Pacific Science Center, U.S. Geological Survey, Santa Cruz, CA, [4]Hawaiian Wildlife Tours, Kilauea, HI

Hanalei Bay, Hawaii is situated in a dynamic and harsh environment that includes high wave energy, heavy fresh water influx, high turbidity, and high sedimentation. These conditions result in overall low coral cover (ca. 14%) that is predominated by encrusting growth forms. Coral settlement patterns were examined at four sites, two inside and two outside of the bay, from 2003 to 2005 during the peak summer spawning period. Five terracotta tile arrays were deployed at every site each year. A total of 11,008 larvae were documented on the underside of the tiles. The most abundant coral larvae were from the genus *Montipora* (98.9%), which typically has high settlement rates but low survival compared to *Pocillopora* spp (0.1%) and *Porites* spp (0.1%) larvae. Total settlement rate increased each year and was higher in the outer bay compared to the inner bay.

Current patterns within the bay indicated that flow was weak during the summer spawning period and direction varied horizontally and vertically. Current flow was weakest and oriented into the bay at the site which experienced the lowest settlement. This site was also closest to the main freshwater source. Settlement rates were lower following years with high sediment discharge rates that coincided with spawning events. Settlement rates around Hanalei Bay (18,264 ± 3,314 larvae $m^{-2}$ $year^{-1}$, maximum annual mean ± SE) were higher than rates along other exposed coastlines in Hawaii and were some of the highest reported in the world. Coral cover has been increasing over the past decade but remains low in spite of high settlement rates. This is likely due to the harsh environment and potential anthropogenic inputs into the bay.

## 10.284

**Spatial Variation in Reef Fish Foraging Substratum Use: Ecological and Functional Implications**

**João Paulo KRAJEWSKI*[1,2]**, Roberta BONALDO[2], Paulo GUIMARÃES JR[3], Sergio FLOETER[4]

[1]Departamento de Zoologia, Universidade Estadual de Campinas, Campinas, Brazil, [2]School of Marine and Tropical Biology, James Cook University of North Queensland, Townsville, Australia, [3]Depto. de Física da Matéria Condensada, Universidade Estadual de Campinas, Campinas, Brazil, [4]Depto. de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianópolis, Brazil

We studied the foraging substratum selection of five abundant mobile benthic carnivorous reef fish species in three nearby reefs of Fernando de Noronha Archipelago, Northeastern Brazil. Although the studied reefs are only few 100s m apart and have similar habitat characteristics, we recorded variations in foraging substratum selection in some species among reefs. Overall, the grunt *Haemulon chrysargyreum* foraged mostly on short algae, *Haemulon parra* mostly on soft substrata, the wrasse *Halichoeres dimidiatus* foraged mostly on *Sargassum* spp., *Halichoeres radiatus* was a generalist and the goatfish *Pseudupeneus maculatus* was also generalist, but foraged mostly on soft bottoms. Despite general tendencies in foraging substratum use, both wrasses varied greatly in substratum selection among reefs. The spatial variation on resource use may have profound impacts on other ecological and behavioral aspects of species. For example, we estimated that *P. maculatus* can revolve about twice more sediment in the substratum "epilithical algae matrix" in the study site where this substratum was more strongly selected than in the study site where this substratum was less selected. Thus, besides different populations of a same species present similarities in resource use, reef fish substratum selection may be organized as a geographical mosaic, in which species display local differences in their foraging microhabitat even over small scales. These differences may have important implications on species ecology and functional role on reefs.

## 10.285

**Matrix approach to understanding the ecology and population dynamics of the demosponge Desmapsamma anchorata**

**Elizabeth MCLEAN*[1]**

[1]EEB Program, SUNY at Buffalo, Buffalo, NY

Appraisal and understanding of population dynamics brings us closer to developing sound models that can assist in conserving coral reefs for the future. The distribution and abundance of the Caribbean sponge *Desmapsamma anchorata*, Carter 1882, was initially surveyed, followed by experiments on spatial dispersion patterns, population dynamics and interactions with other organisms. The study was conducted on Media Luna reef, La Parguera, Puerto Rico between 2003 and2005.

*D. anchorata* was aggregated with a variance to mean ratio greater than 1.0 (1.360-4.409) probably due to patchy distribution of suitable substrates. A size-specific matrix model was used to study *D. anchorata* colonies, accounting for growth, survivorship and mortality.

The populations of *D. anchorata* colonies decreased during the study period; their size specific survivorships was not different ($X2 = 2.48$, $df = 2$, $p > 0.05$) across sizes, with the exception of the last period, when survivorship was significantly lower for the larger colonies and higher for medium colonies ($X2 = 15.37$, $df = 2$, $p < 0.005$) probably due to drag forces generated by tropical storm Ivan. Recruitment was largely the result of sexual reproduction rather than asexual fragmentation. Average survival for new recruits was 38% from one period to the other. Recruit mortality was associated with burial by bedload transport caused by wave action. *D. anchorata* was a successful space competitor, associated with diverse sessile organisms, including other sponges. The number of *D. anchorata* colonies associated with gorgonians was proportional to the relative abundance of gorgonian species, suggesting a random distribution. The ecology, distribution and abundance of *Desmapsamma anchorata* populations were affected by a complex interplay of physical effects and biological interactions, wave action being one of the main influences in the observed patterns.

## 10.286

**The Protective Capacity Of Mangroves During Tropical Storms: A Case Study From Wilma And Gamma In Belize**

**Elise GRANEK*[1]**, Ben RUTTENBERG[2]

[1]Environmental Sciences and Management, Portland State University, Portland, OR, [2]Department of Ecology Evolution and Marine Biology, University of California, Santa Barbara, CA

Globally threatened mangrove forest habitat is often considered an important buffer protecting coastlines from wave and storm impacts and coastal erosion. However, there is little empirical data quantifying the protective effects of mangroves during storms, primarily because of the difficulty of predicting where and when a storm will intersect the shoreline, to facilitate data collection before and after storm events. In 2005, opportunistic results from an ongoing study quantifying differences between intact and cleared mangrove areas on Turneffe Atoll, Belize, provided such pre- and post-storm data from tropical storms 'Wilma' (later a Category 5 Hurricane) and 'Gamma'. We compared differences in equipment retention rates of 3 types of experimental devices previously installed in adjacent intact and cleared mangrove areas. Retention rates were greater in intact mangrove areas, empirically demonstrating the protective capacity of mangroves during moderate magnitude storm events. The results support the assumption that removal of mangroves diminishes coastal protection not only during catastrophic storm events such as hurricanes or tsunamis, but also during less energetic but more frequent events, such as tropical storms. This highlights the importance of improved coastal zone management, as storm events may increase in frequency and intensity with changing climate, and coastal mangrove forest habitats continue to decline in size and number.

## 10.287

**Lost Of Marine Species At Casa Caiada Beach (Olinda -Pernambuco), Brazil**

**Mara FISNER*[1]**, Carmen MEDEIROS[1]

[1]Oceanography, UFPE, Recife, Brazil

The beach of Casa Caiada located at Olinda County, (7°58,8'-7°59,7' S; 34°50,0'-34°50,3' W), northeastern Brazil, experiences erosion since 1954. The problem appears to had resulted from the combined effect of a low sediment supply and a fast and intense urban occupation. During the 70's and 80's, a series of seawalls was constructed along the Casa Caiada shore on the top of natural beachrocks lines, to propitiated beach protection. If in one hand the intervention locally reduced the coastal erosion, on the other hand the reduction on the hydrodynamics propitiated the sedimentation of fine sediments with prejudice to marine corallines species. In 2003, the presence of the Scleratinia *Siderastrea stellata* and *Favia gravida,* of the zoanthids *Zoanthus* sp and *Palithoa* sp, of the actiniaria *Anemonia sargassensis* and echinodermata, cirriped and bivalve were reported at the area by Pereira *et al.* as well as the fact they was being stressed by the sedimentation. None of those species could be found in the area during our visual surveys conducted during four years. Increase in mean water temperature with values above 25 ºC during winter and reaching 31ºC during summer with averages value and suspended solids concentration of 36 ppt were verified. The enclosing of the beach resulted also in decline of water quality. Total and fecal coliforms concentrations were well above level for primary contact.

Literature citaded:

Pereira, L.C.C.; Jiménez, J.A.; Gomes, P.B.; Medeiros, C. and Rauquírio, A.M.daC. 2003. Effects of the sedimentation on scleractinian and actinian species in artificial reefs at the Casa Caiada beach (Brazil). Journal of Coastal Research SI35:418-425.

## 10.288

**Assessment Of The Model Hydrozoan, *hydractinia Echinata*, As A Surrogate For Coral Early-Life Stage Toxicity Assessments**

**Marion NIPPER*[1]**, R. Scott CARR[2], Misti GROHMANN[1]

[1]Center for Coastal Studies, Texas A&M University-Corpus Christi, Corpus Christi, TX, [2]Marine Ecotoxicology Research Station, CERC, US Geological Survey, Corpus Christi, TX

Coral reefs have suffered a variety of insults since the advent of the industrial era and agricultural monoculture practices, in the form of pollution, excessive nutrient discharges and climate change. The effect on coral recruitment, survival and sensitivity to disease needs to be better understood. The infrequent spawning of corals makes it impossible to conduct year-round early-life stage research with this group. The Cnidarian classes Anthozoa (including corals) and Hydrozoa share a sessile phase with polyps of a homologous nature. Both classes have similar embryological development leading to a planula larva, with metamorphosis induced by specific cues. The similarities of these two Cnidarian classes suggest that colonial hydroids would be good representatives of corals in a variety of laboratory experiments. The current study had the objective of analyzing the usefulness of a model hydrozoan, Hydractinia echinata (Hydrozoa, Hydractiniidae), as a surrogate for corals in assessing the effects of contaminants on recruitment. The present research focused on the effects of several contaminants, including polycyclic aromatic hydrocarbons (PAHs), pesticides and heavy metals, on early development and metamorphosis. The sensitivity of the metamorphosis of H. echinata to contaminants studied thus far, including copper, sodium dodecyl sulfate and phenanthrene was equivalent to or higher than that of larvae of several species of coral for which data were available in the scientific literature. Results to date suggest that H. echinata is a promising candidate surrogate for assessing the potential effects of contaminants, and possibly other stressors, on coral recruitment.

## 10.289

**Dispersal Of Coral Larvae With Respect To Egg Buoyancy And Relative Effects Of Wind-Driven Surface Currents**

**Masako NAKAMURA*[1]**, Kazuhiko SAKAI[1]

[1]Sesoko Station, Tropical Biosphere Reserch Center, University of the Ryukyus, Motobu, Japan

Spatial and temporal variability in coral recruitment is affected by larval dispersal. Larval dispersal may be limited by egg buoyancy. Moreover, wind-driven surface currents may determine recruitment pattern as investigated in other marine sessile invertebrates. We expected that difference in egg buoyancy would result in different effects of wind-driven surface currents on larval dispersal. We predicted that larvae from positively buoyant eggs would disperse away from their natal reefs and their dispersal process would be influenced by wind-driven surface currents. In contrast, larvae from negatively buoyant eggs would settle on their natal reefs. Coral recruitment and percent cover of corals were assessed around Iriomote Island (Japan) using settlement plates and random quadrat method. Acroporid corals were the most abundant in adult and recruitment communities. Spatial variability in their recruitment had a large annual fluctuation, and the number of recruits was not correlated with adult percent cover. The annual fluctuation of acroporid recruitment was likely to be explained by the wind-driven surface currents. Contrary, although relative abundance in adult and recruitment communities was low, positive correlation between the adult percent cover and number of recruits was detected in pocilloporid and poritid corals. Most acroporid and poritid corals release positively buoyant eggs. The most abundant pocilloporid species in our study areas were *Pocillopora verrucosa* and *P. eydouxi*, and they release negatively buoyant eggs. The results in acroporid and pocilloporid corals therefore supported our hypotheses, but that in poritid corals did not. Acroporid corals, which are more susceptible to environmental changes, are more likely to explore new space by dispersing larvae away from the parent colonies, while the two others, relatively resistant, tend to disperse larvae locally for filling local empty patches.

## 10.290

**Spatial Trends Of Macrobenthic Community On Reef-Associated Sea-Grass Beds in Coastal Area Weno Isl. Chuuk State, Fsm.**

**PARK HEUNG SIK*[1]**, PAIK SANG GYU[2]

[1]OPEN & TROPICAL OCEAN RESEARCH DIVISION, KOREA OCEAN RESEARCH DEVELOPMENT INSTITUTE, ANSAN, KYEONGGI-DO, Korea, Republic Of, [2]KOREA OCEAN RESEARCH DEVELOPMENT INSTITUTE, ANSAN, KYONGGI-DI, Korea, Republic of

Reef-associated sea-grass beds are characterized by benthic community as well as coral-reef fishes as nursery. Sea-grasses are important in their interactions within coral reefs. These systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities. Seagrass providing food and shelter for diverse variety of organisms lagoon for many of reef species similar to mangrove forests in Chuuk. According to vertical scale from land to open sea by transect method using quadret, benthic community structure have been influenced by several types of habitats based on sea-grass beds such as density and species composition. The seagrass bed is dense and mostly sandy on the area close from coastline to middle of area of the end of reefs sheltered. Coverage by three of species, Cymodocea rotundata, Enhalus acoroides and Syringodium isoetifolium dominated over 70% at this area. But it showed the changes by spatially. A total of 14 species of macro-invertebrate were associated with all seagrass beds. Holothuroideans, Synaptula sp., Bohadschia mamorata, and Holothuria hilla were commonly distributed, and echinoideans Echinothrix sp., Mespilia globules and Tripneustes gratilla also observed neighboring of middle area which sea-grass showed sparse density. As results by multivariate analysis, based on the number of density of each species, spatial distribution of benthic community showed clear separation along the transect. Sea-grass density influenced to the sedimentary characteristics as well as reef formations. It also may affected to the benthic community in reef area .

## 10.291

**Feeding Macroecology Of Territorial Damselfishes (Perciformes: Pomacentridae)**

**Sergio FLOETER*[1]**, Diego BARNECHE[1], Carlos FERREIRA[2], Daniela CECCARELLI[3], Daniella FRENSEL[1], Daniel DINSLAKEN[1]

[1]Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianópolis, Brazil, [2]Biologia Marinha, Universidade Federal Fluminense, Niterói, Brazil, [3]James Cook University, Townsville, Australia

Little is known about large scale feeding patterns of reef fishes. Territorial damselfishes constitute an important functional group of fishes distributed all over tropical and warm temperate reefs. Their feeding and behavioral activities are important in structuring reef benthic communities. Data on these activities, obtained over the last three decades, was used in macroecological analyses on this group. A database on feeding (bites) and chasing (agonistic) rates, maximum and mean body size, average territory area and local Sea Surface Temperature (SST) was assembled for several species of territorial damselfishes distributed worldwide. The genera Stegastes and Pomacentrus provided most of the data and were analyzed separately. A positive correlation between bite rates and SST was observed for the genus Stegastes (r2=0.463; p=0.001), but not for Pomacentrus (r2=0.054; p=0.517) or the entire Pomacentridae family (r2=0.066; p=0.134). A negative correlation between body size and SST was observed for Stegastes (r2=0.569; p=0.003) and Pomacentridae (r2=0.198; p=0.020), however it was not observed for Pomacentrus (r2=0.163; p=0.246). We observed a negative correlation between body size and bite rates for both Stegastes (r2=0.430; p=0.014) and Pomacentrus (r2=0.523; p=0.018) but not for Pomacentridae (r2=0.042; p=0.299). We also observed negative correlations between bite rates and maximum body size for both Stegastes (r2=0.272; p=0.018) and Pomacentrus (r2=0.462; p=0.030), but not for the entire family (r2=0.073; p=0.114). No relationship was found between feeding rates and territory area for Stegastes (r2=0.203; p=0.224), Pomacentrus (r2=0.188; p=0.244) or Pomacentridae (r2=0.127; p=0.113). In general, tropical species are smaller and have higher feeding rates than species living in higher latitudes. This study showed that some previously recognized local patterns can also be observed in the global scale, which can be related with physiology, ecology and evolution of pomacentrid fishes, highlighting the importance of macroecological analyses.

## 10.292

**Spatial Distribution Patterns Of Pomacentrid Fishes Before Settlement On A Fringing Coral Reef**

**Takuro SHIBUNO*[1]**, Yohei NAKAMURA[2], Yoshiro WATANABE[2]

[1]Seikai National Fisheries Research Institute, Ishigaki, Japan, [2]Ocean Research Institute, The University of Tokyo, Nakano-ku, Japan

Pomacentridae is site-attached and a most diverse and abundant group on coral habitats (tarbular and branching coral areas), whereas rare in the surrounding habitats (e.g. coral rubble area, seagrass bed) despite the spatial proximity of the two habitats. However, newly settled juveniles of pomacentrids were often found on small coral patches within surrounding habitats, suggesting that many pomacentrid larvae are distributed in surrounding habitats before settlement. To investigate the degree to which larvae are distributed in coral habitats or in the surrounding habitats, we investigated spatial distribution patterns of pre-settlement pomacentrids on a fringing coral reef at Ishigaki Island, southern Japan, on 26 July, 5, 16, and 25 August 2006. Pre-settlement pomacentrids were collected using light traps, the traps moored in the tarbular coral areas, branching coral areas, coral rubble areas, and seagrass beds, respectively. During the study period, 5258 larvae of 33 taxa were collected in the four habitats. Of these, 2668 larvae of 23 taxa were collected in the tabular coral areas, 1535 larvae of 20 taxa in the branching coral areas, 433 larvae of 17 taxa in the coral rubble areas, and 622 larvae of 11 taxa in the seagrass beds. These results demonstrated that many pomacentrid larvae are distributed not only in the coral habitats but also in the surrounding habitats before settlement.

## 10.293

**Spatial Distribution Patterns Of Pre-And Post-Settlement Chaetodonid And Lethrinid Fishes On A Fringing Coral Reef**

**Yohei NAKAMURA*[1]**, Takuro SHIBUNO[2], Yoshiro WATANABE[1]

[1]Ocean Research Institute, The University of Tokyo, Tokyo, Japan, [2]Seikai National Fisheries Research Institute, Ishigaki, Japan

Most coral reef fishes experience a pelagic larval stage at offshore. After the pelagic stage, individuals migrate to reefs and settle into various habitats (e.g. coral area, seagrass beds), thereafter entering the benthic juvenile stage. Spatial distribution patterns of fishes from pelagic to benthic environments is important to understand the structuring mechanism of fish communities in coastal habitats, however, such process remains poorly understood. We investigated spatial distribution patterns of pre- and post-settlement fishes (Chaetodontidae, Lethrinidae) on a fringing coral reef at Ishigaki Island, southern Japan, on 26 July, 5, 16, and 25 August 2006. Visual transect surveys conducted in tarbular coral areas, branching coral areas, coral rubble areas, and seagrass beds revealed that newly settled juveniles of chaetodonids were restricted to the tabular and branching coral areas, whereas those of lethrinids were restricted to the seagrass beds. Larval sampling by light traps in the four habitats, on the other hand, revealed that pre-settlement chaetodonid and lethrinid fishes were distributed in all the habitats. These results indicated that although many reef fish larvae are distributed in various habitats before settlement, they settle on species-specific habitats (coral habitat for chaetodonids vs. seagrass habitat for lethrinids). The habitat choice of reef fish larvae at settlement is one of the potential mechanisms to explain spatial distribution patterns of coral reef fishes.

## 10.294

**Impacts Of Sediment On Coral Recruitment At Koh Samui, The Gulf Of Thailand**

**Sittiporn PENGSAKUN*[1]**, Wanlaya KLINTHONG[1], Kanwara SANGMANEE[1], Thamasak YEEMIN[1]

[1]Biology, Marine Biodiversity Research Group, Bangkok, Thailand

Changing land use practices in Koh Samui, Southern Thailand, have resulted in inputs of sediment into the nearshore water. The present study aims to examine impacts of sediment on coral recruitment. Sedimentation rates on coral communities of Koh Samui were investigated in 2006-2007 by using sediment traps, a diameter of 5 cm and 11.5 cm in length. Sedimentation rates varied temporally in a range of 6.21 (in February) - 24.52 (in November) mg/cm2/d. The sedimentation rates on coral reefs of Koh Samui were relatively high. Field observations on coral recruits on natural reef substrates were conducted to monitor changes of juvenile coral colonies. The highest diversity of coral recruits was only 0.38 recriut/m2. The dominant juvenile coral colonies were *Fungia, Porites, Favites,* and *Favia*. Mortality rates of juveniles coral colonies were very high. To examine the impacts of sediment on settlement of corals, experimental settlement plates consisted of 15x15 cm tiles in horizontal, oblique, and vertical positions were deployed. The settlement tiles were submerged for two-month intervals. The density of coral recruits on the lower surface of horizontal tiles was 117.37 recruits/m2 which was about two times higher than that of the upper surface. The dominant coral recruits on settlement tiles were *Pocillopora damicornis* and *Porites* spp. The results provide the scientific evidence of effects of sediment on coral recruitment in the Gulf of Thailand.

## 10.295

**Spatio-Temporal Patterns Of Coral Recruitment in The Bolinao-Anda Reef Complex, Northwestern Philippines**

**Maria Vanessa BARIA*[1]**, Porfirio ALIÑO[1], James GUEST[2], Andrew HEYWARD[3]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Biology, Newcastle University, NE1 7RU, United Kingdom, [3]Australian Institute of Marine Science, Crawley, Australia

Coral recruitment is a major structuring factor of coral reef assemblages. Understanding the early recruitment processes that maintain the diversity of reefs in the Philippines will be crucial for the sustainability of this most diverse yet most threatened ecosystem. This study assesses spatial and temporal coral larval settlement patterns in four selected areas and two depths in the Bolinao-Anda reef complex, northwestern Philippines using quarterly deployment of replicated settlement plates for 1 year from November 2006 to November 2007. Variations in spatial and temporal patterns of early recruitment on the tiles were observed among sites and depths. Coral spats were highest during the period February to May 2007 with values ranging from 47 to 607.7 recruit $m^{-2}$among stations (234.9 average recruit per $m^{-2}$). This coincides with the peak in broadcast spawning activity at these sites (March to June). Among the 4 sites, the southernmost site in Caniogan, Anda consistently had the highest larval settlement. Unlike other sites, Caniogan is relatively embayed site, protected from strong wave action. This feature may enhance larval retention thereby increasing possibilities of successful larval recruitment. Currently we are looking at the composition of juvenile and adult assemblages at all sites and examining the mechanisms such as sedimentation inundation, algal overgrowth and grazing and other disturbance which influence survivorship to its eventual juvenile and adult assemblage.

## 10.296

**Prey Selectivity Of Coralliophila Abbreviata And C. Caribaea (Coralliophillidae, Neogastropoda) in Morrocoy National Park, Venezuela. An Experimental Approach.**

**Carlos DEL MONACO*[1]**, Estrella VILLAMIZAR[1], Samuel NARCISO[2]

[1]Universidad Central de Venezuela, Caracas, Venezuela, [2]Fundacion por la Defensa de la Naturaleza, Chichiriviche, Venezuela

Coralliophila abbreviata and C. caribaea are tropical gastropods of the Caribbean Sea. These gastropods have shown themselves to be important corallivores. The objective was to evaluate the prey selectivity of C. abbreviata and C. caribaea in some coral reefs of Morrocoy National Park by experimental (C. abbreviata) and descriptive methods (C. abbreviata y C. caribaea). The descriptive methods were utilized in the locations of Cayo Borracho, Cayo Peraza, Cayo Sombrero, Playa Mero, Playuelita and Punta Brava. The experiment was realized in Cayo Sombrero. We estimated coral abundance and richness, number of Coralliophila, and coral species as associated by means of 12 quadrates of 1 m2 in 3 sites of each location. In the experiment we used 8 exclusion cages with 5 coral colonies of different species equidistant to 10 individuals of C. abbreviata in each cage. As for the descriptive method, we observed in situ a higher predator-prey relation between C. abbreviata and the hexacoral species M. annularis. M. annularis presented 56,82% of the total interactions in all localities, followed by D. strigosa (19,32%), A. agaricites (12,22 %), C. natans (4,55 %) and A. tenuifolia (3,13 %). C. caribaea presented a higher predator-prey relation with the octocoral species E. caribaeorum (42,59 %) and the hexacoral species C. natans (24,07 %), M. faveolata (11,11%), P. porites (7,41 %) and D. strigosa (11,11 %). The experiment showed a major relation between C. abbreviata and M. annularis because it exhibited 53,33 % of the total interactions, followed by C. natans (17,78%), A. tenuifolia and D. strigosa (11,11% each) and A. agaricites (6,67%). The results of the experiment coincided with the results of the descriptive methods indicating a prey selectivity of C. abbreviata by M. annularis probably due to a major nutritional quality and tissue regeneration rate.

Key words. Coralliophila sp, prey selectivity, coral reefs, Morrocoy National Park.

## 10.298

**Tubiculous Coral Symbionts Induce Morphological Change And Enhance Growth in *montipora***

**Gerick BERGSMA*[1,2]**

[1]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA, [2]Moorea Coral Reef Long Term Ecological Research Program, Moorea, French Polynesia

Coral morphology and growth rate drive reef accretion and production, and mechanisms controlling coral structure regulate habitat for reef associated organisms. Processes that alter coral morphology and growth can therefore significantly affect reef communities. In the lagoons of Moorea, French Polynesia, tube-dwelling amphipods and polychaetes induce the formation of long, finger-like branches in otherwise encrusting or plating species of *Montipora*. I conducted surveys and field experiments to determine the extent to which these symbionts alter *Montipora's* morphology and growth. My surveys demonstrate that these symbiont-induced formations (which I have termed "fingers" to distinguish them from ontogenetic branches) are ubiquitous throughout the lagoons, and add considerable 3-dimensional structure to the reefs. My experiments show that symbionts dramatically increase rates of linear extension in fingers by creating novel substrate, effectively enhancing colony growth. Furthermore, the induced morphology increases colony survival, and may alter the ability of colonies to reproduce and compete for space. These results suggest that symbionts substantially change reef structure, and likely impact reef community dynamics.

## 10.299

**Coral Growth Processes And Environmental Conditions Around Okinotorishima Island, Japan**

Nobuo MIKAMI[1], **Michio KITANO*[2]**, Hidekazu YAMAMOTO[2], Toshiyuki TAKAO[2], Akiyoshi NAKAYAMA[1], Wataru ANDO[3]

[1]National Research Institute of Fisheries Engineering, Kamisu City, Japan, [2]ECOH Corporation, Taito-ku, Japan, [3]Fisheries Infrastructure Development Center, Chuuou-ku, Japan

Okinotorishima is the southernmost island of the Japanese territory, approximately 1,740 kilometers south-southwest of Tokyo. The island consists of a lagoon surrounded by submerged coral reefs, extending 4km east-west and 1.7km north-south. Regarded as a good fishing ground, the Fisheries Agency of Japan formulated the projects to increase coral cover around the island. Commencing in 2005, surveys were conducted on five occasions on the following: coral distribution, coral growth at 17 fixed survey sites, coral size distribution, coral recruitment, water quality, water temperature and water flow.

The results of the coral distribution showed that coral cover exceeded 30 % in the central portion of the lagoon. There is knoll topography around the center. From the analysis of coral growth, growth rates were confirmed to differ by area, being higher in the central portion.

As for coral recruitment, many colonies were observed in the west part of the lagoon. The water quality and water temperature were horizontally homogeneous across the lagoon. From a 60-day consecutive water flow investigation, we were able to obtain the data both in calm and stormy (e.g. typhoon) conditions. Water motion was simulated using a numerical model. Under calm sea conditions, the main flow was dominated by a southwestwardly flow. Under the typhoon conditions, rapid-flow of water entered the lagoon from all directions with the passage of the storm.

These results suggested that the coral recruitment on Okinotorishima Island was governed by the water flow in calm sea conditions. It was also estimated that the growth of corals was influenced by storm surges during typhoons in addition to the topograpy of the island.

## 10.300

**Physiological Performance Of Giant Clams (Tridacna Maxima, T. Squamosa, T. Derasa) in A Recirculation System**

**Andreas KUNZMANN*[1]**

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany

Giant clams are effective filter feeders and at the same time autotrophic due to their symbiosis with zooxanthellae. While juveniles rely on both heterotrophic and autotrophic feeding, adult clams depend more on excellent light conditions. Clams also play a potential role for bio-cleaning as additional water treatment module in a closed recirculation system and are a highly valuable resource for the international aquarium trade.

Therefore, the importance of auto- and heterotrophy to growth, survival, zooxanthellae development and nutrient uptake of juvenile giant clams Tridacna maxima and T. squamosa was investigated. In addition experiments on the photosynthesis, metabolism and calcification were performed with 5-8 cm specimens of T. maxima and 10-12 cm specimens of T. derasa in an intermittent flow-through respiration system. Animals were reared in a recirculation system under different light conditions and different concentrations of nutrients. Both particulate organic (Tetraselmis algae) and dissolved inorganic (ammonia and phosphate) food was given.

Results show that light intensity and spectra have a significant effect on survival and length or weight increase. Nutrient concentrations only seem to play a role, when clams are kept in optimum light conditions. In this case fertilization with NH4 and PO4 is more effective than feeding with algae. However, the concentration of zooxanthellae is only moderately increasing with increasing nutrient concentration. Moreover photosynthesis, respiration rates and calcification seem to be linked to light conditions but not to increasing nutrient concentrations. It is concluded that juvenile clams depend more on autotrophy to satisfy nutritional requirements. The uptake of nutrients is limited and needs to be tested with larger clams and a variety of nutrient combinations.

## 10.301

**Effects Of Light Availability On *in Situ* Juvenile Growth Rates Of The Brooding Coral *favia Fragum* in Bermuda**

**Laura STOPPEL*[1]**, Gretchen GOODBODY-GRINGLEY[1,2], Robert WOOLLACOTT[1]

[1]Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, [2]Bermuda Institute of Ocean Sciences, St. George's, Bermuda

The scleractinian *Favia fragum* is found in shallow reef environments throughout the Caribbean and Western Atlantic Ocean. A hermaphroditic brooder, *F. fragum* develops larvae internally and planulates during its reproductive season on a monthly basis coupled to the lunar cycle. *F. fragum* adults are often found in semi-protected parts of the reef where light is not always most abundant. Likewise, larvae of *F. fragum* tend to preferentially settle on the undersides of substrates where light may be limiting. Growth of juvenile corals, however, is known to be affected by light availability. In this study we examined the effects of light availability on the juvenile growth rates of *F. fragum* in Bermuda. Newly settled metamorphs were placed under three shade regimes on an inshore patch reef for 37 days. Due to its symbiosis with photosynthesizing zooxanthellae we expected higher juvenile growth rates under ambient light conditions, as this would facilitate the most photosynthesis, with growth rates decreasing as shade increased. Contrary to this hypothesis however, we found significantly higher juvenile growth rates under moderate levels of shade than under ambient light or heavy shade conditions. Heavily shaded treatments also experienced the highest degree of mortality. Our results suggest that although moderate amounts of shade may promote higher growth rates in juveniles of this species, there is a threshold of minimal light availability below which coral growth and survival are adversely affected.

## 10.302

**Zooplankton Abundance Much Higher Near the Surface on the 2 m Deep Back Reef of Moorea, French Polynesia**

**Alice ALLDREDGE*[1]**

[1]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

Zooplankton distribution on a broad, 2 m deep backreef exposed to a unidirectional current year round was examined in Moorea, French Polynesia. Zooplankton, predominantly copepods and crustacean larvae, were up to 10 times more abundant at 10-20 cm below the surface then at 100 cm below the surface or near the bottom both day and night. Aggregation near the surface became detectable within 2 m of the well-mixed trough directly behind the reef crest indicating that zooplankton behavior, rather than greater consumption of plankton near the bottom by planktivores, generated the distribution. Laboratory studies of zooplankton exposed to turbulence around corals in a laboratory tank suggest that the zooplankton were not avoiding increased turbulence near the bottom. Much higher abundance near the surface during the day and on full moon nights than on new moon nights, suggests that light may be an important cue causing zooplankton to swim upward. The horizontal flux of zooplankton, as determined by drift nets, was 4-5 times higher near the surface and much higher than predicted by the slightly higher flow rate occurring there. Clearly, reef zooplankton are adapted to avoid the higher predation pressure expected near the bottom from fish, corals, and other planktivores. But these results also have important implications for the distribution, growth rates, and sizes of organisms on shallow reefs. A difference in bottom depth or in the height above the bottom of only a few tens of centimeters may dramatically affect the quantity of zooplankton food available to corals and other sessile planktivores. Likewise planktivorous fish foraging only slightly higher in the water column on shallow reefs may reap disproportionately larger benefits.

## 10.303

**Effects Of Coral Spat Characteristics On Post-Settlement Survivorship**

**Yoko NOZAWA*[1]**

[1]Biological institute on Kuroshio, Otsuki, Kouchi, Japan

Scleractinian coral spat have various characteristics consisting of a combination of several parameters, e.g. initial size, polyp size, growth rate (i.e. spat size), budding rate, and presence/absence of zooxanthellae at settlement. These different characteristics of coral spat apparently affect post-settlement survivorship. Understanding of which parameters are most important in influencing post-settlement survivorship should have significant ecological and evolutionary meaning for scleractinian coral species. The objective of this study is to examine the effects of coral spat characteristics on post-settlement survivorship, focusing on the above five parameters. The study was started in summer 2007 at Nishidomari, Kochi, Japan (132°44′, 32°46′), and is planned to continue for one year. Spat of nine coral species were obtained from July to August, 2007; *Acropora japonica*, *Acropora solitaryensis*, *Echinophyllia aspera*, *Favites abdita*, *Favites pentagona*, *Favites russelli*, *Platygyra contorta*, *Pocillopora damicornis*, *Stylophora pistillata*. Spat characteristics of these species are largely grouped by the five parameters as follows; (1) initial size: small (0.16-0.39 mm2 in average: *Ea*, *Fa*, *Fp*, *Fr*, *Pc*), large (0.59-4.56 mm2: *As*, *Aj*, *Pd*, *Sp*), (2) polyp size of each species: small (ca. 1 mm diam.: *As*, *Aj*, *Pd*, *Sp*), large (5-15 mm diam.: *Ea*, *Fa*, *Fp*, *Fr*, *Pc*), (3, 4) growth and budding rates: slow (*Ea*, *Fa*, *Fp*, *Fr*, *Pc*), fast (*As*, *Aj*, *Pd*, *Sp*), (5) presence of zooxanthellae: yes (*Pd*, *Sp*), no (*As*, *Aj*, *Ea*, *Fa*, *Fp*, *Fr*, *Pc*). The spat settling on one side of tiles (10 x 10 cm) were mapped and photographed under a stereomicroscope at the start of experiments. Four to six replicate tiles per species were fixed to rock vertically at 5 meters depth. The tiles were retrieved to measure survival and size of each spat monthly for the first three months, and then every three months. Here I will discuss the results from this study.

## 10.304

**High Recruitment Of Hard Corals At Archipiélago Los Roques National Park, Venezuela**

**Adriana HUMANES*[1]**, Carolina BASTIDAS[2]

[1]Laboratorio de Comunidades Marinas y Ecotoxicología, Universidad Simón Bolívar, Caracas, Venezuela, [2]Departamento de Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela

Los Roques National Park (LRNP) is a marine protected area of exceptional ecological value because of the high-quality of its coral reefs with respect to species diversity and coral live cover. At this protected area, reef builders such as acroporids that have suffered decline during the past three decades are showing signs of recovery. Recruitment is one of the main processes that can determine patterns of recovery, distribution and abundances of corals in this area. To evaluate the effects of settlement and early survival of hard corals on the potential of recovery of LRNP, 120 unglazed terracotta tiles of 25x25 cm were deployed horizontally, between 3 and 5 m deep, and directly over the substratum at four reefs. A visual survey of the lower side of each tile was made with a binocular dissecting microscope to quantify and identify hard coral settlers. The position of all coral recruits in the tiles was mapped in each survey and they were identified to the lowest possible taxonomic level. Preliminary results showed high recruitment (between 39.12 ± 31.09 and 395 ± 660.19 recruits per m2 per month) and high survival rates after one month (38.75 – 68.75 %) in comparison to other Caribbean reefs, emphasizing the importance of this protected area. Furthermore, survival rates were lower at the two sites nearest the populated island, suggesting that the implementation of additional management strategies could benefit corals and other reef species.

## 10.306

**Spatial Variation in The Distribution Of Initial And Terminal Phase Parrotfishes At Fernando De Noronha Archipelago, Northeastern Brazil**

**Roberta BONALDO*[1]**

[1]Australian Research Council Centre of Excellence for Coral Reef Studies and School of Marine Biology, James Cook University, Townsville, Australia

Parrotfishes (Labridae, formerly Scaridae) are herbivorous reef fishes with complex sexual and social systems. Most parrotfish species are protogynous hermaphrodites that change color and sex when adults, from initial phase (IP) females or males to terminal phase (TP) males. The distribution of IP and TP individuals of three *Sparisoma* species was studied at Fernando de Noronha, an oceanic archipelago off Northeastern Brazil. Visual censuses were conducted on five reefs on the main island and six sites on secondary islands of the archipelago. In the main island, IP individuals of the three species were more abundant than TPs, but in the other study sites TP individuals were found in similar or higher numbers than IPs. In sites where IP individuals were more abundant, TPs were found swimming constantly, apparently patrolling territories and chasing away conspecifics. In contrast, in reefs were the relative abundance of TPs was higher, these individuals were predominantly found on feeding activities. Thus, TP individuals of the studied species seen to have different behaviors according to the site, which probably drive the differences on relative abundances of IP and TP individuals around the archipelago. These results are similar to the distribution pattern of *Sparisoma viride* in the Caribbean, and emphasize the complexity of parrotfishes' social systems, especially *Sparisoma* spp. The marked variation on the abundance and behavior of different *Sparisoma* species highlights the importance of considering not only species abundance, but also intraspecific behavioural patterns when formulating management strategies on reef ecosystems.

## 10.307

**Spatial Variability in The Community Structure Of Juvenile Corals in La Parguera, Southwestern Puerto Rico**

**Emmanuel IRIZARRY-SOTO*[1]**, Ernesto WEIL[1]

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Juvenile coral abundances and community structure have been shown to be variable at spatial and temporal scales. Recent studies have shown that small spatial scales play important roles in the abundance and community assemblages of juvenile corals. In this study abundances and community structure of juvenile corals were evaluated using a nested ANOVA design to assess the spatial scale at which variability was higher. Six reefs were surveyed across the insular platform off La Parguera, southwestern Puerto Rico in an inshore-offshore gradient. All juveniles were counted and identified to at least genera in six randomly placed 1m2 quadrats in each of four 20m long transects in each of four depth intervals (0-3, 4-10, 10-15 and >15m) in four of the six reefs, and a deep habitat (>15m) in the two offshore reefs. Mean overall density of juvenile corals was 1.53 ± 0.11 col/m2 with only 38 % of the variability explained by habitat (depth) and 52 % by factors not evaluated. Juvenile coral densities increased from 0.5 ± 0.11 col/m² in shallow habitats to 2.78 ± 0.39 col/m2 in intermediate depths. Shallow juvenile communities were dominated by Diploria strigosa while intermediate and deep habitats were dominated by Montastraea cavernosa, M. faveolata and Stephanocoenia intersepta (Bray-Curtis). Results indicate that medium to small spatial scales (<10m) are important in shaping the abundance and community structure of juvenile corals in reef habitats of southwestern Puerto Rico.

Key words: juvenile corals, community structure, spatial variability, Puerto Rico

## 10.308

**Marine Habitat Structure and Health Status Heterogeneity Effects on Coral Reef Fish Assemblages in Martinique**

**Yann ROUSSEAU*[1]**, Philippe LENFANT[2], René GALZIN[2], Jean-Philippe MARÉCHAL[1]

[1]OMMM, Fort de France, Martinique, [2]EPHE - University of Perpignan, Perpignan, France

The relation between habitat degradation and fish communities structure was assessed at 12 sites along the Martinique Caribbean coast in two different habitat types: bank reef and fringing reef. Four health index (from very good to very degraded) were used to qualify the reef status, each site belonging to one of the 4 categories. Fish and benthos data were collected using visual census at a depth of 8 to 13m. Fish were counted during 2 passes (4m belt and 2m belt) along a 50m long transect: 1) number and size class of mobile and fearful species and 2) territorial species. Point intercept was used for the benthos (100pt/transect). Each site was sampled twice in triplicate during both the dry and wet season, 2007. Univariate (abundance, species richness, diversity index) and multivariate statistics (PERMANOVA, PCoA, CCA) were used to analyze the data. Comparison were made between the fish assemblages and the different habitat attributes. The analysis of the fish population structures was performed on key species (abundant species, commercial species), principal families and trophic groups. Preliminary results show differences in fish species composition, abundance and biomass according to health status and habitat type. The information will be compiled to model fish assemblages changes with reef health status.

## 10.309

**Reef Ecology in the Dry Tortugas (Florida, USA): Death by Temperature, Life by *Diadema?***

**Ilsa B. KUFFNER*[1]**, Valerie J. PAUL[2], Raphael RITSON-WILLIAMS[2], T. Don HICKEY[1], Linda J. WALTERS[3]

[1]Florida Integrated Science Center, U.S. Geological Survey, St. Petersburg, FL, [2]Smithsonian Marine Station at Fort Pierce, Fort Pierce, FL, [3]Department of Biology, University of Central Florida, Orlando, FL

The Dry Tortugas, a unique and isolated atoll-like reef system, has experienced degradation similar to other Caribbean reefs. To understand better how recent disturbances (e.g., low and high temperature extremes, diseases, etc.) have influenced modern community structure, we conducted detailed species-level surveys of macroalgae, scleractinian and gorgonian corals, herbivorous fishes and urchins, and substratum composition (e.g., rugosity) in shallow (3 – 6 m depth) low-relief reef and hardbottom communities. By characterizing the current communities we hope to gain knowledge about the ecological process of herbivory inside vs. outside of the "no-take" Research Natural Area (RNA) designated by the U.S. National Park Service in 2007. *Diadema antillarum* was present and fairly evenly distributed at all 18 randomly selected sites surveyed (nine inside, nine outside the RNA). Mean densities ranged from 0.01 to 0.54 individuals m-2, with 11 of the 18 sites having densities above 0.10 individuals m-2. Both *D. antillarum* density and scleractinian coral species richness were positively correlated to rugosity of the substratum, which explained about a third of the variance in both cases. *Diadema antillarum* density was also positively related to percentage of the substratum composed of *Acropora cervicornis* rubble, explaining an additional third of the variance in this variable. Small (< 1-m-diameter) live colonies of *A. cervicornis* were noted at 12 of the 18 sites. Our data indicate that testing the hypothesis that *A. cervicornis* rubble acts as nursery habitat for *D. antillarum* would be worthwhile. We suggest the possibility of a positive feedback mechanism between these two "recovering" species. It will be instructive to document changes in these populations over the next decade as fish populations in the RNA diverge from those in the rest of Dry Tortugas National Park.

## 10.311

**Depth-Variable Predation On Post-Settlement Stages Of Coral Reef Fishes**

**LANCE JORDAN*[1,2]**, KENYON LINDEMAN[3], RICHARD SPIELER[1,4]

[1]oceanographic Center, Nova Southeastern University, Dania Beach, Fl, [2]national Coral Reef Institute, Dania Beach, [3]marine And Environmental Systems, Florida Institute Of Technology, Melbourne, Fl, [4]national Coral Reef Institute / Guy Harvey Research Institute, Dania Beach

Despite spatial protections from direct fishing pressure, destruction and modification of settlement and post-settlement habitats may also lead to substantial population declines. Many studies of commercially important reef fishes have found that settlement occurs more frequently in shallower habitats. However, it remains unclear whether the *sine qua non* of settlement habitat for most species is related to depth, refuge quality, or predator pressure. To examine these variable factors, we deployed 16 replicate, artificial patch reefs (1m3) on sand plains at three depths: 7m, 12m, and 21m. Half of the reefs at each site were randomly chosen and caged with plastic mesh, excluding piscivorous fishes. Newly settled and early juvenile stages of several species of grunts (*Haemulon* spp., Haemulidae), which dominate nearshore hardbottom reef fish assemblages in the study area, were visually censused and collected every two weeks (during new and full moon phases) from May–August 2006. Comparing caged versus uncaged reefs allowed for examination of relative predation intensity at several depths while limiting the confounding effects of habitat variability and refuge quality. When pooling data from all sites and collection intervals, caged reefs demonstrated significantly higher abundances of newly settled *Haemulon* spp. The greatest difference in settling *Haemulon* spp. abundance, between caged and uncaged replicates, occurred at 12m depth ($p<0.05$, ANOVA). At this depth, newly settled *Haemulon* spp. abundance was 14 times greater on caged replicates than on uncaged replicates. The shallowest depth exhibited the lowest difference of newly settled *Haemulon* spp. abundance, between caged and uncaged replicates ($p>0.05$, ANOVA); with the lowest density of piscivorous fishes ($p<0.05$, ANOVA). The high recorded abundances of settling *Haemulon* spp. on similarly shallow nearshore hardbottom habitats suggest that depth-structured differences, in the form of lower predator pressures, are a significant ecological attribute of nearshore hardbottom essential fish habitats in southeast Florida, USA.

## 10.312

**Is The Diadema Antillarum Recovery Depressing Herbivorous Fish Abundances?**

**Aaron ADAMS*[1]**, Robert MILLER[2], John EBERSOLE[3]

[1]Center for Fisheries Enhancement, Mote Marine Laboratory, Pineland, FL, [2]University of California Santa Barbara, Santa Barbara, CA, [3]University of Massachusetts Boston, Boston, MA

Recent, patchy recovery of *Diadema antillarum* from the Caribbean-wide mass mortality of 1983-84. has been associated with well-documented reductions in algal cover and increased coral recruitment. Less is known about the dynamic of urchin recovery as it involves fishes, although substantial evidence points to resource competition between herbivorous fishes and *Diadema*. In the U.S. Virgin Islands, for example, the *Diadema* die-off was followed by 3-4 fold increases in population densities of herbivorous fishes, mostly juvenile scarids and acanthurids.

These post-dieoff data addressed only one direction of the two-way herbivorous fish/urchin interaction – the compensatory increase of herbivorous fishes in response to a decrease in *Diadema*. As *Diadema* recovers, will abundances of herbivorous fishes decrease in response to increases in *Diadema*? How will recovery of *Diadema* be affected by herbivorous fishes, will there be priority effects?

Between October 2004 and March 2005, we counted *Diadema* and fishes along 25 x 2m transects on backreef and fore-reef habitats at 11 sites on St. Croix, USVI. *Diadema* densities were significantly negatively correlated with densities of herbivorous fishes in all 3 fish size classes: "post settlement" (<3cm, $r = -0.317$, $p<0.001$); "recruit" (3-5cm, $r = -0.152$, $p<0.05$); and "adult" (>5cm, $r = -0.211$, $p<0.01$).

Temporal information supports the inference that the inverse relationships between *Diadema* herbivorous fishes are causally related. Comparisons with transect data from October 2000 from 6 of the study sites showed that *Diadema* densities had increased and herbivorous fish densities had declined over the 5 years between counts. Additional research is needed to elucidate the competitive mechanisms producing these results and the degree to which competition from herbivorous fishes may hinder more general recovery of *Diadema* — especially since high densities of herbivorous fishes are most likely to be found in marine protected areas where we would most like to see rapid recovery.

## 10.313

**The importance of habitat type and presence of conspecifics in habitat selection of a coral reef fish**

**Chantal HUIJBERS*[1]**, Ivan NAGELKERKEN[1]

[1]Animal Ecology and Ecophysiology, Radboud University Nijmegen, Nijmegen, Netherlands

Habitat selection of coral reef fish may be influenced by a variety of factors such as shelter, food availability, presence of conspecifics, habitat size, etc. In this study, a field experiment was designed to test habitat preference of the reef fish species *Haemulon flavolineatum*. Choice experiments were conducted *in situ* in experimental enclosures using four shallow-water habitat types in which this species naturally occurs: coral reef, rubble, mangroves and seagrass beds. A second experiment tested the degree to which presence of conspecifics or heterospecifics plays a role in habitat selection. Odours from the experimental habitats were blocked to ascertain that choices were based purely on vision. Five different life stages were tested, i.e. recruits (2 – 3.5 cm) and small juveniles (4 – 6 cm) from rubble habitat, small (4 – 6 cm) and larger (> 12 cm) fishes from seagrass beds, and larger individuals (10 – 14 cm) from the coral reef. Individuals of all life stages, except the smallest individuals from the rubble habitat, preferred mangroves as a habitat. In addition, their preference did not differ between mangroves harbouring conspecifics and conspecifics alone, although conspecifics were always preferred above heterospecifics. Only the recruits from the rubble habitat did not prefer a single habitat, and chose more often for conspecifics alone than conspecifics combined with a habitat type. This suggests that for recruits any structure may be sufficient as shelter, while presence of conspecifics appears to play an important role. For larger individuals, the experiment indicates that the structural complexity of mangroves is most attractive for *H. flavolineatum*, probably because of the better protection against predators.

## 10.314

**Predation, Size Composition And Distribution Of Crown-Of-Thorn Starfish On Lankayan Island Reefs: Result Surveys 2005 To 2007**

**Fung Chen CHUNG*[1]**

[1]Reef Guardian Sdn Bhd, Sandakan, Malaysia

Outbreaks of coral-eating Crown-of-thorns starfish (*Acanthaster planci*) can cause severe damage to coral reefs. These outbreaks have been observed around Lankayan Island since 2005. To develop appropriate control measures, it is necessary to understand the distribution of Crown-of-thorns starfish (COTs). Therefore, the objective of this study was to document the predation, size composition and distribution of COTs from 2005-2007. The size composition and distribution of COTs tend to be associated with reef morphology such as reef depth, coral cover and types. Adult COTs were found at the deeper reefs at 14-20m reef slope. In contrast, smaller COTs were more likely to be found in shallow reefs at 3-10m. The COTs preferred feeding on branching & tabular corals and less on massive and encrusting corals. The distribution of COTs were not evenly distributed, and ongoing monitoring indicated that the outbreak pattern occurred due to mass migration of COTs from reef to reef. Oceanographic current patterns, natural events such as storms, and destructive fishing activities are factors that likely caused COTs outbreaks in Lankayan reefs.

## 10.315

**Bleaching, Pollution And The Coral *oculina Patagonica***

**Roee SEGAL*[1,2]**, Rachel ARMOZA-ZVULONI[2], Ido MIZRACHI[2], Noa SHENKAR[2], Yossi LOYA[2]

[1]Porter School of Environmental Studies, Tel-Aviv University, Tel-Aviv, Israel, [2]Department of Zoology, The George S. Wise Faculty of Life Sciences, Tel-Aviv University, Tel-Aviv, Israel

The aim of this research was to study the effect of land based industrial and household pollution on bleaching dynamics, colony size and reproduction effort in the encrusting coral *Oculina patagonica*. A one-year monitoring of populations of the coral *O. patagonica* was conducted in 4 sites polluted by an array of pollutants and their 4 reference sites along the Israeli coast of the Mediterranean Sea. Surveys of intra-colonial bleaching percentage showed that during the peak bleaching season (August-September), there were no differences between corals from the polluted sites and those from the reference sites. Recovery was seen during the winter in all sites regardless of pollution impact. The average colony size was significantly smaller in corals from all polluted sites when compared with corals from their reference sites. In general, no differences were found in gonad size, development and sex ratio between populations from the polluted and reference sites. Size frequency distribution of colonies suffering from annual bleaching shifted toward smaller size. This phenomenon was more dramatic in the polluted sites in the southern part of Israel with minimum of average colony area in Ashdod (8.8 ± 1 cm2) compared to their reference site Palmachim (13.4 ± 1 cm2) and to the northern site where no bleaching or pollution was evident (Achziv; 257.9 ± 50 cm2). Therefore, populations of the coral *Oculina patagonica* reproduce even in highly polluted sites. Despite this, the lower average size of the colonies in the polluted sites, results in a lower reproductive fitness of the population, since fewer polyps are reproducing. The additive effect of pollution and bleaching, which was previously shown to cause partial mortality to the colonies, resulting in a further decrease in colony size, will eventually negatively affect reproductive fitness of populations of this coral in these areas.

## 10.316

**Underestimated Eroder Among Reef Fishes -Experimental Comparison Between Ctenochaetus Striatus And Acanthurus Nigrofuscus (Acanthuridae)**

**Helmut SCHUHMACHER*[1]**, Roland KRONE[2], Peter van TREECK[3]

[1]Hydrobiology, Universitaet Duisburg-Essen, Essen, Germany, [2]Marine animal ecology, Alfred-Wegener-Institute for polar and marine research, Bremerhaven, Germany, [3]Universitaet Duisburg-Essen, Essen, Germany

The acanthurid fish species *Ctenochaetus striatus* and *Acanthurus nigrofuscus* are common detritivore browsers. Less is known about their erosion potential. We offered coral limestone for grazing in 24h-aquarium experiments and recorded the feeding behaviour by video. *C. striatus* produced 15 times more calcareous sediments (faeces and loose material) compared to *A. nigrofuscus* despite of a 5 times higher biting rate of *A. nigrofuscus*. This discrepancy can be explained by different feeding techniques of the species. *A. nigrofuscus* performed careful picking bites only, whereas *C. striatus* showed a more differentiated feeding behaviour: soft sweeping of the surface alternating with chafing the substrate with grasping bites at which the whole body was shaking and exerting trust. Hereby a special palate structure (bow of hard knobs in the upper jaw) is engaged which allows to rasp the reef substrate (Krone et al. 2006). The measured eroded masses per bite and the number of bites per individual were related to the population densities of the two species on three reef crests in the Northern Red Sea. Based on these calculations, *A. nigrofuscus* attains maximum erosion rates of 2.6 g m-2 yr-1 and may therefore not be regarded as a relevant bioeroder, but *C. striatus* achieves erosion rates of up to 70.0 g m-2 yr-1 which is in the same order as that of the co-occuring sea urchin *Diadema setosum*.

## 10.317

**The Feeding Ecology Of Select Herbivorous Fishes in Two Reef Habitats Of Cuba**

Alain DURÁN[1], **Rodolfo CLARO*[1]**

[1]Departamento de Biología Marina, Instituto de Oceanología, La Habana, Cuba

The feeding activity and the impact of three herbivorous fishes (Sparisoma viride, Scarus iserti and Acanthurus coeruleus) was studied at two coral reefs during the dry (February) and rainy (August) seasons of 2006. The reef at Acuario (National Park Guanahacabibes) is relatively pristine, while the reef at the north coast of Havana City (IdO) is subjected to pollution and fishing pressure. Herbivore fish composition and foraging intensity were measured for all Acanthurid and Scarid species, by measuring the total bite rates per 1 m2 of reef substrate during 5 minutes intervals (25 replicates). Concurrently, species foraging intensity was mesured for juvenile, intermediate, and adult phases number of bites in 10 min., 10 replicates). Algal consumption rate was estimated using a coefficent of consumed biomass per bite, for each size class. The algal cover was sampled at 20 m linear transects with 4 replicates at each site. Food items were assessed sampling algae at the observed bited substrates. Compared to Acuario, herbivores in IdO showed lower species richness and higher density, with the exception of large-sized parrotfish, which were almost absent due to intense fishing. The highest bite rate was observed for the smallest fish size, but net comsuption rate was three times greater in adult fishes. S. viride had lower levels of foraging intensity than A. coeruleus and S. iserti, possibly due to larger consumption per bite. Levels of foraging activity were lower in February. Algal cover was lower in Acuario where herbivore density was higher but fish size was smaller. In both locations epilithic algae were the preferred food.

## 10.318

**Variation in Social Foraging By Fishes Across A Coral Reef Landscape**

**Peter AUSTER*[1]**, James LINDHOLM[2]

[1]University of Connecticut, Groton, CT, [2]California State University Monterey Bay, Seaside, CA

Coral reef landscapes are composed of a matrix of habitats which exhibit a gradient of complexity at multiple spatial scales. This variation has been shown, in part, to influence the composition of fish communities. It follows that such variation will also influence the type and rate of species interactions. In this study, we quantified the rates of social foraging bouts in relation to community composition across four distinct habitat types (continuous reef, coral rubble-sand, reef edge, and spur and groove) at Conch Reef in the Florida Keys National Marine Sanctuary (USA). The purpose of dividing the reef landscape into particular habitat units was to ascertain if rates of social foraging vary in consistent ways in relation to habitat attributes. Results indicated that there while there were no clear divisions in species composition that could be correlated with habitat type, comparisons of rates of social foraging based on total (mixed and single species foraging groups) and mixed species bouts alone showed that rates of social foraging across habitats were not equal. Further, both Fishers diversity and species richness measures were not equal across habitat types, with lowest mean values in coral rubble habitat where rates of social foraging were highest. These results highlight the complexity of facilitative species interactions in coral reef landscapes.

## 10.319

**Recruitment Potential And Recruitment Survival As A Function Of Habitat Degradation**

**Suzanne MILLS*[1]**, David LECCHINI[2], Pascal DUMAS[2], Eric PARMENTIER[3]

[1]Biologie et Ecologie Tropicale et Méditerranéenne, UMR 5244 EPHE-CNRS-UPVD, Perpignan, France, [2]UR 128 CoRéUs, Institute for Research and Development (IRD), Noumea, New Caledonia, [3]Laboratoire de Morphologie Fonctionnelle et Evolutive, Université de Liège, Liege, Belgium

Knowledge of the recruitment potential, as well as post-recruitment survival, between different reef habitats, would improve the management of target species and conservation of reef ecosystems. Many coral reefs have been subjected to, and continue to suffer from, habitat degradation due to both natural and anthropogenic stress. However, the effects of habitat degradation on larval recruitment potential and on the survival of settled recruits are currently not known. We aimed to distinguish between these two processes by simultaneously measuring survival and recruitment of vertebrate and invertebrate larvae across habitats differing in their percentage of coral cover (healthy vs dead: 50 % vs 12 % coral cover) with a 100 % sand habitat as a control. Recruitment and survival were monitored after 10, 20, 40 and 80 days on atolls in French Polynesia. Lower recruitment was identified for multiple molluscan, gastropod and sponge species in the control sand habitat, possibly reflecting the lack of habitat and/or conspecifics attraction cues, either acoustic or chemical. On the other hand polychaetes and opistobranchs showed higher recruitment in control sand habitats. One molluscan species, the pearl oyster, of considerable economic importance in French Polynesia, showed lower growth in the control sand habitat. Differences in recruitment and survival will be discussed as a function of coral cover and habitat degradation, as well as consequences for reef ecosystem conservation and management.

## 10.320

**Effect of the Herbivorous West Indian Spider Crab (Mithrax spinosissimus) on Patch Reef Algal Communities in the Florida Keys (USA)**

**Angela MOJICA*[1]**, Mark BUTLER[1]

[1]Biological Sciences, Old Dominion University, Norfolk, VA

Many Caribbean coral reefs have changed from coral- to algal- dominance, and the decline of piscine and echinoderm grazers in these communities has played a significant role in this phase-shift. Virtually unknown, however, is the effect of the herbivorous West Indian spider crab (Mithrax spinosissimus) on coral reef community structure. Therefore we examined the foraging ecology and impact of spider crab herbivory on inshore patch reefs in the Florida Keys, Florida (USA). Crabs were held individually for 24 hrs and fed either four naturally-occurring algae (Ulva sp., Laurencia sp., Dyctiota sp., and Halimeda sp.), or clumps of mixed macro-algae (Halimeda sp. + Dyctiota sp.) from the reef to determine diet preferences and consumption of crabs by size and sex. Preliminary analysis of these results showed that fleshy macro algae are preferred by M. spinossissimus over Halimeda sp. Rates of consumption obtained under laboratory conditions were compared with those obtained in the field, by encaging a single crab in cages that excluded all herbivores greater than 2cm in diameter. Rates of benthic algal production and macroalgal growth, estimated in situ on caged and un-caged natural plots and experimental plates surpassed the consumption rates possible by individual crabs. Our results indicate that M. spinosissimus as potential important consumers of macroalgae on reefs, but their ability to regulate reef macro-algal abundance or composition is diminished by their low density, low mobility, and perhaps lower activity in predator-rich environments such as reefs.

## 10.321

### *Leptoseris* in Hawaii: The Deepest Photosynthetic Corals In The World?

**Samuel KAHNG*[1]**, James MARAGOS[2], Eric HOCHBERG[3], Richard KLOBUCHAR[4]

[1]College of Natural Science, Hawaii Pacific University, Kaneohe, HI, [2]Pacific/Remote Islands National Wildlife Refuge Complex, U.S. Fish & Wildlife Service, Honolulu, HI, [3]Hawaii Institute of Marine Biology, Kaneohe, HI, [4]Waikiki Aquarium, Honolulu, HI

Despite its ecological importance, the photosynthetic deep reef below 50 m around the world is poorly understood. Most coral reef science is performed well within the depth limits of recreational SCUBA diving. However, zooxanthellate scleractinian corals occur far below these depths in clear, oligotrophic waters. In Hawaii, photosynthetic corals have been observed growing in situ down to 153 m off the Big Island. Around most of the Main Hawaiian Islands, there is extensive deep reef habitat associated with the insular shelves which extend laterally several km offshore to depths of 100-120 m where they are typically bordered by steep fossil carbonate slopes. In 2001-2006, HURL deep-water surveys in Hawaii observed that the dominant shallow-water reef building corals (i.e., *Porites*, *Montipora*, and *Pocillopora*) were rare below 60 m. However, zooxanthellate scleractinians of the genus *Leptoseris* were abundant between 60-120 m. In many areas, coral cover exceeded 50% providing complex habitat for an abundance of reef fish and invertebrates. To date, taxonomic analysis has identified *Leptoseris hawaiiensis*, *Leptoseris yabei* (new record for Hawaii), and at least two undescribed, congeneric species. Observations suggest that *Leptoseris* spp. possess specialized photosynthetic physiology for thriving in low light. Preliminary analysis on colonies in culture at the Waikiki Aquarium in Honolulu, Hawaii suggest that the coral growth rates are comparable to shallow-water corals, photosynthesis is the primary source for energetic requirements, and pigment densities are an order of magnitude higher than shallow-water corals. Further research into distribution, physiology, and ecology are needed to properly manage this understudied but important habitat. In particular, examining the environmental factors determining lower depth limits will provide insight on how these important habitat builders will react to future changes in climate and optical water quality.

## 10.322

### Sea Urchin Herbivory in Hawaiian Shallow Water Ecosystems: *echinothrix* As Allies With *tripneustes*

**Holly JESSOP*[1]**, Misaki TAKABAYASHI[1], Marta DEMAINTENON[1], Camille BARNETT[1], Nate OLSON[1]

[1]Marine Science, University of Hawai`i at Hilo, Hilo, HI

*Tripneustes gratilla* sea urchins have been shown to be important grazers on Hawaiian coral reefs, helping to prevent overgrowth of algae and also significantly consuming invasive algal species that have become problematic in Hawai‘i. To add to this body of knowledge, we have conducted research on herbivory by Diadematid *Echinothrix* urchins, which co-exist with *T. gratilla* and are also prevalent on Hawaiian reefs. The objective of this research was to assess the comparative and combined potential grazing impacts of *T. gratilla* and *Echinothrix* species on invasive algal populations in Hawai‘i. Our research program utilized three different methodological avenues: 1) laboratory no-choice feeding trials of two-week duration to quantify grazing rates on the invasive algae *Gracilaria salicornia*, 2) ecological field surveys to measure urchin abundances and to investigate interspecific habitat partitioning, and 3) isotope analyses to determine relative urchin trophic positions and *in situ* feeding habits. Our results of urchin grazing rates that are significant and similar, differences in spatial distribution on reefs, and no evidence for in situ partitioning of food resources, suggest that *Echinothrix* species may be important allies with *T. gratilla* in the control of algae in Hawai‘i. These results should be useful to conservation managers working to understand and prevent coral reef degradation and macroalgal phase shifts in Hawai‘i.

## 10.323

### The Ecological Significance Of The Spotted Spiny Lobster And The Long Spined Sea Urchin On Patch Reef Communities in The Florida Keys

**Meredith KINTZING*[1]**, Mark J. BUTLER IV[1]

[1]Biology, Old Dominion University, Norfolk, VA

The degradation of coral reefs in the Caribbean has been attributed to many factors including global climate change, disease, eutrophication, overfishing, and sea urchin (*Diadema antillarum*) mass mortality. For example, the loss of piscine predators and herbivores to overfishing is thought to dramatically alter coral reef community structure. However, large invertebrate predators, such as lobsters, are also heavily exploited and their impact on coral reef communities is largely unknown. In the Caribbean, the Spotted Spiny Lobster (*Panulirus guttatus*) is an abundant resident of shallow reefs and a omnivorous predator of echinoderms, crustaceans, polychaetes, and other benthic taxa. *Panulirus guttatus* is an obligate dweller of reefs and displays high site fidelity, so unlike other sympatric species of lobster, it is more likely to directly impact reef communities. We are investigating the trophodynamics of *P. guttatus* on patch reefs in the Florida Keys (Florida, USA) and are experimentally testing the hypothesis that high densities of *P. guttatus* inhibit recovery of *D. antillarum* via predation on urchin recruits. Our study couples gut content analysis, laboratory feeding trials, and manipulative field experiments. Preliminary results indicate that *in situ* changes in lobster density, hence predation, alters the composition of reef macroinvertebrate communities. Our initial laboratory studies also show that *Diadema* display strong behavioral responses to lobster chemical cues, which may result in changes in macroalgal community structure on reefs.

## 10.324

### Secondary Succession Of Coral Reef Communities At Urasoko Bay, Ishigaki Island, The Ryukyus (Southern Japan)

**Hideo OHBA*[1]**, Kazumasa HASHIMOTO[2], Kazuyuki SHIMOIKE[3], Takuro SHIBUNO[2], Yoshimi FUJIOKA[4]

[1]Department of Marine Biosciences, Tokyo University of Marine Science and Technology, Tokyo, Japan, [2]Ishigaki Tropical Station, Seikai National Fisheries Research Institute, Okinawa, Japan, [3]Japan Wildlife Research Center, Tokyo, Japan, [4]National Research Institute of Aquaculture, Mie, Japan

We need to clarify the causes of coral reef death and their recovery processes for the restoration of dead coral reefs. Observations of secondary succession of coral reef communities was carried out at Urasoko Bay, Ishigaki Island, the Ryukyus, southern Japan from 1995. Three study sites were established in Urasoko Bay: outer reef flat (Sta. A), inner reef flat (Sta. B) and inshore-side moat (Sta. C). Four permanent quadrats (1 m x 1 m) were put on each site and all organisms were scraped from the substrate surface in all quadrats in March 1995. The percent cover, number of species and colonies of hermatypic corals as well as the percent cover of marine algae in each quadrat were measured once a year. Except some quadrats at Sta. B and C, whose substrata are composed of rubble from dead branching corals, the immigration of coral larvae and the cover of hermatypic corals gradually increased toward summer of 1998, but most colonies of *Acropora* spp. died during large-scale coral bleaching between summer and fall of 1998. However, new coral recruitment started again and the coral cover at Sta. A and B achieved 90-100% during 2004-2005. Coral species recruited on the rocks at Sta. A and B were tabular and corymbose *Acropora* spp. and those at Sta. C were massive *Porites* spp. in both recovery periods. Thick non-articulated coralline algae covered the rock surface for 2-3 years before the recovery of hermatypic coral communities. It is suggested that the non-articulated coralline algae play a role in construction of firm substrata for settlement and growth of hermatypic corals on the dead corals. The tabular *Acropora* community around the healthy outer reef flat in Ishigaki Island seems to recover fully in 6-7 years.

## 10.325

**Within And Among-Site Variability in Early Post-Settlement Survivorship Of A Brooding Coral**

**Megan PORTER*[1]**, Wade COOPER[1]

[1]Division of Marine Biology and Fisheries, RSMAS, University of Miami, Miami, FL

Surviving the first few days to weeks after settlement is a difficult yet crucial stage for many marine invertebrates, including corals. Despite the importance of this stage for recruitment dynamics, information on early post-settlement survivorship rates, and the processes controlling these rates, remains limited due to logistical difficulties in studying these cryptic and microscopic stages *in situ*. To address these deficiencies, the goals of this study were to quantify the early post-settlement survivorship of the brooding coral *Porites astreoides*, and to assess variability in these rates both within and among four patch reef locations. To accomplish this, larvae were settled onto small substrate chips in the laboratory, transplanted to the reef within four to six days after settlement, and monitored *in situ* using fluorescent techniques, both in 2006 and 2007. Overall, survivorship among the four sites in both years ranged from 1% to 25% surviving the first month after settlement. Survivorship was slightly lower in 2006 than 2007, and was significantly different among sites in 2007 but not 2006, although the rankings of sites were similar. In both years, survivorship was highly variable within a site, suggesting spatial patchiness in the mechanisms leading to mortality. Although this study did not address specific mechanisms of mortality, quantification of these early survivorship patterns is a useful first step towards proposing more detailed hypotheses on the processes which structure recruitment dynamics.

## 10.326

**Differences in Coral Reef Fish Assemblages Between Mangrove-Poor And Mangrove-Rich Islands**

**Jessica HARM*[1]**, Martin SPEIGHT[1]

[1]Zoology, University of Oxford, Oxford, United Kingdom

Visual surveys of coral reef fish were conducted on two islands (and associated cays) off the Caribbean coast of Honduras, Cayos Cochinos (mangrove poor) and Utila (mangrove rich). Local populations on both islands exploit reefs, seagrass, and mangroves, and Utila suffers from higher fishing pressure compared to Cayos Cochinos, the latter having a conservation plan and no-take zones. Cayos Cochinos houses only one small mangrove stand (length= 246m), while Utila houses two large mangrove lagoons and fringing mangroves on its north side (total length >1400m). A total of 108 species (excluding cryptic species, gobies/blennies) were found during the survey. Species richness was higher on Utilian coral reefs. Eight randomly laid out 50m transects were surveyed at each site (six sites per island). There was a significant difference ($p<0.001$) between fish assemblages on the two islands; this trend was also present when comparing juveniles. Multivariate plots show that although significantly different, juvenile fish assemblages in fringing mangroves are more closely related to juveniles on coral reef than mangrove lagoon juveniles are to coral reef juveniles. Out of 17 coral reef fish whose juveniles were found in mangroves but absent from reefs, six species had significantly higher ($p<0.05$) adult coral reef fish abundances on Utila than Cayos.

Microhabitat surveys were performed on all transects using point-contact sampling. Hard coral was not significantly different between islands. Utila had significantly higher dead coral, while Cayos Cochinos had significantly more foliose algae. However, apart from the damselfish *Abudufduf saxtalis* (negatively correlated with algae on both islands), there were no clear trends between fish abundances and microhabitat characteristics. The absence of fishing pressure and predictable habitat correlations indicates that mangroves have a positive effect on coral reef fish abundances and species richness. Future studies will target water quality and other abiotic differences between the islands.

## 10.327

**Impact Of The 2005 Coral Bleaching Event On *porites Porites* And *colpophyllia Natans* At Tektite Reef, Us Virgin Islands**

**Kevin WHELAN*[1]**, Jeff MILLER[2], Olga SANCHEZ[3], Matt PATTERSON[4]

[1]South Florida Caribbean Inventory and Monitoring Network, National Park Service, Miami, FL, [2]South Florida Caribbean Inventory and Monitoring Network, National Park Service, St. John, Virgin Islands (U.S.), [3]Environmental Studies Department, Florida International University, Miami, FL, [4]South Florida Caribbean Inventory and Monitoring Network, National Park Service, Palmetto, FL

In 2005, mass coral bleaching occurred at a number of north-east Caribbean reefs. The impact of the 2005 coral bleaching and subsequent White plague disease type II on *Porites porites* and *Colpophyllia natans* was monitored by using a time series of photographs from Tektite Reef, Virgin Islands National Park, St. John. Over 92 % of the P. porites and 96 % of the *C. natans* experienced extensive (> 30 % of colony bleached) bleaching. During the study, 56 % of *P. porites* and 42 % of *C. natans* experienced whole colony mortality within the sample plots. While all *P. porites* whole colony mortality was directly attributed to coral bleaching, the majority (82 %) of the *C. natans* colonies that experienced total mortality initially showed signs of recovery from the coral bleaching event before subsequently dying from White plague disease type II.

## 10.328

**Relationships Between Reef Fish Assemblages And Coral Habitat Characteristics in The Bay Islands (Honduras)**

**Yolande BOUCHON-NAVARO*[1]**, Max LOUIS[1], Pedro PORTILLO[1], Claude BOUCHON[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe

In the Caribbean, the reef coral communities exhibit a general decline which may affect the reef fish communities. With the aim of a better understanding of the factors controlling the distribution and the structuration of fish assemblages on coral reefs, simultaneous studies on fish and benthic communities, as well as habitat characteristics, were carried out in the Bay islands (Honduras). At 18 stations located in Utila, Roatán and Guanaja, visual counts of fishes were carried out along 5 band-transects (30m long x 2m large) and the benthic communities were quantitatively studied with a linear transect method (50m long) on the same sites in order to collect 15 habitat descriptors corresponding to abiotic factors (depth, substrate rugosity, water transparency...) as well as biotic factors (quantitative data on corals, other Invertebrates and algal components on the benthic communities). Partial canonical correspondence analyses (CCA) and partial redundancy analyses (RDA) were respectively used to test the quantitative distribution of 117 fish species and the structure of the fish communities (29 synthetic variables: species richness, abundance, biomass, diversity indices, trophic groups...) against the 15 environmental descriptors.

CCA identified three variables that statistically explained the fish distribution: depth (17.3% of the variance of the data), substrate rugosity (10.1%) and the bottom coverage by algal turf (8.8%). RDA revealed that six environmental descriptors were significantly correlated to the synthetic variables of the fish community: depth (30.3% of the variance of the data), bottom coral coverage (28.1%), substrate rugosity (13%), the proportion of coral colonies exhibiting necrosed tissues (10.4%), the bottom coverage with brown macroalgae (7.6%) and the percentage of coral species presenting necrosed tissues (5.9%). The results of these analyses highlight the close relationships between the fish and the coral communities, but also the importance of the state of health of these communities.

## 10.329

**Ichthyological Colonization On The Coral Reefs in The French West Indies**

**Yann FREJAVILLE*[1]**, Yolande BOUCHON-NAVARO[1], Max LOUIS[1], Lionel REYNAL[2], Claude BOUCHON[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe, [2]Laboratoire de ressources halieutiques, IFREMER, Le Robert, Martinique

Reef fisheries in the Caribbean exhibit regularly decreasing CPUE during the last decades. In order to better understand the reef fish dynamics, the aim of the present work was to study the colonization of coral reef fishes after a pelagic larval development stage. The success of settlement governs the post larval supply of the reef fish stocks. Monthly samplings of post-larval fishes settling on a coral reef of Guadeloupe Island were carried out with a crest net over 15 months. In complement, samplings of pelagic patches of micronekton were realized with a mesopelagic trawl (30 tows) off the coasts of Martinique Island.

A total of 3867 settlers belonging to 50 families were sampled on the reef of Guadeloupe. An average colonization of 9 individuals by linear meter of the reef front and per hour was recorded. The colonization on the reef is close to the "competition" model, based on the hypothesis that the fishes settle in excess relatively to habitat and resources provided by the reef. The most abundant families of settlers are the Gobiidae (50% of total number, 43% of relative occurrences), then the Clinidae and the Scaridae. The main environmental factor governing the colonization is the nycthemeral cycle and the most prefered period is located between 3:00 am and 5:00 am. The other favourable factors are: strong hydrodynamic conditions, nebulosity, wind direction and abundance of drifting debris.

A total of 678 post-larvae belonging to 54 families were collected off Martinique coasts. A phenomenon of nycthemeral vertical migration was observed. Fish colonization revealed to be actively controlled by the behaviour of the competent post-larvae.

The results of this study suggest that predation and competition during the settlement stage, combined to the degradations of the habitat, are among the main factors limiting the stocks of adult coral reef fishes.

## 10.330

**The Effect Of Fisheries Management On Species-Composition Of Crustose Coralline Algae, With Implications For Coral Recruitment**

**Jennifer O'LEARY*[1]**, Juan Carlos BRAGA[2], Tim MCCLANAHAN[3]

[1]Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]Departamento de Estratigrafía y Paleontología, Universidad de Granada, Granada, Spain, [3]Coral Reef Conservation, Wildlife Conservation Society, Mombasa, Kenya

Fishing can change species composition at lower, un-harvested trophic levels and alter ecological processes. We demonstrated (in other work) that fishing reduces the cover of crustose coralline algae (CCA) in Kenya by changing the dominant grazers. Here, we test whether species composition of CCA is impacted by fishing. CCA is thought to be the primary settlement substrate for coral recruitment; however, some CCA species induce coral settlement but others actually inhibit it. Thus, changes in CCA species composition can profoundly impact coral recruitment. We compared CCA composition along line-intercept transects in 3 management regimes in Kenya: fully fished, gear-restricted, and marine protected (with 3 sites/regime). We expected fished areas to have primarily thin CCA able to withstand low-intensity but frequent sea urchins grazing and protected areas to have primarily thick CCA able to withstand deep, but infrequent fish grazing. We sampled, photographed, and described each visually different CCA along three 10 m transects at each site. We grouped CCA into 60 groups that were visually similar using external morphology and conceptacle size, shape, and spacing (using a 25x scope). We did a preliminary analysis to determine which groups distinguished between management regimes. Twenty-two groups were important, and from each of these groups we randomly selected 6 samples and identified them to species level. We had correctly grouped specimens of the same species for 11 of the 22 groups (using a cutoff of 75% correctness). These 11 groups contained 6 CCA species. We are now using these 6 species to determine whether their relative abundance differs based on management. We will discuss our results in terms of the suitability of available CCA substrate for coral recruitment. This type of study, linking CCA taxonomy with field ecology, has not previously been undertaken due to the difficulties of identifying CCA in the field.

## 10.331

**High Biomass Of Fishes in Rarotonga (Cook Islands): Testing Whether High-Fish-Herbivory Biomass Facilitates Recovery**

**Teina RONGO*[1]**, Dr. Robert VAN WOESIK[1]

[1]Biological Sciences, Florida Institute of Technology, Melbourne, FL

Protecting coral reefs from over-fishing clearly leads to increases in local fish populations, yet whether increases in fish biomass, particularly herbivorous fishes, leads to clear cascading and positive influences on the reef benthos is not clear. We specifically test whether restoring the biomass of herbivorous fishes facilitates coral recovery following disturbances on Rarotonga, in the southern Cook Islands. Over the past 15 – 20 years, these reefs have witnessed a cultural shift away from subsistence fishing because of chronic fish poisoning (ciguatera). The lack of fishing pressure has led to high herbivorous fish population densities, up to 1 to 3 indv/m2, and population densities of urchins (1 – 6 indv/m2) suggests some top-down control. Given the high densities of herbivores we hypothesize that coral recovery is imminent. Over the past 10 years coral recruitment has been relatively high at most sites, but there is no evidence of significant change in the corals' size-frequency distribution. The fore reefs of Rarotonga have remained depauperate of corals and are still dominated by turf algae. Predation pressure by the coral-eating seastar, *Acanthaster planci* has been chronic on Rarotonga over the last decade, preventing coral recovery. Therefore, while herbivory may reduce algal overgrowth and facilitate post-settlement survival of corals, predation pressure also plays a key role in understanding the effectiveness of marine protected areas.

## 10.332

**Nutrient enrichment triggers a macroalga to overgrow and a sea anemone to attack coral**

**Pi-Jen LIU*[1]**, Hsing-Juh LIN[1], Tung-Yung FAN[2,3], Shiue-Ming LIN[1], Kwang-Tsao SHAO[4]

[1]Life Sciences, National Chung Hsing University, Taichung, Taiwan, [2]National Museum of Marine Biology & Aquarium, National Museum of Marine Biology & Aquarium, Taiwan, [3]National Museum of Marine Biology & Aquarium, Pingtung, Taiwan, [4]Research Center for Biodiversity, Academia Sinica, Taipei, Taiwan

The coral reefs of Kenting National Park in southern Taiwan have been degrading over the past decade. Many areas of the reefs have shifted to sea anemone-dominated or macroalgal-dominated reefs. The preliminary results of LTER at Kenting clearly revealed the severe impacts of anthropogenic factors were hypothesized the causes of the degrading of the coral reefs. The factors simulation by Ecosim also revealed not only one factor caused coral degraded. A nutrient-addition mesocosm experiment demonstrated that nutrient enrichment triggered aggressive competition for space by a macroalga and a sea anemone on coral when the levels of herbivory and carnivory were reduced as a result of simulated overfishing. The phase change which occurred during the experimental period replicated what has happened in the field over the past 10 years. In low-nutrient controls, abundances of alga Codium edule and sea anemone Mesactinia genesis remained low, and they coexisted with branching coral Acropora muricata. Combined nitrogen and phosphorus additions markedly increased the photosynthetic efficiencies of coral, coverage of macroalga, and asexual reproduction of sea anemone. After 35 d of nutrient addition, the macroalga began to overgrow the coral where it was in contact with live coral, but not with dead coral. The coral finally died after 122 d when totally overgrown by the macroalga. Within a few days of contact with live coral, sea anemone was observed to induce and develop acrorhagi tentacles which were used to attack and kill neighboring coral. Nevertheless, the sea anemone was not observed to attack the macroalga, but avoided the prolific macroalga in enriched tanks. The response of the macroalga to nutrient enrichment was more rapid, and its negative impacts on the coral were more severe than those of the sea anemone. Our results indicate that nutrient enrichment might be a major cause of the phase shifts from coral- to macroalgal- or sea anemone-dominated reefs.

## 10.333

**Herbivory And Predation At Ningaloo Reef, Western Australia**

**Mat VANDERKLIFT*[1]**, Russ BABCOCK[1], Geordie CLAPIN[1], Julia PHILLIPS[1], Nicole MURPHY[1], Damian THOMSON[1]

[1]CSIRO Marine & Atmospheric Research, Perth, Australia

The outcomes of fishing practices that target predators on coral reefs can be complex, and depend on the intensity of interactions in local food webs, in particular interactions between predators and herbivores, and between herbivores and macroalgae. We surveyed 48 sites inside and outside 3 marine sanctuaries along ~100 km of the coast of the Ningaloo Marine Park (Western Australia), with the aim of quantifying the structure of the coral reef food web and the intensity of the interactions between trophic levels. We quantified the abundance of fish, large mobile invertebrates and macroalgae, rates of grazing on macroalgae and rates of predation on sea urchins and gastropods. The abundance of herbivorous fish (especially scarids, acanthurids and pomacentrids), and of the herbivorous sea urchin *Echinometra mathaei*, was high in fished and unfished areas. Rates of grazing on the macroalgae *Lobophora* and *Sargassum* did not vary consistently between fished and unfished areas, and typically exceeded 40% d-1. Observations suggested that *E. mathaei* fed on fragments of drifting algae. Rates of predation also did not vary consistently between fished and unfished areas. *E. mathaei* were preyed upon heavily, especially by the large predatory wrasse *Coris aygula*. Gastropods (the corallivorous *Drupella* and the herbivorous *Tectus*) were infrequently preyed upon. Along the Ningaloo Reef, the abundance of herbivores is high and rates of herbivory are correspondingly intense. Neither appear to be influenced by current rates of fishing pressure.

## 10.334

**Effects Of Coastal Development On Coral Reef Fish Communities in Dubai, Uae**

**Paolo USSEGLIO*[1]**, John BURT[2,3], Andrew BAUMAN[1], Peter F. SALE[4,5]

[1]International Network on Water, Environment and Health, Dubai, United Arab Emirates, [2]Natural Science and Public health, Zayed University, Dubai, United Arab Emirates, [3]Biological Sciences, University of Windsor, Windsor, Canada, [4]Biological Sciences, University of Windsor, Windsor, ON, Canada, [5]International Network on Water, Environment and Health, Hamilton, Canada

Worldwide, unprecedented rates of development along tropical coastlines are causing severe degradation to coral reef ecosystems. While the effects of large-scale coastal development (i.e. dredging, coastal modification, agriculture) on coral reefs are relatively well understood, their consequences on the associated fish communities are less known. Here we examined changes in coral reef fish communities associated with a coral reef that was adversely affected by an adjacent large-scale coastal development in Dubai, UAE. Pre and post impact censuses were performed during the fall of 2006 and 2007 respectively, 6 months before and after the impact. An increase in sediment load from the development led to a significant loss in both coral cover and diversity within the reef; at the time of the study, however, the physical complexity of the reef had not changed. This loss of live coral led to extensive changes in the structure of the fish community associated with the reef. We found a 17% reduction in the overall abundance of fishes, with only 47% of the pre-impact richness. Substantial changes in species composition were also apparent; previously common invertivore species disappeared completely, and were replaced by one herbivorous species. The results of this research suggest that reductions in live coral cover, without substantial changes in the physical structure of the reef, may have profound effects on the abundance, diversity and composition of coral-associated reef fish communities.

## 10.335

**Recruitment Of Scleractinian Corals On A Marginal Coral Community in Northern Taiwan**

**Ming-Jay HO*[1]**, Chang-Feng DAI[1]

[1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan

Coral communities in Yen-Liao Bay (25° 3' N, 121° 56' E) in northern Taiwan are typical marginal coral communities characterized by low coral coverage and very limited reef-building activity. The main environmental conditions restricting reef development are low sea temperature, strong northeast monsoon and high turbidity in winter. According to the results of a monitoring study from 2003 to 2007, the living coral coverage was decreasing after the impacts of typhoons and coastal construction activities. In order to know the recovery potential of these coral communities, the seasonal variation of coral recruitment was investigated using ceramic plates from May 2006 to May 2007. Plates were deployed at 3 selected reefs in Yen-Liao Bay and retrieved for examination in 3-month intervals. The results showed that coral recruits were only found in summer and early autumn (from June to October) corresponding to the breeding season of corals in this area. The recruitment rate (115 recruits/$m^2$) was higher than that reported in Nanwan Bay (29.8 recruits/$m^2$), a tropical coral reef in southern Taiwan. The higher recruitment rate in Yen-Liao Bay may be related to the circulation pattern that tends to concentrate planula larvae in this semi-enclosed bay. Unlike tropical reefs, coral recruits in Yen-Liao Bay settled mainly on the upper and vertical surfaces on most plates. In addition, there is a significant negative correlation between the number of recruits on vertical sides and the depths. This suggests that reduced light due to high turbidity may be the major factor that affects the settlement and survival of coral recruits in this area.

## 10.336

**The Recovery Of Corals From Disturbances And Potential Modulating Effects Of Settling Algae**

**Dorothea BENDER*[1]**, Guillermo DIAZ-PULIDO[2,3], Sophie DOVE[2]

[1]University of Bremen, Bremen, Ghana, [2]Centre for Marine Studies, The University of Queensland, Brisbane, Australia, [3]Universidad del Magdalena, Magdalena, Colombia

Coral-algal competition is an important aspect of coral reef ecosystems especially during reef degradation, where scleractinian corals are replaced by algae. The recovery of coral populations is likely to depend on the algal species or groups that colonise degraded reefs. Therefore to understand this recovery first requires a thorough understanding of the competitive interactions between corals and algae. However, there is very little empirical information addressing the effects of macroalgae on the regeneration of coral tissue. In this study we experimentally manipulated the type of algae that colonise dead corals and looked at the effects on the tissue regeneration of two common corals species around Heron Island, Great Barrier Reef, Australia, Acropora pulchra and A. aspera after disturbances. These corals apparently have different recovery strategies in terms of rate and behaviour. The filamentous green alga Chlorodesmis fastigiata (turtle weed), the foliose brown alga Lobophora variegata, turf algae (mainly Hincksia sp.), and the crustose coralline alga Porolithon onkodes algae were chosen for this study as they are also common in this region. Preliminary results suggest that the outcome of the regeneration process is highly variable and depends on the species of coral and algae involved. For instance, C. fastigiata slowed the recovery rate of A. pulchra but not of A. aspera.

## 10.337

**Abundance And Destructions Of Acanthaster Planci (L) On Reefs Off Zanzibar Town**

Ali USSI[1], **Christopher MUHANDO*[2]**

[1]Marine Biology and Resources management, Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania, [2]Institute of Marine Sciences, Zanzibar, Tanzania

Outbreak of Acanthaster planci, crown of thorns starfish (COTS), in Zanzibar has been increasing from the past two decades. COTS plague emerged from year 2000 still persist in some of off Zanzibar town reefs (Pange, Nyange and Murogo). Recognizing the significance of outbreaks, both ecologically and economically to the livelihood of local communities, a study aiming at estimating COTS density, distribution of their population and comparing feeding rates among size categories (juveniles (¡Ü 19cm), sub adults(20-29cm) and adults >29cm) was conducted in June 2007 at Murogo. COTS density was estimated using belt transects (50mx5m, n=30) while the population structure was evaluated by taking length frequency measurements. Feeding rates were estimated from scaled feeding patches, using CPCe, photographed from observed feeding individuals (at least 50m apart, n=32) which were haphazardly selected from the population. Mean COTS density was 6individuals/100m2. The population was dominated by middle sized individuals. The mean feeding rates were 113.66cm2/meal/day, 232.26cm2/meal/day and 244.12cm2/meal/day for juveniles, sub adults and adults respectively. However, the rates were not statistically significant among size categories (1-way ANOVA). Results from this study are in support of initiating regular COTS eradication programs as a management option for such small reefs as density is as high as the destruction rate. However, more studies are needed to determine the most vulnerable coral species and monitor the rates of reef recovery and recruitment of COTS population after removal so that the impact of destruction on change of reefs community and patterns of outbreaks can predicted.

## 10.338

**Scleractinian Coral Recruitment Patterns To Reefs Physically Damaged By Ship Groundings**

**Ewelina RUBIN*[1]**, Alison MOULDING[1], Jose LOPEZ[1], David GILLIAM[1], Richard DODGE[1], Vadimir KOSMYNIN[2]

[1]Oceanographic Center, Nova Southeastern University, Dania Beach, FL, [2]Bureau of Beaches and Coastal Systems, Florida Department of Environmental Protection, Tallahassee, FL

The scleractinian corals of the Florida reef system face a number of environmental stress factors, among which ship groundings are considered to be one of the most physically damaging. In particular, a part of the Florida reef tract located near Port Everglades, Broward County, USA has been commonly affected by ship groundings which have caused severe injuries to the local reef ecosystem. In 2004, physical damage of at least 30,000 m2 area was caused by the groundings of two large cargo ships, the Eastwind and Federal Pescadores. The present study was designed to measure any possible differences of scleractinian coral recruitment patterns (recruit diversity and richness) and rates (# per area) to these injured sites in comparison to undamaged reef sites. Coral recruitment rates were measured on unglazed ceramic tiles deployed for a period of one year from February 2007 to February 2008 at five different locations including: two control sites, one high coral cover site and the two ship grounding sites. Morphometrics as well as multiple genetic markers (ITS region, CO1 and beta-tubulin genes) were used to identify the coral recruits. It is hypothesized that the final results will reveal significant differences in recruitment rates at the ship grounding sites in comparison to the control sites. Based on the coral recruitment rates and patterns, this study will increase understanding of the potential of natural coral recovery after acute physical damage.

## 10.340

**Estimation Of Fish Herbivory On Antillean Coral Reefs**

**Dorothée KOPP*[1,2]**, Yolande BOUCHON-NAVARO[1], Sébastien CORDONNIER[1], Alexandre HAOUISEE[1], Max LOUIS[1], Claude BOUCHON[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe, [2]UMR 5119 CNRS-IFREMER-UM2 ECOLAG, Université Montpellier 2, Montpellier, France

Worldwide, coral reefs present alterations of their coral communities in the way that corals, are progressively supplanted by macroalgae. In this context there is a need to identify the processes able to limit the proliferation of algae. Herbivores have a certain capacity to maintain low macroalgal covers on the reef, but the importance of the role of herbivorous fishes in the resilience of this ecosystem is not yet well known. For that purpose an experiment was conducted in Guadeloupe Island (French West Indies) on several reefs located in protected and non-protected areas. The grazing pressure by Acanthurid and Scarid fishes was evaluated by counting fish bites in different algal facies (algal turf on rocky substrate, algal turf on coral rubble, macroalgae assemblages, calcified Chlorophyta). Algal consumption by these fishes was evaluated by quantitative analyses of their gut contents combined with the evaluation of their density on the reefs by visual censuses. In parallel, an experiment was designed to estimate the algal turf productivity throughout the year and at different depths.

In situ counts of fish bites revealed that species feed preferentially on algal turf and avoid macroalgae. The algal consumption (dry weight) varied between 0.4 and 2.8 g.m-2.d-1 and was higher inside marine protected areas than on fished reefs. Herbivory pressure was also higher on reef flats than on reef slopes, where it decreased according to depth and, in parallel, with the algal turf coverage which also diminished with depth. The results confirm that herbivorous fishes exert a control on the reef algal asssemblages and that they play a significant role in maintaining low algal covers where they are abundant enough (marine protected areas). On overfished reefs, brown macroalgae have the possibility to proliferate and are no longer consumed by herbivores if the plants can reach their full size.

## 10.341

**Spatial Distribution Of Herbivorous Reef Fishes in Guadeloupe (Fwi): The Influence Of Environmental Factors**

**Dorothée KOPP*[1,2]**, Yolande BOUCHON-NAVARO[1], Max LOUIS[1], Claude BOUCHON[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe, [2]UMR 5119 CNRS-IFREMER-UM2 ECOLAG, Université Montpellier 2, Montpellier, France

The exuberant development of benthic macroalgae that enter in competition with corals is one of the major phenomena that threaten coral reefs in the Caribbean. As herbivorous fishes have a preponderant role in maintaining low macroalgal cover on the reefs, it is important to understand the influence of environmental factors on their distribution. For that purpose, the quantitative distribution of herbivorous fishes was studied on seven reef sites distributed around the island of Guadeloupe (FWI). Fifteen stations were distributed on reef flats and outer ref slopes to 30 m deep. Fish density was evaluated by visual censuses on band-transects of 150 m long by 2 m wide. In parallel, 15 environmental descriptors concerning the habitat and the benthic communities were collected on the same transects, using a linear points intercept technique. The descriptors were separated into different data sets: algae (Rhodophycea, Pheophycea, algal turf), benthic Invertebrates (corals and others), substrate characteristics (sand, rubble, rock) and three other variables related to the status of protection, the season and depth. Data were analyzed by variance partitioning in association with canonical redundancy analyses.

Whatever the type of data considered (presence-absence, density or biomass), herbivorous fishes were mostly controlled by the coverage rate of corals and other Invertebrates (from 17,1 to 20,1% of the total variance of the data) and algal assemblages (15,3 to 18,3%). Depth is the third variable explaining 13,2 to 19,9% of the data variance. The status of protection of the reefs plays a significant role only for the biomass distribution of herbivorous fishes (17,5% of the variance) that are more abundant in marine protected areas. These results suggest that herbivorous fishes are closely related to certain characteristics of their habitats and that they are likely to be very sensitive to changes of the composition and structure of benthic communities.

## 10.342

**Ecological Forecast Using Rapid Survey Reef Demographics**

**Phillip DUSTAN*[1]**, Alison MOULDING[2], Drew WHAM[1], Judy LANG[3]

[1]Department of Biology, College of Charleston, Charleston, SC, [2]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [3]Independent, Ophelia, VA

The distributions of adult and juvenile reef corals were compared along transects at four paired inshore and offshore stations off Broward Country, FL (control, treated wastewater outfall, inlet mouth, and a treated wastewater outfall adjacent to an inlet). Coral coverage varied from 1-4%. Adult corals that were present in both 2004 and 2007 and as juveniles in 2007 are the principal species presently on the reef: Montastraea cavernosa, Stephanocoenia intersepta, Solenastrea bournoni, Siderastrea siderea, Dichocoenia stokesi, Porites astreoides, and Meandrina meandrites. Species present as adults but not juveniles may be undergoing local reproductive failure, not contributing to the future, and therefore thought of as remnants. Species that could only be found as juveniles, and not adults, may originate upstream and unable to survive for more than a few years under present environmental conditions.

In stark contrast to these present observations, data from the coral-dominated fore reef off Discovery Bay, Jamaica, 1970-74, revealed that species that exhibited juvenile distribution patterns which may be classified into the broad categories of K-selected, with small colonies generally rare and independent of the adult abundance (i.e. Montastraea annularis complex), or more of an r-selected pattern with many more juveniles than adults (i.e. Agaricia agaricites).

Our observations reinforce the obvious; as reefs degrade, species decrease in abundance, their relative abundance patterns change and some undergo reproductive failure. Our data come from two very different systems: southeast Florida's high latitude, low coral cover, highly stressed, and perhaps near end-stage communities and, representing a coral-dominant phase, the 1970's luxuriant, pre-crash, reefs of the Jamaican north coast. These observations may help interpret rapid survey data as comparisons between juvenile and adult populations may provide a glimpse into the trajectory of stressed reef-coral populations.

## 10.343

**The Effect of Reef Health on the Early Recruitment of Fish**

**Cormac NOLAN*[1]**, Bret DANILOWICZ[2], Daniel GLEASON[2]

[1]School of Biology and Environmental Science, University College Dublin, Dublin, Ireland, [2]College of Science and Technology, Georgia Southern Univeristy, Statesboro, GA

Unfortunately, the term "today's coral reefs" refers to an increasingly degraded and algal covered substrate. There is little doubt that this decreased coral cover is detrimental to the ecological functioning of reefs. One important economic product of coral reefs that may be impacted by these changes are their fisheries. Since the vast majority of reef fish utilise a pelagic larval phase, the successful settlement of larval fish to a reef and their initial survival is related to the future catch in fisheries. But what is the effect of decreased coral cover on the early recruitment of fishes? We monitored fish recruitment at two spatial and temporal scales in sites varying by coral cover at Turneffe Atoll, Belize. Abundance and species richness were significantly higher in areas of higher coral cover. This significant difference remained even after the effect of substrate complexity was removed, suggesting there are properties of live coral other than refuge availability which are attractive to fish larvae or facilitate their early survival. Thus, if the trend of decreasing coral cover on reefs continues, fish populations associated with coral reefs will continue to decline, which exacerbates the existing problems stemming from over-fishing.

## 10.344

**Integrating Oceanography And Marine Ecology: What Affect Does The Río Aguán Have Upon The Benthic Reef Community Of Los Cayos Cochinos, Honduras?**

**Jonathan SHRIVES*[1,2]**, Greg COWIE[3], Martin SPEIGHT[1]

[1]Zoology, University of Oxford, Oxford, United Kingdom, [2]Operation Wallacea, Lincolnshire, United Kingdom, [3]Earth Science, University of Edinburgh, Edinburgh, United Kingdom

This investigation looks at the feasibility of integrating oceanographic and ecological techniques to better understand and assess the differences in reef benthic community structure within the Marine National Monument Cayos Cochinos (MNMCC), Honduras. These techniques are then used to look at the role of riverine impact upon the region.

A grid of ten sample stations was adapted to the reefs of MNMCC. At each station a series of oceanographic, geochemical and ecological surveys was conducted. A conductivity-temperature-depth probe, coupled with an acoustic current meter, was used to investigate water column structure and flow, salinity and suspended Chlorophyll-a. Isotopic C:N analysis of suspended and sinking sediments from stations and transects was used to asses the presence of terrestrial sediments. Water samples were also analysed for nutrient content. The benthic community at each station was analysed using random digital photo-quadrats and compared with uni-variant, multi-variant and spatial statistics.

There is a significant difference ($P<0.05$) between sites in benthic substrata. Sites with high sediment flux differ in percentage cover of macro-algae, such as *Dictyota Spp.*, which dominates reefs in the region with a mean of 33.26% cover in quadrats (n=600). Hard corals only represent 12.01% of cover (n=600). Sites also differ in C:N isotopic ratios, and thus marine to terrestrial influence. Dissolved nutrients were only detected at trace levels, and found unsuitable as a technique for future studies.

Local, island run-off was shown to be more influential in the region than expected. Although there are still problems in directly 'marrying-up' and integrating oceanographic science to ecology, it is shown to be an important tool for both management authorities and marine ecologists alike.

## 10.345

**Aggression By Three Damselfish Species: Who Is The Keystone?**

**Amelia MARCH*[1]**, Alfred BEULIG[1]

[1]Natural Sciences, New College of Florida, Sarasota, FL

Damselfish are widely considered to be a keystone group. Damselfish territoriality is thought to enhance diversity by decreasing predation and grazing by competitors. As part of a study of aggression in damselfish, we investigated territoriality in three species: Stegastes adustus, S. planifrons and S. partitus on coral reefs in Bocas del Toro, Panama. We measured aggression by observation of frequency of agonistic behaviours selected from an ethogram and noted territory sizes as well as size differences of individuals within species and size ranges among species. Our hypothesis was that species with larger defended territories and greater aggression would have a greater impact on the reef (and qualify as a keystone species) than those with less aggression and smaller territories. Further, that interspecific aggression would not be less intense than intra specific aggression and that there may be a relationship between size of individual and territory size. Results showed that there were no significant differences in aggression and territory size between S. planifrons and S. adustus but both were significantly greater in these measures than S. partitus. Larger fish (and the larger species)had larger territories. We suggest that the former may fulfill the role of keystone species in view of greater algal growth and productivity in their territories than that of S. partitus who may have a lesser role on the reef but increase efficiency of resource exploitation by using the leftovers.

## 10.346

**Foraging Activity By Different Size Classes Of *halichoeres Poeyi* (Labridae) in The Southeastern Brazilian Coast**

**Gabriela AZEVEDO*[1]**, João Paulo KRAJEWSKI[2], Mariana GAMA[3], Carlos Eduardo LEITE FERREIRA[3]

[1]Departamento de Biologia Marinha, Universidade Federal Fluminense, Rio de Janeiro, Brazil, [2]Departamento de Ecologia, Universidade Estadual de Campinas, Campinas, Brazil, [3]Departamento de Biologia Marinha, Universidade Federal Fluminense, Niterói, Brazil

Wrasses (Labridae) include about 500 fish species, with varying feeding habits, distributed in tropical and subtropical reefs. Most wrasses are protogynous and have different life and sexual phases that may behave differently. The black-ear-wrasse, *Halichoeres poeyi*, is abundant in reefs in the tropical and subtropical western Atlantic and forages on benthic invertebrates. We studied the foraging activity of *H. poeyi* of four size classes, (1) very small, total length (TL) < 10 cm; (2) small, 10 < TL ≤ 15 cm , (3) medium, 15 < TL ≤ 20 cm and (4) large, TL > 20cm, at rocky reefs of Arraial do Cabo (23º 44'S – 42ºW), Southeastern Brazilian coast. Our main objective was to investigate whether foraging substratum use and feeding rates differ among different size classes. To record fish foraging activity, we followed focal individuals for 3 - 5 min and recorded the number of bites comparatively on seven substratum types: epilithic algae matrix (EAM) (different turf algae with associated sediments), encrusting calcareous algae, sand and rubble, sand, *Millepora* spp. colonies, zoanthids and bare rock. The substratum use data was then compared to the availability of the substratum types. Although ontogenetic differences on *H. poeyi*'s diet have been recorded in the Caribbean, probably because of ontogenetic variation in crushing strength and pharyngeal jaw gape, our results indicated that all size classes fed mostly on the same substratum, namely EAM. Moreover, we found that the feeding frequency decreased with fish size, but significant differences were found only between large individuals (TL>20cm) with all other size classes. As *H. poey* is a protogynous species, large individuals probably had lower feeding rates because terminal males spend large amount of time patrolling their territories, similar to other wrasses.

Financial support : CNPq.

## 10.347

**Symbiosis and adaptation in *Eunicella singularis*, a Mediterranean gorgonian**

**Didier FORCIOLI*[1]**, Pierre Laurent MERLE[1], Carlo CERRANO[2], Paola FURLA[1], Denis ALLEMAND[3]

[1]ECOMERS, Nice-Sophia Antipolis University, Nice Cedex 2, France, [2]DipTeRis, Universita di Genova, Genoa, Italy, [3]Scientific Centre of Monaco, Monaco, Monaco

The Mediterranean sea is renown for the richness and diversity of its gorgonians. Among these, *Eunicella singularis* is the only symbiotic species, harbouring photosynthetic Dinoflagellates (*Symbiodinium* sp.) within its endodermic cells, as tropical reef building corals do.

Compared to the well studied tropical symbiotic Cnidaria, little was known of *E. singularis*. It shows a very wide bathymetric distribution (-10 to more than -40 meters deep), but its symbiotic diversity, a key adaptative parameter in tropical species, was still undescribed. In the past years, *E. singularis*, as its tropical counterparts, has suffered several mass mortality events, linked to a global rise in sea temperature. We therefore studied in this species the eventual conflicts between the long term adaptations imposed by the symbiotic life in temperate waters and short term responses to sudden ecological modifications.

We characterised the symbiont population of nearly 200 colonies, both genetically (PCR RFLP and sequence variability of nuclear and chloroplastic rDNA), and biologically (symbiont density and chlorophyll concentration). These colonies were sampled at two depths in each of five locations along the Northwestern Mediterranean coast. Reciprocal transplantations of depth and surface colonies were also performed.

A single *Symbiodinium* clade (A') was found in all the colonies sampled, over all depths and locations. Low within clade diversity was observed both among and within colonies, without any clear geographical or bathymetric differentiation. Surprisingly, within colony chlorophyll contents and symbiont densities were consistently lower in deeper populations, both naturally and after transplantation. These results apparently make of *E. singularis* a model of symbiosis quite different from the tropical Cnidaria/Dinoflagellate associations, but still victim to the same global environmental changes.

## 10.348

**Temporal Variation Of Sea Urchin Density in Some Caribbean And Pacific Reefs Of Colombia**

**Guillermo DUQUE*[1]**, Sonia BEJARANO[2], Alberto RODRIGUEZ[3]

[1]Ingenieria ambiental, Universidad Nacional de Colombia, Palmira (Valle), Colombia, [2]Biosciences, Marine Spatial Ecology Lab, Exeter, United Kingdom, [3]SIMAC, INVEMAR, Santa Marta, Colombia

Sea urchin dynamics play a fundamental role in coral reef balance, as the action of some species regulates algal biomass or may cause severe bioerosion upon the reef framework. Beginning from 1999, the Colombian Coral Reef Monitoring System (SIMAC) has evaluated the density of different echinoid species every year at shallow (3-5 m), mid -depth (10-12 m) and deep (15-18 m) reef sites of some important of Colombian Caribbean reef areas, using 20 m2 permanent transects. Starting in 2002, surveys have also been performed in shallow (3-6 m) and intermediate (9-12 m) Pocilloporid reefs of Gorgona in the Pacific. Seven urchin species were found during surveys in the Caribbean and six in the Pacific, and they were generally more abundant in shallower reefs. Eight of the 38 monitoring sites experienced significant increments or reductions of sea urchin totals or species while the rest of the sites remained stable or evidenced fluctuations that do not represent significant changes. Given the localized nature of the observed changes, it is proposed that they could be rather the result of short migrations of some species among different habitats. Most densities of Diadema antillarum observed in the Colombian Caribbean reef sites ranged from 0 to 16.3/20m2, being similar to those in other Caribbean localities, but a relatively unusual situation was observed in Urabá: average density of D. antillarum at mid depth level in all years are significantly higher than some of the values reached in the shallow level. Although the density of D. antillarum before mass mortality was never quantified in Colombia, the actual situation of some monitored sites compared to qualitative descriptions made by other authors in the nineties reveals that a localized population recovery has occurred.

## 10.349

**Territorial Tenacity in The Rock-Boring Sea Urchin: Is There No Place Like Home?**

Alfred BEULIG[1], **Alex HIBBERD*[1]**

[1]Natural Sciences, New College of Florida, Sarasota, FL

Echinometra lucunter, the rock-boring sea urchin, lives in hollow burrows carved into rocks and dead coral and is said to have a strong territorial affiliation with these burrows. We tested the hypothesis that the strength of this affiliation may be influenced by distance of removal from the burrow or set of terrain obstacles that might deter sea urchins from returning to their burrow. Marked individuals were removed from the nesting site and transported three and nine m. away and placed on rock or sea grass substrates. Placement site was marked and coded for each animal and after 24 hr compass heading and distance moved from site of displacement was recorded. Results showed a strong navigational ability and territorial affinity with 75% of the subjects showing statistically significant progress toward the home burrow. Individuals displaced to grass showed greater mortality and greater, but statistically non-significant, distances moved. We conclude that burrow affinity significantly reduces predation in the daytime on sea urchins.

## 10.350

**Non-Random Distribution Of Fishes On Two Dominant Habitat Types Within A Shallow Reef in Northeastern Brazil**

**Paulo MEDEIROS*[1]**, Renato GREMPEL[1], Allan SOUZA[1], Martina ILARRI[1]

[1]Departamento de Sistemática e Ecologia, Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba, João Pessoa, Brazil

Many reef fishes, particularly the site-attached species, show marked habitat selectivity on reef environments. Therefore, even in patchy reefs, where habitat distinction is often precluded, fishes tend to show a somewhat corresponding distribution to their favored environmental variables. The present study aimed at comparing the distribution of fishes on two dominant habitat types, reef flat (RF) and reef crest (RC), at Picãozinho reef in Northeastern Brazil. For that purpose, six 20 x 2m belt transect replicates were conducted haphazardly on each habitat, where fishes and environmental variables data were collected. On RF and RC, 246 and 214 fishes from 22 and 14 species, respectively, were recorded. Highly significant differences between the habitats were detected for depth, encrusting coralline algae, rubble and sand, fish richness, fish diversity and evenness (RF > RC) and for rugosity, turf algae, living coral and holes (RF < RC). These differences were crucial for the distribution patterns observed for species such as *Coryphopterus glaucofraenum*, *Pseudupeneus maculatus* and *Sparisoma* spp., which were significantly more abundant on RF and *Labrissomus nuchipinnis* and *Stegastes fuscus*, which were significantly more abundant on RC. Further, roving herbivores, planktivores, mobile invertivores (RF > RC), territorial herbivores and carnivores (RF < RC) also showed significant differences. The observed differences on fish assemblages emphasize the distinct distributional patterns of fish on reef environments. Also, our data showed that RF, once considered a low complexity habitat, sustained a rich and diversified ichthyofauna, composed mainly of haemulids and scarids, while RC was largely dominated by territorial damselfishes. Both univariate and multivariate analysis identified clear segregation patterns among fish species, which reflected their underlying non-random habitat preferences.

Financial Support: CNPq, CAPES

## 10.352

**Recruitment And Resilience On Coral Reefs**

**Carrie MANFRINO*[1,2]**, Elizabeth WHITEMAN[1]

[1]Central Caribbean Marine Institute, Princeton, NJ, [2]Department of Geology and Meteorology, Kean University, Union

Marine protected areas have become the most widely used tool to manage reef ecosystems. Underlying this tool is the assumption that protection of herbivores will reduce macroalgal cover and increase coral recruitment. Increasing evidence supports the first half of this assumption but there is little empirical evidence for the latter. In most locations it is impossible to separate the independent effects of disturbance and concurrent phase-shift to macroalgae dominance on coral recruitment.

On shallow reefs surrounding Little Cayman, significant loss of live coral cover was observed between 1999 and 2006. This loss is almost entirely accounted for by loss of live Montastrea spp. During the same period there was no significant change in the abundance or density of herbivorous fish species, and no significant change in the size structure of each species. In addition, there was no increase in the percent cover of fleshy macroalgae.

The total density of juveniles and the relative proportions of juvenile coral species did not change following this disturbance to the reef ecosystem. Juvenile coral community structure displayed significant spatial variation both between and within reefs. In general, densities of brooding Agaricia spp. and Porites spp. were higher than the spawning Montastrea spp and Siderastrea spp. Growth and survival of juvenile corals did not differ between species.

Taken together, our results illustrate that, following a disturbance event causing significant live coral cover loss, coral recruitment was maintained at levels observed prior to ecosystem disturbance. Moreover, there was no change in herbivorous fish populations and no shift to a macroalgae dominated system. Our results confirm the effectiveness of management strategies focused on herbivorous fish populations but also suggest that in locations in which grazing is controlled, coral recruitment can rapidly contribute to coral recovery.

## 10.353

**Testing Inorganic Nutrient Addition Effects On The Stability Of Coral-Algae Interactions in Coral Reefs**

**Andreas HAAS*[1]**, Malik NAUMANN[1], Florian MAYER[1], Mohammed AL-ZIBDAH[2], Mohammed RASHEED[2], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center LMU München, Munich, Germany, [2]Marine Science Station, Yarmouk University, Aqaba, Jordan

Recent studies in fringing reefs of the Northern Red Sea revealed that the in-situ stability of coral-algae interactions in coral reefs was highly variable with fast overgrowth of coral by algae in fall and close to equilibrium between both groups of organisms in summer. This may be caused by measured 3 fold higher concentrations of inorganic nutrients in fall and winter, thereby promoting algae growth with concomitant equilibrium shift. A long term experiment was conducted in order to study the effect of different kinds of inorganic (ammonium, phosphate, nitrate) and organic (monosaccharides) nutrients onto the stability of one of the most dominant coral-algae interaction of the Northern Red Sea involving branching corals of the genus *Acropora* and a typical consortium of benthic turf algae. Nutrients were added in concentrations 5 fold higher compared to the annual average concentrations and the areas of living and dead coral tissue were measured in regular intervals. This confirmed that increased inorganic nutrients concentrations can strongly affect the stability of interactions between corals and algae either via direct stimulation of algae growth or via facilitation of organic matter release by benthic algae triggering microbial oxygen consumption with associated coral mortality.

## 10.354

**Localized Fish Community Response To A Rapid Habitat Phase Shift From Coral Rubble To Overgrowth By Caulerpa Sp. At Aldabra Atoll, Southern Seychelles Islands**

Raymond BUCKLEY[1,2], Ben STOBART[3], Nigel DOWNING[4], **Kristian TELEKI*[5]**

[1]College of Ocean and Fishery Sciences, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, [2]Fish Program/Marine Resources, Washington Department of Fish and Wildlife, Seattle, [3]Marine Reserves, Spanish Institute of Oceanography, Mallorca, Spain, [4]Cambridge Coastal Research Unit, Cambridge University, Cambridge, United Kingdom, [5]International Coral Reef Action Network (ICRAN), Cambridge, United Kingdom

The value and utility of coral reef habitats to reef fish assemblages are often greatly degraded by algal invasion, possibly resulting in significant loss of reef fish diversity. However, reef fish community responses to rapid overgrowth of low relief, spatially heterogeneous coral rubble habitat by spatially heterogeneous macro-algae habitat have not been documented. We examine changes in the predominantly juvenile fish communities at 10m and 20m depths at a mixed coral rubble (70%) and *Halimeda* (30%) site off the northeast coast of Aldabra Atoll, from 1999 through 2006. *Caulerpa* was detected at the site in May 2003 at 20m, and remained scarce through April 2005. This *Caulerpa* habitat proliferated dramatically by December 2006 to cover completely the 20m depth transect. No *Caulerpa* has been detected at 10m. Multivariate analyses of fish assemblages showed no directional change over time at either 10m or 20m, although there are consistently higher counts of fish species and abundances at 10m. The 2006 surveys at both 10m and 20m are similar to low counts in 2003, but there is no indication of any dramatic changes in fish community structure in response to the phase shift to *Caulerpa* habitat. We conclude that in this low profile coral rubble dominated area, it is likely that the spatial heterogeneity of the *Caulerpa* habitat is either a sufficient substitute habitat for the juvenile fishes, or it does not prevent fish from accessing the buried coral rubble habitat. The combined coral-algal habitat may enhance settlement, survival, and ontogenetic habitat shifts for juvenile fishes at the site. Future monitoring should reveal any long-term changes to the fish community, and the residence time of the *Caulerpa* invasion.

## 10.355

**Nutrients And Herbivores: What Do We Know About Their Relative Importance On Coral Reefs?**

**Jennifer SMITH*[1]**

[1]NCEAS, University of California, Santa Barabara, Santa Barbara, CA

Coral reefs are among the most diverse and productive ecosystems on the planet but are also significantly threatened by numerous natural and anthropogenic disturbances. Phase shifts or alternate stable states where reef building corals are replaced by fleshy algae have become more and more common. While large scale global impacts such as climate change are clearly important, local impacts such as overfishing and nutrient pollution can also alter community dynamics. The relative importance of these top-down and bottom-up controls on reef community structure have been debated by scientists for years. Thus my goals were to test the independent and interactive effects of nutrient enrichment and herbivore exclusion on benthic community structure on a coral-dominated reef in Hawaii and to follow this empirical approach with a global meta-analysis. My results show that both nutrients and herbivores are important in regulating benthic community structure but more importantly, they do so in different ways. Herbivores tend to reduce fleshy algal abundance while promoting the abundance of calcifying algae and coral. Nutrient enrichment alone tends to enhance algal growth rates but not necessarily abundance as herbivores can often consume this extra production. Finally the simultaneous effects of herbivore removal and nutrient enrichment lead to different benthic assemblages, largely dominated by fleshy algae. Results from both empirical and meta-analytic approaches suggest that overfishing and nutrient pollution are important to the management and future conservation of coral reefs.

## 10.356

**Natural Lesions, Recovery And Partial Mortality in A Population Of Montastraea Annularis At A Caribbean Reef**

**Elvira ALVARADO CH.*[1]**, Alberto ACOSTA[2]

[1]Facultad de Ciencias Naturales, Universidad Jorge Tadeo Lozano, Bogota, Colombia, [2]Facultad de Biologia, Pontificia Universidad Javeriana, Bogota, Colombia

Populations of *Montastraea annularis* are showing signs of decline evidenced by high partial and total mortality, and low recruitment rates. Due to the high number of ramets (n= 9646) with partial (42%) and total (12%) mortality found in 102 colonies of *M. annularis* in a Marine Protected Area of Colombia, we followed 88 healthy ramets to observe type, size and duration of natural lesions. During a year, six types of lesions were found. 47% were caused by predation and 35% by interaction with algae. Bleaching (8%), interaction with sponges (1%) and with borrowing organisms (2%) as well as yellow blotch disease (0.5%) were the other type of natural lesions. Most lesions were less than 5cm2but some were as big as 60cm2. Size of lesions was not correlated with type. From May through September abundance of lesions increased affecting between 10 and 50% of superficial area of ramets. 83% of the lesions recovered,13% did not and 4% changed type. In general lesions from predation and bleaching recovered in less than three months, while those caused by interaction with algae did not. Nevertheless we observed that some lesions caused by predation (N=13), bleaching (N=7) and yellow blotch (N=3), were invaded by algae turning into patches of partial mortality. In most of the lesions with algae, recovery was rare and lesions grew and became permanent features. By the end of the year, 25% of the ramets had partial mortality. These results suggest that chronic perturbations caused by predation and more frequently and intense bleaching events can be part of the causes for the decline in cover of *M. annularis* at the Caribbean reefs, as algae quickly invade these lesions.

## 10.357

**Response Of Hard Bottom Fish Assemblages To Red Tide Outbreaks Off Southwestern Florida.**

**David SNYDER*[1]**

[1]CSA International, Inc., Stuart, FL

Fish kills from red tide outbreaks have been reported off Florida's west coast for decades, but rarely has the response of fish assemblages been directly observed for particular habitats. Following multiple red tide outbreaks during the summer and fall of 2005 and 2006, resident fishes either died or emigrated from hard bottom habitats in nearshore (5 to 7 m) and offshore (12 to 15 m) waters offshore Venice, Florida. Dead or dying fishes observed during 2005 and 2006 were reef-associated forms such as eels, sea basses (Serranidae), grunts (Haemulidae), porgies (Sparidae), jawfishes (Opistognathidae), filefishes (Monacanthidae), and porcupinefishes (Diodontidae). Survey transects established for monitoring epibiota within nearshore (n = 18 transects) and offshore (n = 5 transects) sites during 2005; but prior to the initial red tide outbreaks, allowed qualitative assessment of pre-outbreak fish assemblages. In fall of 2007, fishes were censused along these same transects following a summer with no red tide outbreaks. In total, 41 taxa had re-colonized the hard bottom areas, several of which were not present prior to the 2005 and 2006 outbreaks. Overall, *Lagodon rhomboides*, *Serranus subligarius*, *Sparisoma* sp., *Halichoeres bivittatus* , *Epinephelus morio*, *Diplectrum formosum*, *Diplodus holbrooki*, and *Lutjanus synagris* accounted for 71% of the numbers of fishes observed in 2007. Taxa observed were represented by adult, juvenile, and newly settled individuals. Qualitative differences in species composition among years, depths, and transects were visualized with ordination analyses on a binary resemblance matrix. The results are compared to other documented cases of reef fish recovery following catastrophic mortality

## 10.358

**Comparison Of The Feeding Ecology Of The Introduced Snapper *lutjanus Kasmira* And Native Goatfishes in Hawai`i**

**Brett SCHUMACHER*[1]**, James PARRISH[2,3]

[1]Division of Aquatic Resources, Hawaii Dept. of Land & Natural Resources, Honolulu, HI, [2]Hawaii Cooperative Fishery Research Unit/Dept. of Zoology, USGS/University of Hawaii at Manoa, Honolulu, HI, [3]Hawaii Cooperative Fishery Research Unit/Dept. of Zoology, USGS/University of Hawaii at Manoa, Honolulu

*Lutjanus kasmira* (Family: Lutjanidae) has a broad native geographic range, and is found in near-shore reef habitats from Eastern Africa through Polynesia. However, it was not present in Hawai`i until it was deliberately introduced during the mid-twentieth century. *L. kasmira* was introduced to provide a new fishery resource, but it has not gained much acceptance in this regard. Many fishers consider *L. kasmira* to be a nuisance, and blame it for declines in catches and populations of native fishery species. *L. kasmira* is purported to compete with and/or depredate a variety of resource species, including ornamental fish species such as *Zebrasoma flavescens* (Family: Acanthuridae), food fishes such as *Mulloidichthys vanicolensis* (Family: Mullidae), and crustaceans such as *Ranina ranina* (Family: Raninidae). To address these concerns, we analyzed the feeding ecology of *L. kasmira* and three native species of goatfish: *M. flavolineatus, M. vanicolensis*, and *Parupeneus multifasciatus*. The pair of species with the greatest taxonomic dietary similarity was *L. kasmira* and *P. multifasciatus*. This finding was somewhat surprising considering that our data indicate that these species feed at different times of day. The congeners *M. flavolineatus* and *M. vanicolensis* had the second greatest dietary similarity of the species in this study. *L. kasmira* was found to consume larger prey on average than any of the native species. The suggestion that *L. kasmira* preys on native resource fish and crustacean species was not supported by our data. Ultimately, our analyses did not detect evidence of ecological interactions that would be likely to adversely affect populations of these native fishery species through predation or competition for food.

## 10.359

**Population Projections And Management Recommendations For The Threatened *acropora Palmata*: What Life History Stage Should We Protect?**

**Tali VARDI*[1]**, Dana E. WILLIAMS[2,3]

[1]Scripps Institution of Oceanography, La Jolla, CA, [2]Cooperative Institute for Marine and Atmospheric Studies, University of Miami RSMAS, Miami, FL, [3]Southeast Fisheries Science Center, NOAA Fisheries, Miami

Acropora palmata was once the dominant hermatypic coral throughout the Caribbean, Florida, and Bahamas. Since the 1980s it has suffered a 97% decline in abundance throughout its range and was included on the US Endangered Species List in 2006. Despite the dramatic nature of this decline, and the implications a potential extinction would have for loss of habitat to other species, neither abundance nor rates of decline have been documented systematically throughout the Caribbean. In Autumn 2007, abundance of A. palmata was estimated in Florida, Puerto Rico, Jamaica, Virgin Gorda, and Curaçao. Abundance in Florida was dramatically lower than in other sites. Causes of the rarity of A. palmata in Florida have not been clearly identified. To explore population changes in more detail, a size-based population model was developed to help identify life history stages most affected. Based on A. palmata's population trajectory since 2004, as measured by a standardized, size-based demographic monitoring protocol in the Florida Keys, the local population will reach a stable distribution in 20 years. At that time, the current population structure, in which 35% are pre-reproductive and 45% are reproductive, will have become dominated by pre-reproductive individuals with only 20% of colonies capable of sexual reproduction. This loss of large individuals would also reduce the number of asexually derived fragments, leading to an overall reduction in abundance of colonies in Florida. Parallel research on the island of Curacao shows both a greater abundance of A. palmata overall and no significant change in the relative abundance of larger individuals. These results suggest that protecting the largest adults may reverse the current trend toward a left-skewed A. palmata population structure in Florida.

## 10.360

**Top-Down Factors Explain Benthic Community Structure On A Near-Pristine Coral Reef Ecosystem**

**Kimberly PAGE-ALBINS*[1]**, Peter VROOM[2], Celia SMITH[3], Edward DEMARTINI[4], Scott GODWIN[5]

[1]Zoology, Oregon State University, Corvallis, OR, [2]Joint Institute for Marine and Atmospheric Research, Honolulu, HI, [3]Department of Botany, University of Hawaii at Manoa, Honolulu, HI, [4]Coral Reef Ecosystem Division, NOAA Fisheries, Honolulu, HI, [5]Hawaii Institute of Marine Biology, Kaneohe, HI

The debate continues over the relative contributions of top-down mechanisms such as removal of herbivores, and bottom-up mechanisms such as eutrophication, to coral reef decline and phase shifts from coral to algal dominated reefs. While it is likely that both of these mechanisms influence coral reef community composition, the dominant mechanism regulating a particular community is likely determined, in part, by the level of anthropogenic impact present. In order to effectively manage remaining intact reef systems, it has become increasingly important to pinpoint which factors regulate the composition of coral reef communities. Here, we examine models of top-down and bottom-up community regulation in a near-pristine coral reef system, Pearl and Hermes Atoll (PHA), Northwestern Hawaiian Islands. PHA represents one end of a continuum in coral reef health. Percent cover of benthic organisms along with herbivorous fish density and biomass, urchin density, and nutrient availability were measured. Multi-linear regressions revealed that for each of the benthic functional groups examined (coral, frondose macroalgae, crustose coralline red algae, and turf algae) herbivorous fish density was a significant explanatory factor. Herbivorous fish biomass and urchin density were also significant explanatory factors in models explaining benthic community composition. When all benthic functional groups were combined in a multivariate analysis, herbivorous fish density combined with wave exposure was identified as having the highest significant correlation with benthic community composition at PHA. Conversely, nutrient availability, based on algal tissue nutrient content, did not correlate with percent cover of benthic organisms. These results suggest that at PHA, a site which represents one end of a global continuum ranging from near-pristine to highly degraded, top-down mechanisms have primacy over bottom-up mechanisms.

## 10.361

**The Effect Of Increased Seawater Temperature On The Skeletal Development Of *favia Fragum* And *porites Astreoides* New Recruits**

Lara GATES[1,2], **Samantha DE PUTRON*[2]**

[1]The College of William and Mary, Williamsburg, VA, [2]Bermuda Institute of Ocean Sciences, St Georges, Bermuda

Recent studies show that rising seawater temperatures affect the vitality of both adult corals and planulae. Data is lacking, however, concerning the intermittent life-history stage - new settled coral recruits (spat). The proper development of spat is critical to the success of the coral, as well as the success of the reef in terms of population sustainability. To address this, an analysis of spat skeletal development with respect to temperature was performed. Adult corals of two common brooding species, *Favia fragum* and *Porites astreoides* were collected from Bermuda's inshore platform just prior to their known planulation period during the summer of 2007, and planulae were collected in aquaria upon release. Planulae were settled and grown in varying temperatures. Upon termination of growth, skeletons were evaluated quantitatively in terms of height and volume as well as qualitatively concerning maturity of development. *F. fragum* spat grown in the highest temperature (33°C) were significantly smaller than those grown in ambient temperature (28.5°C) over the course of one and two weeks of growth. Similar results were found within the first week of growth for *P. astreoides* spat. Qualitatively, the evaluation of maturity of *F. fragum* skeletons indicated reduced developmental stage with higher temperatures. In addition, visual observations of the live spat revealed that those in higher temperatures appeared white and transparent while those in lower temperatures maintained a green translucence, indicating possible bleaching (zooxanthellae loss) in the higher temperature treatments. These results suggest a biological basis for decreased growth in higher temperatures via the expulsion of zooxanthellae resulting in a lack of energy or shortage of skeletal 'building blocks'. In this age of predicted global warming, our results suggest a possible disruption of foundational skeletal development, which may lead to decreased survivorship of coral recruits of some species and subsequent depletion of coral reefs.

## 10.362

**Recruitment Dynamics Of Scleractinian Corals in A Network Of National Parks And Marine Protected Areas: West Coast Hawai'i Island**

**Lawrence BASCH*[1,2]**, Angela LEEMHUIS[3], James WHITE[3], William WALSH[4]

[1]National Parks Service, Honolulu, HI, [2]University of Hawaii, Cooperative Ecosystems Study Unit, Honolulu, [3]University of Hawaii, Cooperative Ecosystems Study Unit, Honolulu, HI, [4]Hawaii State Department of Land and Natural Resources, Division of Aquatic Resources, Kailua-Kona, HI

Maintenance of adequate levels of coral settlement and recruitment is vital to sustain coral reefs. Because early life stages are often more susceptible than adults to environmental stressors, data on settlement and recruitment can help predict potential effects of disturbance from, and resilience to environmental change. This study is a large scale, multi-year effort to assess recruitment of Scleractinians along the west coast of Hawai'i Island in support of long term benthic monitoring and marine protected area management. Terra cotta tiles have been used at nine sites over three years as settlement substrate to help determine spatial and temporal variation in coral settlement and recruitment. Tiles are replaced biannually before and after known seasonal peaks in coral reproduction and recruitment.

Several spatial and temporal trends were discovered in this ongoing study. Peak settlement of coral larvae consistently occurred across years in summer (approximately April-September) in species with and without planktonic larvae. Most species showed spatial patterns in settlement patterns at the 1-10 km scale (between sites). The northernmost site, Waikalio, had significantly higher densities of juvenile corals with settlement among sites decreasing immediately toward the south. *Porites* spp. had the highest recruitment overall, followed by *Montipora* spp., then *Pocillopora* spp. for most sites. Most *Montipora* spp. juveniles observed were single polyps with little or no extension of skeleton beyond the corallite wall; none had multiple polyps.

The north to south pattern in settlement density suggests large scale oceanography is not driving settlement-recruitment dynamics. Possible alternative influences include smaller, sub regional differences in ocean currents, habitat structure, disturbance regimes, and anthropogenic influences.

Combined with emerging oceanographic data, this work provides an initial basis for long term benthic monitoring of ecological change in, and conservation of, park's marine resources.

## 10.363

**Experimental Assess Of Macroalgae Overgrowth On A Species Of Pocillopora (Antozoa) In A Mexican Tropical Pacific Locality**

**Norma CORADO NAVA*[1]**, Dení RODRÍGUEZ[2]

[1]Biología Comparada, Universidad Nacional Autónoma de México, México, D.F., Mexico, [2]Biologia Comparada, Universidad Nacional Autonoma de México, México D.F, Mexico

The coral communities' deterioration by macroalgae overgrowth is increasingly important around the world. Algae and corals compete for substrate and speculate that in terms of environmental stress algae are better competitors affect coral growth, reproduction and survival. This paper was developed in the western tropical Pacific (Playa Las Gatas, Guerrero, Mexico) and its main objective was to assess the effect of macroalgae assemblage produces on Pocillopora and vice versa. They took out 2 experimental treatment simulating different levels of coralline stress: a) by contact, where branches of live coral and healthy are joined a piece of dead coral and overgrowth by an ensemble macroalgae b) court, where coral branches injured were alive and well with a cross section of the apical portion and on the cut surface are joined a piece of dead coral overgrowth by a macroalgae assemblage. Controls included: a') b') with fragments of live coral and healthy, and c) branches of live coral and healthy only injured. The experimental setting, monitoring and sampling were doing with SCUBA equipment, and for monitoring was used a non-destructive method for photography. Our results show that both branches of live coral and healthy who are join by contact to the macroalgae assemblage, and those who were injured by cut, and joined to the macroalgae assemblage survived and continued growing, covering at least partially the macroalgae assemblage on coral dead fragment. Indeed, several of the branches that were only injured by the apex court, grew again without presenting macroalgae. These results suggest that while the reefs are "healthy" will not be overgrowing by macroalgae, in spite of close contact and independently of the surrounding environmental conditions.

## 10.364

**Outwelling Of Detrital Matter Onto Coral Reefs And Seagrass Beds By An Introduced Mangrove, *rhizophora Mangle*, in Hawai`i**

**Matthew LURIE*[1]**, Celia SMITH[1]

[1]Botany, University of Hawaii at Manoa, Honolulu, HI

Coastal wetland invasions by exotic flora and fauna have the potential to greatly modify near shore coastal ecosystems, thus threatening a variety of ecosystem processes and many cultural practices such as subsistence fishing. Introduced mangroves in the Indo-West Pacific region represent an invasion that is drastically altering the landscape, replacing native wetland species, and impacting watershed dynamics. The Red Mangrove, *Rhizophora mangle*, was introduced to the Hawaiian Islands in 1902 on the Island of Moloka`i by farmers for erosion control. Since then, mangroves have rapidly colonized low energy intertidal zones and mudflats on all the Main Hawaiian Islands. Coastal mangroves have the potential to distribute organic matter onto adjacent coastal zones such as coral reefs and seagrass beds through the process of outwelling. This process has not been explored in locations where mangroves are not native. This study identifies the nature of organic carbon and nitrogen flux originating from mangroves onto Hawaiian near shore coastal systems and its potential to be incorporated into neighboring food webs. Flora and fauna collected at multiple trophic levels in both mangrove-invaded and non-invaded coastal sites are investigated using stable isotopes 13C and 15N signatures along with mixing models. Studies that identify key ecosystem processes occurring in mangrove stands and determine how they are influencing adjacent ecosystems, specifically coral reefs and seagrass beds, can lead to informed adaptive management of these integrated regions.

## 10.365

**Fish Larval Flux in A Marine Reserve in Southern Guimaras, West Central Philippines**

**August SANTILLAN*[1]**, Wilfredo CAMPOS[2]

[1]Division of Biological Sciences, University of the Philippines Visayas, Miag-ao, Philippines, [2]Division of Biological Sciences, University of the Philippines Visayas, Miag-ao, Iloilo, Philippines

Fish larval flux rates were studied in a marine reserve in Southern Guimaras, West Central Philippines in April and November 2003 with the use of surface and near-bottom plankton nets (335um mesh) moored in the two major channels connecting the area with surrounding waters: the shallow northern channel, where current direction reverses with the tides, and the deeper central channel where water consistently flows outside of the reserve. Variation in the hourly concentration of fish eggs and larvae in the catches corresponded closely with the tidal cycle. Differences in concentrations between surface and bottom nets in the two channels suggest net influx of eggs and larvae into the reserve in April, and are consistent with the use of seagrass beds and extensive mangrove stands within the reserve as nursing areas. The taxonomic and ontogenetic composition of the larval assemblage observed during the study is further discussed in this context.

## 10.366

**Deriving Conservation Strategies From Philippine Reef Fish Distributions**

**Cleto NAÑOLA JR.* [1,2]**, Porfirio ALIÑO[2]

[1]Biological Sciences, University of the Philippines Mindanao, Davao, Philippines, [2]Marine Science Institute, University of the Philippines, Quezon, Philippines

Previous nationwide reef fish distribution patterns from over 1,000 underwater fish visual census transect have shown interesting results both in its evolutionary and ecological context. Aside from contributing to the discussions on the likely possible mechanisms on whether the hypotheses on the center of overlap or center of origin to address biodiversity concerns, ecological insights can be derived to assist on the nationwide and local conservation strategies. Also cumulative species area curves in the marine biogeographic regions in the South China Sea, Sulu Sea, Celebes Sea, Visayan Seas, North and South Pacific Seas show the differential reef fish diversity potentials in each region. We propose the processes involved in the evolutionary history of reef fishes that is responsible for the formation of these sub-regions and the major structuring forces that influence ecological conditions for these regions is derived.

The biogeoraphic regions derived from reef fish distribution provide leads to the prioritisation of conservation areas including the marine corridors based on representativeness and the diversity values. This provides the framework for integrating the insights that suggests the potential diversity pool for the region vis-à-vis the local diversity potential in a local area. The state of the reefs and their pressures (e.g. overfishing and number of fisher per fishing area and the bleaching events) and interventions in the area (no-take MPA) provide natural experiments to improve our understanding of these areas. In complement with our monitoring of particular reefs sites, we show that there are various vulnerabilities and susceptibilities to these different threats. These insights are important to level off desired outcomes with local partners so that expectations on reef recovery and fish biomass build up are realistic and lead to proactive actions.

## 10.367

**Comparison Between Extension Rate And Coral Coverage Of Coral Lifeforms**

**Yumi FUCHINOUE*[1]**, Tomoko OKASHITA[1], Takeshi MAEKAWA[1], Ryota NAKAJIMA[1], Rajuddin KUSHAIRI[2], Ross OTHMAN[3], Tatsuki TODA[1]

[1]Soka University, Tokyo, Japan, [2]Universiti Industri Selangor, Selangor Darul Ehsan, Malaysia, [3]Universiti Kebangsaan Malaysia, Selangor D. E., Malaysia

Common field measurements of coral growth are extension rates which are not reliable for quantitatively assessing reef growth due to the diversity of lifeform structures. The purpose of this study was to measure the extension rate and coral coverage of various coral lifeforms. The survey was carried out on fringing reefs at Tioman Island (2°50′00″N; 104°10′00″E) in Malaysia. Observed corals were categorized into five lifeforms: *Acropora* branching (ACB), *Acrpora* digitate (ACD), *Acropora* tablate (ACT), Coral encrusting (CE), and Coral massive (CM). Coral extension rates (m year-1) and coral coverage (m2 year-1) were measured from digital photographs by image analysis software. The coral extension rate was measured by linear growth corals. The coral coverage was calculated using the outline structure of the coral. ACD (77.1 ± 13.5 mm year-1) and ACB (69.7 ± 23.3 mm year-1) showed the highest coral extension rates of all five types. However, ACD and ACB showed significant differences in coral coverage. Coral coverage of thick and close spacing ACD was 60% while thin and broad spacing ACB showed coral coverage was 22%. Other lifeform structures showed similar coral coverage to ACB. The results show that careful attention must be made to lifeforms structures when measuring reef growth from extension rate. Further, the present study confirmed that image analysis techniques are suitable for estimating the reef growth of diverse structures of coral lifeforms.

## 10.368

**Long Term Population Patterns Of *coralliophila Abbreviata* in Relation To Host Coral *acropora Palmata***

Margaret MILLER[1], **Ashley CEDZO*[2,3]**

[1]National Marine Fisheries Service, Southeast Fisheries Science Center, National Oceanic and Atmospheric Administration, Miami, FL, [2]Department of Biology and Marine Biology, University of North Carolina at Wilmington, Wilmington, NC, [3]National Marine Fisheries Service (Ernest F. Hollings Scholar), National Oceanic and Atmospheric Administration, Miami

Corals are declining in health and cover worldwide due to a wide range of influences. Specifically, corals of the Acropora genus are rapidly dying off throughout the Caribbean. In addition to the anthropogenic effects experienced on these reefs, there are also natural processes affecting the corals. One such process is predation by corallivorous snails. The purpose of this research was to determine long term population patterns of the corallivorous snail, Coralliophila abbreviata, in relation to abundance and condition of its host coral, Acropora palmata. Annual surveys are conducted at six study sites in the upper Florida Keys, USA. In addition to the total number, size, and condition of coral colonies, number and size of snails found on each colony is measured. Over nine years (a period with substantial A.palmata mortality), three of the sites, as well as the overall mean for the six sites, showed statistically significant correlations between coral abundance and snail density. That is, as total live tissue cover at the site decreases, the number of snails per total live area increases. This inverse correlation of coral abundance with snail density indicates a positive feedback as snail predation appears to exacerbate other sources of coral mortality. This positive feedback likely results from the utilization of alternate host coral species by the snails.

## 10.369

**Recruitment Of *oulastrea Crispata* On Artificial And Natural Subtrata in Tung Ping Chau Marine Park, Hong Kong Sar, China**

Wai Chun MA[1], **Put ANG, JR.* [1]**

[1]Marine Science Laboratory, Department of Biology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong

Coral recruitment is a rare and slow process in Hong Kong. The seasonal and annual variations on the recruitment of *Oulastrea crispata* were monitored for a period of four and a half years from 1998 to 2003 on the artificial experimental granite rocks and the natural sedimentary boulders. Recruitment of this coral species was recorded every season on the experimental granite rocks but its rates fluctuated seasonally, with the highest mean (± SD) rate recorded in 2000 winter (7.72 ± 1.25 recruits/m2), and the lowest in 2002 autumn (0.34 ± 0.30 recruits/m2). The fluctuation in recruitment rate, however, was not statistically significantly different among seasons. The annual rate of recruitment on the experimental granite rocks remained the same over the four and a half years of sampling. In contrast, recruitment was not recorded every season on the natural substrata. The mean seasonal recruitment rate also fluctuated highly with the highest rate recorded in 2000 winter (4.67 ± 5.89 recruits/m2), and lowest in 2001 spring and 2002 spring (0 recruits/m2). Recruitment rate of *Oulastrea crispata* was not affected by the density of the existing coral colonies. The fluctuation in recruitment rate may be due to the variation in coral larval availability.

## 10.370

**Facultative Symbiosis Between Coral And Seagrass**

**Yoshikatsu NAKANO*[1]**, Sayuko NINOMIYA[2], Takahiko INOUE[2], Yuka YANO[3], Preetika SINGH[3], Makoto TSUCHIYA[3]

[1]Sesoko st., TBRC, University of the Ryukyus, Okinawa, Japan, [2]TOKYO KYUEI CO., Ltd., Saitama, Japan, [3]University of the Ryukyus, Okinawa, Japan

Corals and seagrasses often establish combined communities in the moat. This community structure had been understood as the result of competition between them for substratum. Recently, however, we found some evidences that let us interpret the relationship between *Thalassia hemprichii* and the branching coral: *Montipora digitata* as facultative symbiosis in the process of succession of their combined community. Seagrasses generally make habitat segregation by the particle size of substratum. *T. hemprichii* prefers gravelly substratum. Branching form corals supply a large amount of gravel in the moat. As the biomasses of both organisms increased in the community, the erect stem-leaves of *T. hemprichii* grew bigger and clustered being close each other in the gravelly substratum supplied as dead fragments of *M. digitata*. Such a high density population of *T. hemprichii* is supported by highly porous structure of substratum and a large amount of nutrient originated from suspended organic matter filtered due to the complex structure of a meadow. Growth form of *M. digitata* changed to slender in the dense meadow. This growth form easily causes fragmentation. The survival rate of these fragments may increase in a stable meadow rather than on bare substratum. This facultative symbiosis could be observed around large *M. digitata* population. Such a population provides micro atoll-like topography in the shallow area of the moat. This area may be supplied with gravelly substratum in its periphery, establishing the combined community like a protection from current and wave erosion. *T. hemprichii*, a generalist, distributing wide range in the moat may easily recruit on such gravelly substratum. A large-scale facultative symbiosis may occur in shallow gravel areas under a special condition after the corruption of a large branching coral community. This facultative symbiosis may dissolve at a certain point in the process of succession.

## 10.371

**The sea urchins of Zanzibar and their effect on local coral communities**

**Omri BRONSTEIN*[1]**, Yossi LOYA[1]

[1]Tel Aviv University, Tel Aviv, Israel

As part of a GEF/World Bank targeted research on coral bleaching and local ecological responses, a study aimed at assessing the impact of sea urchin populations on coral communities around the island of Zanzibar was conducted. Between October 2006 and November 2007, surveys of urchin populations were performed every 4 months at 6 locations around the island. Data on species assemblage, densities and size frequency distributions was obtained. Results show dominance of two urchin species, Diadema setosum and Echinometra sp., in 5 out of 6 stations, with D. setosum dominating the western side of Zanzibar (56% - 98%) and Echinometra sp. dominating the eastern side (60% – 97%). Average densities of D. setosom and Echinometra sp. ranged from 0-29.5 and 0-88.4 individuals m-2 respectively. To estimate the daily rate of bioerosion by a single urchin, experiments were conducted on Echinometra sp. using the ignition-loss method. Skeletons of the coral Acropora formosa collected from the study sites were used as the food source. Individual CaCO3 bioerosion rates for Echinometra sp. were used to assess the dependence of bioerosion rates on urchin population densities. Despite the fact that individuals from denser populations erode at lower rates (0.012±0.001 g day-1) than those from less dense populations (0.028±0.002 g day-1), overall bioerosion per area was significantly greater in areas with denser populations. The data obtained here sheds new light on our knowledge of urchin populations in protected and unprotected reefs around Zanzibar and emphasizes the significant role of urchins in bioerosion of the reef. The dense populations of sea urchins on the coral reefs of Zanzibar and their significant role in bioerosion stress the need for long term monitoring and in depth research of this group in the reef.

## 10.372

**Stress Resistance in An Extreme Environment: Lessons Learnt From A Temperate Symbiotic Sea Anemone**

Milena PALKA[1], **Simon DAVY*[1]**

[1]Marine Biology, Victoria University of Wellington, Wellington, New Zealand

Coral bleaching, is of huge global concern. In contrast to tropical corals, which are highly sensitive to fluctuations in environmental parameters such as temperature, light and salinity, zooxanthellate invertebrates in temperate waters rarely bleach despite highly variable conditions. Here we are testing the effects of combined salinity-light stress on the temperate sea anemone, *Anthopleura aureoradiata* and measuring photosynthetic health and symbiosis stability. We are employing pulse amplitude modulated (PAM) fluorometry, a powerful yet simple and non-invasive tool, for measuring various aspects of photosynthesis through chlorophyll fluorescence. In the field, the effects of fluctuating environmental factors on *A. aureoradiata* are being evaluated using Diving PAM. In the lab, anemones are being exposed to varying levels of salinity (10-60 ppt) and light (1-420 µmol photons/m2sec) and photosynthetic health is being measured with Imaging PAM. Because *A. aureoradiata* resides on shallow mudflats and in rock pools, it is likely to be exposed to considerable environmental fluctuations. Since it has never been seen to bleach, we hypothesize that the resistance of *A. aureoradiata* to changes in salinity is a function of the robust photophysiology of its zooxanthellae. It is expected that photophysiological stress, specifically zooxanthellar expulsion and loss of photosynthetic capacity, will only occur at extreme levels of salinity and light. Remarkably, preliminary results have shown that algal photosynthetic health was maintained while the anemone itself clearly suffered from tissue damage. Zooxanthellae exposed to extreme levels of salinity did not acclimatize to treatments as readily as those exposed to ranges closer to the norm (Fv/Fm at 0.462 and 0.502 respectively), when held at the highest light levels. The algae are least affected at the lowest irradiance, and hence light appears to be exacerbating the impact of salinity. Thus, the data collected to date supports the idea that these zooxanthellae have a robust photosynthetic stability.

## 10.373

**Dynamic Of The Population Size Frequency Distribution in Two Scleractinian Coral Species On Heron Reef, Gbr**

**Juan ORTIZ*[1]**, Glen HOLMES[1]

[1]Centre for Marine Studies, The University of Queensland, St Lucia, Australia

Coral reefs are under constant and increasing stress as a consequence of a variety of factors (e.g. over-fishing, agricultural runoffs, global warming, ocean acidification). Under these adverse conditions coral growth and its variability is a key factor for understanding the potential consequences of these disturbances. In this study we measure growth (two-dimensional growth and tri-dimensional growth). The annual growth rates over a tree year period of two species of scleractinian corals (*Pocillopora damicornis* and *Stylophora pistillata*) in four different sections of Heron reef (Great Barrier Reef, Australia) will be presented. Preliminary results for the first two years of the study show that both species presented considerably high growth rates (between 34 and 87%). Both populations were skewed towards small colonies in the first year but the skewness was significantly reduced for the second year. This bias toward bigger colonies was accompanied by a reduction in the number of colonies despite the fact that the total combined cover for this two species did not change. This study emphasizes how significant ecological patterns can be masked when coral cover is used on its own as an indicator of coral reef status. Our results may help coral reef managers to determine what areas of the reef are more likely to be affected by disturbances that can either be size specific or genotype specific.

## 10.374

**Experimental Evaluation Of Post-Settlement Movement in The Coral-Associated Goby *gobiodon Histrio***

Marlene WALL[1], Joerg OTT[1], **Juergen HERLER*[1]**

[1]University of Vienna, Vienna, Austria

Crypto-benthic reef fish play an important role in the functions of coral reef ecosystems. Worldwide degradation of reef puts habitat specialized fishes at high risk by habitat loss. To receive a better understanding of the susceptibility of coral-associated fishes to habitat loss, post-settlement movement was surveyed in *Gobiodon histrio*. After observing movement patterns under natural conditions in the northern Red Sea, a combination of manipulative field and laboratory experiments were conducted. In the field, the homing ability was tested by displacing individuals in different distances from their home coral. A considerable difference was observed between minimum and maximum displacement (0.5m = 100%; 4 m = 16.4% of fishes returned). Aquarium experiments were designed to test for the assumption that *Gobiodon histrio* can distinguish its host-coral from a choice of different colonies. In addition, a partner finding experiment was performed. In both experiments a high fidelity for host corals (75%) and partners (60%) was observed. The study indicates a high movement rate for single adults. In contrast, breeding pairs show a high stability in their habitat choice. Social structure of *G. histrio* in the northern Red Sea shows similarities to the Western Indo-Pacific but differs in the proportion of single adults, which is much lower in the latter. The high proportion of single adults and their high movement rate indicates a limitation of high quality habitats (particular *Acropora* species) for breeding. The apparently more generalized behaviour results from occupation of sub-optimal corals by single adults while moving and searching for breeding corals and partners. This study shows that *G. histrio* frequently moves between corals but this depends on the social status of fishes. Vulnerability of populations to habitat loss increases highly when particular corals are affected by damage.

## 10.375

**Effects of Sedimentation on the Distribution and Ecology of the Reef Zoanthid *Palythoa caribaeorum***

**Veronica ACEVEDO*[1]**, Paul YOSHIOKA[2], Wilson RAMIREZ[3]

[1]Marine Sciences, University of Puerto Rico, Ponce, Puerto Rico, [2]Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico, [3]Geology, University of Puerto Rico, Mayaguez, Puerto Rico

The present study determines different aspects of the ecology of the zoanthid *Palythoa caribaeorum* in various coral reefs at La Parguera, southwest coast of Puerto Rico. On each reef 4 different depth zones were selected; reef crest, shallow reef front, deep reef front, and the sand plain. Three 1 x 10m (10m2) transects were surveyed in each zone to estimate densities, size-frequency distributions and percent cover of *Palythoa*. Studies of the effects of sedimentation on the distribution of *Palythoa* were performed in Enrique and Media Luna reefs. Percent coverage of *Palythoa* was highest in the crest zone and decreased with depth at both reefs. Colony densities were not significantly different among reefs or zones. Size frequency distributions were dominated by small colonies and were significantly different among reefs and zones. Water column sedimentation rates were significantly higher in Media Luna compared to Enrique, but depth-related patterns differed between reefs. Sedimentation rates were greatest in the shallow crest zone at Enrique, but at Media Luna were greatest in the deep sand plain zone. These patterns may be caused by the resuspension of the sediments. Bedload transport was not statistically different between Enrique and Media Luna. At both reefs the highest bedload transport occurred in the sand plain zone followed by the crest zone and the reef front. The results do not show any correlation between *Palythoa* percent coverage and water column sedimentation. There is an adverse relationship of *Palythoa* percent coverage and bedload transport. The relatively high abundances of *Palythoa* and high bedload transport in the reef crest may be the result of strong wave action that cleans excess sand off colony surfaces. Alternatively, bedload transport accumulates and buries *Palythoa* colonies in the sand plain areas.

## 10.376

**Trophic Cascades On Caribbean Coral Reefs: Invasive Lionfish (Pterois Volitans And P. Miles) Predation On Cleanerfish in The Bahamas**

**Stephanie GREEN*[1]**, Isabelle CÔTÉ[1]

[1]Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

Invasive species are an emerging anthropogenic stressor threatening coral reef community assemblage and species diversity. Since 2004, two species of venomous, piscivorous Indo-Pacific lionfish (*Pterois volitans* and *P. miles*) have invaded coral reef communities in the Bahamas. The ultimate impact of these predators on Caribbean coral reef fish communities will depend on the importance of the species they interact with in maintaining the structure of reef food webs. Our analyses of lionfish stomach contents from patch reefs around New Providence, Bahamas, revealed a high prevalence of predation on cleanerfish species, including both obligate cleaning gobies and a range of facultative cleaners. Comparisons of dietary contents to prey availability on the reef suggest preferential predation on cleaners. Cleanerfish can dramatically reduce ectoparasite loads of their clients, and have been shown, at least in the Indo-Pacific, to drive patterns of reef fish diversity. To examine whether lionfish trigger a disturbance in Caribbean reef fish community assemblages through predation of cleaners, we measured the densities of lionfish, cleanerfish and fish clients on patch reefs around New Providence. Overall cleanerfish density was inversely correlated with lionfish density, and client fish diversity but not abundance, covaried positively with cleaner density, but negatively with lionfish numbers. These results suggest that the lionfish invasion may affect reef fish diversity by disrupting an important symbiotic relationship. Thus, lionfish could trigger quantifiable trophic cascades on coral reefs as they continue their rapid spread around the Caribbean.

## 10.377

**Effect Of Short-Term Nutrient Enrichment On Photosynthesis in Crustose Coralline Algae**

**Cheryl SQUAIR*[1]**, Celia SMITH[1]

[1]Botany, University of Hawaii, Honolulu, HI

Crustose coralline algae (CCA) are important components of reef ecosystems. They provide substrate stability, are major producers of sand and provide settling cues to a variety of invertebrates, including many species of coral. Owing to their slow growth and a lack of basic ecophysiological data, few studies have examined how this important group of organisms will be affected by anthropogenically-induced changes in their environment. Previous studies have suggested that crustose coralline algae are chronically photoinhibited under the high light conditions experienced on tropical reef flats. Nutrient availability is an important factor affecting whether components of the photosynthetic apparatus damaged under high light can be repaired. Under conditions of low nutrient availability, insufficient nitrogen may be available to effectively repair damage caused by high irradiance. Plants suffering chronic photoinhibition may be more susceptible to assaults such as disease and rising temperatures. Therefore, understanding the physiological dynamics of CCA in the field is critical to understanding how they may respond to future global change. This study sought to examine how nutrients affect the photosynthetic physiology of CCA in a high light backreef area of the near-pristine fringing reef of Ofu, American Samoa. Pulse Amplitude Modulated (PAM) Fluorometry was used to measure relative photosynthesis in CCA with and without experimental nutrient enrichment, over a six-week period, at 10 haphazardly selected sites on the backreef. Using a diving-PAM, estimates of the physiological parameters: $\alpha$, $E_K$ and $ETR_{max}$ were made to assess how short-term nutrient enrichment influences the physiology of these important reef calcifiers. Our results suggest that in this low nutrient, high herbivory system, nutrient enrichment may help alleviate photodamage associated with high light environments.

## 10.378

**Preliminary Findings: Can Invasive Macroalgae Facilitate Invasional Meltdown?**

**Rodolf PAN*[1]**, John STIMSON[1], Celia SMITH[2], Durrell KAPAN[3]

[1]Zoology, University of Hawaii at Manoa, Honolulu, HI, [2]Botany, University of Hawaii at Manoa, Honolulu, HI, [3]CCRT, University of Hawaii at Manoa, Honolulu, HI

Gracilaria salicornia (C. Agardh) E. Y. Dawson (rhodophyta) is native to the Philippines, and was unintentionally introduced to the Hawaiian Islands before the 1950s. It is one of five macroalgal species considered invasive on Hawaiian coral reefs. Gracilaria salicornia appears to have the ability to monopolize substrata and out-compete or exclude other species of macroalgae. In Waikiki, Oahu, it has become the dominant macroalga in an area that used to support over 60 species of native macroalgae. Gracilaria salicornia functions as a habitat architect, creating a three-dimensional matrix with its interwoven thalli, and forming dense 'mats' that contain an extensive epifaunal community. The species composition of this community appears to be distinct from surrounding sand and coral rubble substrate. Observations have revealed many motile and sessile invertebrates within its 'mats', some of which are non-indigenous and considered invasive, e.g. the black sea squirt (Phallusia nigra), Herdman's sea squirt (Herdmania momus), an unidentified red sponge (Mycale sp.), and the Philippine mantis shrimp (Gonodactylaceus falcatus). Hawaiian sea-grasses are not luxuriant or tall enough to create much habitat among their foliage, and G. salicornia appears to create a novel habitat on Hawaiian reefs. It may be providing a habitat for organisms which utilize sea grass beds or dense algal mats in other global locations. This project explores whether the invasion of a habitat architect such as G. salicornia could encourage the persistence or invasion of other non-indigenous species, and facilitate synergistic interactions with, and between, these aliens. These synergistic interactions may create momentum in a positive-feedback loop, causing accelerating damage to ecosystems, and eventually resulting in the alteration or destruction of native communities and coral reef ecosystems - invasional meltdown.

## 10.379

**Comparison of Sedimentation in Bays and Reefs below Developed vs. Undeveloped Watersheds, St. John, US Virgin Islands**

**Sarah C. GRAY*[1]**, Kimbrie L. GOBBI[1], Patricia V. NARWOLD[1], Michael D. FOX[1], Kara A. MILLER[1]

[1]Marine Science and Environmental Studies, University of San Diego, San Diego, CA

Increased terrestrial runoff associated with development is one of the most serious threats to coral reefs. Here we present preliminary data from an ongoing study to evaluate if development on St John, US Virgin Islands has impacted the quantity (flux rate), quality (mineralogy, grain size and organic matter content) and spatial variability of sedimentation. Our approach is to compare sedimentation in reefs and bays below developed watersheds to reefs and bays below undeveloped watersheds and to compare bottom sediment and substrate cover today to data from sediment surveys conducted 20 years ago.

For each of seven 10-23 day sediment-trap sampling periods over the rainy season, unsieved sediment flux rates (normalized to watershed area) were at least 1 and up to 51 times higher on the reefs below developed watersheds compared to reefs below undeveloped watersheds. The developed watershed sediment flux rates (3-630 mg $cm^{-2}d^{-1}$) were sometimes within range of rates previously shown to cause "severe to catastrophic" sediment stress to corals. The proportionate increase in sediment flux in response to a major rainfall event was much greater at the developed compared to the undeveloped bays and reefs (storm/baseline flux rate = 210 for the developed vs. 3 for the control reef). Carbonate was the most abundant sediment constituent at all sampling sites except those nearest the shore. Mean siliceous mineral (terrestrially derived) flux rates were 15 times higher (5 vs. 0.3 mg $cm^{-2}d^{-1}$) and mean organic matter flux rates were 10 times higher (3 vs. 0.3 mg $cm^{-2}d^{-1}$) on the reefs below the developed watershed. Analyses of the textural variability, specific mineralogy, and organic matter source of the sediments are underway.

Detailed monitoring of sedimentological processes affecting individual reefs is a critical compliment to ecological monitoring and necessary to evaluate the effectiveness of erosion mitigation strategies.

## 10.380

**Habitat Partitioning By Territorial Pomacentrids**

**Andreza PACHECO*[1]**, Ferreira BEATRICE[2]

[1]Departamento de Oceanografia, Universidade Federal de Pernambuco, Tamandare, Brazil, [2]Departamento de Oceanografia, Universidade de Pernambuco, Tamandare, Brazil

Territorial pomacentrids are very abundant on shallow reefs of the northeastern Brazilian coast. The influence of habitat on the distribution and abundance of juveniles and adults of three territorial species of Pomacentrid (Stesgastes fuscus, S. variabilis and Microspathodon chrysurus) was investigated on four reefs in the Tamandare reef complex. Four categories of reef tops were defined according rugosity and algal cover: low and medium rugosity, both with algae assemblage dominated by Halimeda, Dictyota and Gellidiela; and two high rugosity types dominated by turf algae and by Amphiroa mat, respectively. Fish censuses were conducted using belt-transect method while substrate cover was estimated by point-base method and contour measurements (rugosity). The density of sea urchin Echinometra lucunter was also estimated. S. fuscus was the dominant species in the reef flats with higher rugosity, independent of the prevailing kind of algal cover, with density positively correlated to rugosity. Juveniles of S. fuscus occurred in all types of reef flats, with no significant difference in density. S. variabilis juveniles settled in all reef types, but were less abundant on tops dominated by adults S. fuscus. Adults of S. variabilis occurred only on low and medium rugosity habitats, with higher abundances on medium rugosity flats, being absent on S. fuscus dominated flats, indicating ontogenetic migration or post settlement. There was a negative correlation between densities of adults of Stegastes species, indicating a possible exclusion effect. Abundance of E. lucunter was higher in turf covered habitats. In these areas higher densities of S. fuscus were inversely correlated to higher E. lucunter abundances indicating herbivory competition. Although adults of M. chysurus occurred in flats dominated by Amphiroa mat, they were mostly found at flats dominated by turf algae, coexisting with adults of S. fuscus, while juveniles were restricted to hydrocoral Millepora colonies.

## 10.381

**Competitive Directs Interactions in A Caribbean Reef: Comparing The Competitive Networks in Three Zones Of A Venezuela Reef**

**Jeannette PÉREZ-BENÍTEZ*[1]**, Estrella VILLAMIZAR[2], Humberto CAMISOTTI[3]

[1]LEMAC - UCV, Caracas, Venezuela, [2]IZT - UCV, Caracas, Venezuela, [3]FCLR, Caracas, Venezuela

Most scleractinians corals show a wide range of ecological adaptations, which allows them to colonize virtually all areas of the reef. Variations in species diversity, distribution and abundance on a coral reef are often attributed to processes occurring within the community such as competition and predation (Sammarco, 1982; Connell, 1983) and physical disturbances (Karlson & Hurd, 1993). This study was carried out at the fringing reef off Key Dos Mosquises located south-west of National Park Archipielago Los Roques, Venezuela. The objective of this study was to characterize and compare the different zones of coral reefs (flat, crest and slope), based on "in-situ" observations of the evidence of competitive relationship between scleractinian corals. In each zone were evaluated 5 belt transects of 2 x 10, where each found direct competitive interactions were counted. Among the most relevant results were obtained that competitive relations in the first two zones were very similar, considering the classification of corals according to their degree of aggressiveness, proposed by Lang (1973). In the slope zone the competitive network was more complex because the Presence of more species in direct competition, being much larger number of links or ties between competing species. In general, the "aggressive species" on the reef were: *M. mirabilis and M. annularis* (flat), *M. aliciae* (crest and slope) and *A. lamarcki* (slope), followed by the species *M. faveolata*, *M. cavernosa* and *M. franksi* which were characterized by high frequency of harming its neighbors; while the "subordinate species" were *S. iIntersepta* and *S. siderea*. The competitive relationships vary with the zone of the reef, mainly due to the distribution of species in the depth and possibly differences in the resource constraint in each area.

## 10.382

**Differential Effect Of Early Post-Settlement Processes On The Abundance Of Two Concurrently Settling Coral Reef Fishes**

**Henri VALLES*[1]**, Donald KRAMER[1], Wayne HUNTE[2]

[1]Biology, McGill University, Montreal, QC, Canada, [2]Biology, University of the West Indies, Cave Hill, Barbados

To examine the magnitude, spatial variability and causes of early density-independent (DI) and density-dependent (DD) post-settlement losses in coral reef fishes, we monitored density of *Sparisoma* (Scaridae) and *Stegastes partitus* (Pomacentridae) on three reefs in Barbados (West Indies) for 3-3.5 months following a period of high recruitment and fitted the data to a modified Beverton-Holt model. To assess whether surveys missed early DD mortality, we compared recruitment on reefs to that on standard monitoring units (SMURFs) that excluded predators. Recruitment was >11x (*Sparisoma*) and >3x (*S. partitus*) greater than the initial number of large juveniles/ adults. Mortality was very high (*Sparisoma* 97%; *S. partitus* 91%), indicating that post-settlement processes were more important than settlement in determining local density. Mortality did not vary significantly across sites. After 3-3.5 months, *Sparisoma* densities were similar to those before recruitment. *S. partitus* densities increased, but increases did not match among-site differences in recruitment, indicating that post-settlement processes differed spatially. DI effects did not vary significantly between taxa or sites. DD effects were one order of magnitude higher for *Sparisoma* than for *S. partitus*, possibly due to lower availability of refuge microhabitat for *Sparisoma*. DD effects varied significantly across sites for *S. partitus*, but not *Sparisoma*, perhaps because of lower precision in density estimates for *Sparisoma*. Among-site differences in DD effects for *S. partitus* were associated with differences in recruitment rates and substrate. Predator density was similar across sites. Recruit density on the reefs mirrored captures in SMURFs, indicating that surveys did not miss important DD predation. Our findings suggest that substrate influences rates of DD mortality and therefore local population dynamics, but with markedly different strength for different taxa.

## 10.383

**Variations in Growth Rates Of Juvenile Reef Fish in Mangrove And Seagrass Habitats in The Us Caribbean**

**Ivan MATEO*[1]**, Edward DURBIN[2], Richard APPELDOORN[3], Aaron ADAMS[4]

[1]Fisheries Animal Veterinarian Sciences, University Rhode Island, Kingston, RI, [2]Graduate School of Oceanography, University Rhode Island, Narragansett, RI, [3]Marine Sciences, University Puerto Rico, Mayaguez, Puerto Rico, [4]Mote Marine Lab, Pineland, FL

Many marine fish have a life history in which juveniles occur in habitats that are spatially distinct from those in which adults are found the juvenile phase often occurs in more than one habitat type (e.g., mangrove,seagrass,patch reef, rubble,). When juveniles occur in multiple habitats, it is likely that the different areas will vary in their relative quality as juvenile habitat. Relative quality is frequently assessed by comparing density, growth, and survivorship of juveniles in two or more habitat types. Habitats that promote rapid growth are generally assumed to be high quality areas for juvenile fish and crustaceans because rapid growth implies that sufficient food is available. Also, juveniles will be less vulnerable to size-selective mortality and will attain a larger size at the end of the juvenile period, which may improve recruitment success to the adult habitat.

In the present study the relative quality of mangrove and seagrass habitats for juvenile reef fish populations in St Croix and Puerto has been evaluated by comparing growth rates in two habitat types: Mangrove and Seagrass using otolith microstructure. The width of daily increments in the otoliths on the region that represent the post-settlement period (30-60 days) of juvenile French grunts and Schoolmaster collected in 2006 were compared among mangrove and seagrass habitats in two Islands: St Croix, Puerto Rico. Daily increments were wider in fish collected from mangrove habitats in both islands. Comparison of the results indicates that mangroves support faster growth rates than seagrass habitats during the post-settlement period for these two species.

## 10.384

**Biodiversity And Ecosystem Functioning in Three Coral Reefs At The Mexican Caribbean.**

**Fabian RODRIGUEZ-ZARAGOZA*[1]**, Jesus ARIAS-GONZALEZ[2]

[1]Departamento de Ecología, CUCBA, Universidad de Guadalajara, Guadalajara, Jalisco, Mexico, [2]Recursos del Mar, Centro de Investigación y Estudios Avanzados del I.P.N., Merida. Yucatan, Mexico

Biodiversity and ecosystem functioning relationship changes have functional consequences within ecosystems. Our main objective was to evaluate this relationship in three coral reef sites at the Mexican Caribbean: Puerto Morelos, Yuyum, and Mahahual. Each site differs in geomorphological zones. Puerto Morelos has two and Yuyum and Mahahual have four each. Species and functional groups richness, composition, abundance, and ecological diversity were evaluated for both coral reef fish and hermatypic corals. Ecosystem functioning was assessed by a reef bioconstruction indirect analysis and balance mass models built onto Ecopath with Ecosim (5.1) software. We analyzed trophic functioning based on trophic macro-descriptors, flow indexes, and Ecosim simulations. The data was obtained with visual census and videotransects in four geomorphological zones (depths 3, 6, 10, and 18 m) during 1999 and 2000. The results showed that Mahahual and Yuyum had the highest fish and coral biodiversity and functional diversity. The biggest reef bioconstruction, trophic macro-descriptors, and flow indexes were estimated for them. It means more complex food webs with the highest total system biomass, throughput, production, flow cycling, number of pathways, path length, and a better ecosystem stage of maturity. In contrast, Puerto Morelos had the lowest biodiversity, a simpler food web with lower trophic descriptors, and a lesser ecosystem maturity. It suggests biodiversity enhances species complementariety, sampling effect, and functional redundancy, which increase of natural ecosystem resilience and resistance in coral reefs. Resilience and resistance increments were corroborated with Ecosim simulations. In coral reefs, our study shows a direct and positive biodiversity and ecosystem functioning relationship in a multitrophic system.

## 10.385

**The Caribbean Octocoral *erythropodium Caribaeorum*: Growth Rates in A Reef Of Los Roques National Park**

**Ana YRANZO*[1]**, Estrella VILLAMIZAR[2], Carolina BASTIDAS[3]

[1]Universidad Simón Bolívar, Caracas, Venezuela, [2]Facultad de Ciencias, Instituto de Zoología Tropical, Universidad Central de Venezuela, Caracas, Venezuela, [3]Dpto. de Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela

Gorgonians are one of the components of greatest cover in hard bottom and coral reef communities, and among these *Erythropodium caribaeorum* (Scleraxonia, Anthotelidae) is a common gorgonian from Caribbean reefs. Its encrusting growth form and large competitive abilities potentially benefit this octocoral to colonize different substrates, including various hard coral species. *Montastraea faveolata* is an organism frequently colonized by this octocoral at Los Roques coral reefs. This study aims to estimate *Erythropodium caribaeorum* growth rates in two types of substrates: (1) alive coral, represented by *M. faveolata* colonies, and (2) dead coral. Two *in situ* treatments were used: (a) manipulative, which consisted in 10cm2cuts, and (b) non-manipulative. Growth was determined by photographs, comparing the area of the colony between August and December. Mean growth rates in the manipulative treatment were 2.00±0.90cm2/month and 1.09±0.98 cm2 over alive and dead substrates, respectively. These rates were higher than those colonies under the non-manipulative treatment: 0.19±0.53cm2/month for living substrate and 0.39±0,68cm2 for dead substrate. Growth rates obtained from the non-manipulative treatment are similar to those reported for other Caribbean reefs in any type of substrates.Manipulative treatment increased the distance between the hard coral and the octocoral, probably diminishing the antagonism between them and thus, resulting in a larger growth rate for gorgonians under this condition. Competition for space plays an important role in marine organism's fitness.

Key words: coral reefs, gorgonian, growth, competition for space

## 10.386

**Exploitation And Habitat Degradation As Agents Of Change Within Coral Reef Fish Communities**

**Shaun WILSON*[1,2]**, Rebecca FISHER[2], Morgan PRATCHETT[1], Nicholas GRAHAM[2], Nicholas DULVY[3], Nicholas POLUNIN[2], Rachel TURNER[2], Akuila CAKACAKA[4], Steven RUSHTON[2]

[1]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [2]University of Newcastle, Newcastle upon Tyne, United Kingdom, [3]Simon Fraser University, Burnaby, BC, Canada, [4]University of South Pacific, Suva, Fiji

Overexploitation and habitat degradation are the two major drivers of global environmental change and are responsible for local extinctions and declining ecosystem services. Here we compare the top-down effect of exploitation by fishing to the bottom-up influence of habitat loss on fish communities in the most diverse of ecological systems, coral reefs. Using a combination of multivariate techniques and path analyses we illustrate that the relative importance of coral cover and fishing in controlling fish abundance on remote Fijian reefs varies between species and functional groups. A decline in branching Acropora coral is strongly associated with a decline in abundance of coral-feeding species, and a decrease in coral associated habitat complexity, which has indirectly contributed to reduced abundance of small-bodied damselfish. In contrast, reduced fishing pressure, brought about by declining human populations and a shift to alternate livelihoods, is associated with increased abundance of some piscivores and fisheries target species. However, availability of prey is controlled by coral-associated habitat complexity and appears to be a more important driver of total piscivore abundance compared to fishing pressure. Fishing, by removing predators and competitors for resources, had an indirect positive effect on the abundance of invertebrate feeding fish. Effects of both fishing and coral loss are stronger on individual species than functional groups, as variation in the relative importance of fishing or coral loss between species within the same functional group attenuated the impact of either of these potential drivers at the functional level. Overall, fishing continues to have an influence on Fijian fish communities, however habitat loss is currently the overriding agent of change. The importance of coral loss mediated by climate change is expected to have an increasing contribution to fish community dynamics, particularly in remote locations or where the influence of fishing is waning.

## 11.387

**Molecular Cloning And Expression Analysis Of Yolk Proteins in The Hermatypic Coral *galaxea Fascicularis***

Hideki HAYAKAWA[1], **Toshiki WATANABE*[2]**, Tadashi ANDOH[3]

[1]Ocean Research Institite, The University of Tokyo, Tokyo, Japan, [2]Ocean Research Institute, The University of Tokyo, Tokyo, Japan, [3]Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Japan

During oogenesis corals accumulate yolk, consisting of proteins, lipids and polysaccharides, in the cytoplasm of developing oocytes. In corals, molecular mechanisms by which vitellogenesis (yolk formation) is controlled remain totally unknown. In the present study, cDNAs encoding yolk proteins were cloned in the gonochoric coral *Galaxea fascicularis* and their expression was studied, with the purpose of studying mechanisms of transcriptional regulation and identifying tissues synthesizing those proteins. In eggs released by female colonies of *G. fascicularis*, four major soluble proteins (named GfEP-1 – 4) were detected. GfEP-1 – 3 were not detected in pseudo-eggs (infertile eggs produced by male colonies), and GfEP-4 was present in pseudo-eggs at a lower concentration than in eggs. cDNAs encoding these proteins were cloned and sequenced. The results showed that a single mRNA encodes a long precursor protein (named GfVg), which is subsequently processed to generate GfEP-1 – 3. The GfVg sequence was homologous to vitellogenin, the yolk protein precursor in higher animals including vertebrates. GfEP-4 is encoded by a separate mRNA, and its sequence did not exhibit similarity to any known proteins. Preliminary analysis of egg extracts from four other corals suggest that GfVg, but not GfEP-4, occurs ubiquitously among hermatypic corals. Immuno-histochemical analysis showed that GfVg is synthesized in tissues outside of the ovary and transported to oocytes. GfVg are synthesized in gastrodermal cells covering the inner side of the body wall and transported to oocytes in the mesentery *via* the mesoglea. A preliminary analysis has shown that the transcription of the *GfVg* mRNA is activated in females, but not in males, in the presence of estradiol-17□ at the nominal concentration of 1 mg/L.

## 11.388

**Higher Temperatures Drive Early Larval Release Of Brooding Reef Corals**

**Yu-Chieh HSIEH*[1]**, Tung-Yung FAN[2], Peter J. EDMUNDS[3], Lee-Shing FANG[4]

[1]Institute of Marine Biodiversity and Evolution, National Dong Hwa University, Taiwan, Pingtung, Taiwan, [2]National Museum of Marine Biology and Aquarium, Taiwan, Pingtung, Taiwan, [3]Department of Biology, California State University, Northridge, CA, USA, Northridge, CA, [4]Cheng Shiu University, Taiwan, Kaohsiung, Taiwan

The accurate timing and tight sychronization of reproductive events typically play a critical role in reproductive success, and previous studies have shown that this is particularly important for scleractinian corals. In this study, we described larval release of two brooding reef corals, *Pocillopora damicornis* and *Seriatopora hystrix* in Southern Taiwan, to demonstrate that the timing of larval release can be altered dramatically by temperature. Corals were collected from shallow locations in Nanwan Bay and maintained in outdoor, flow-through systems to quantify daily larval release over multiple years. The mean lunar day representing the peak of larval release cycle was analyzed by circular statistics. The two coral species released larvae throughout the year with lunar cycles in both 2003 and 2005, and importantly, the lunar cycle of larval release shown apparent seasonal variation in each year. The mean lunar day for larval release by the two species was 3.4 to 12.2 in summer (April to October), but 8.3 to 21.9 in winter (November to March). In 2007, however, the lunar cycle of larval release did not show seasonal variation, the mean lunar day of larval release was similar in winter and summer (6.2 to 12.5). Notably, the mean lunar day of larval release in February and March was earlier in 2007 (8.6-9.6) than in previous years (11.5-19.3), and the mean monthly seawater temperature in between November 2006 and February 2007 was 1.1-2.8$^{o}$C warmer than that during the winters of 2003 and 2005 .The early larval release February and March 2007 may be driven by the higher seawater temperature in winter 2006. These results are important as they suggests that coral reproductive timing may be influenced by rising temperatures associated with global warming.

## 11.389

**Gametogenesis Of The Hermatypic Coral *siderastrea Siderea* in Broward County, Fl, Usa And The Effect Of Bleaching On Fecundity**

**Adam T. ST.GELAIS*[1]**, Alison L. MOULDING[1], David S. GILLIAM[1], Vladimir KOSMYNIN[2], Richard E. DODGE[1]

[1]National Coral Reef Institute, NSU Oceanographic Center, Dania Beach, FL, [2]Florida Department of Environmental Protection, Tallahassee, FL

Massive Caribbean scleractinians are slow to replace themselves in the population due to long life spans, low recruitment, and slow growth rates. Disruption of reproductive synchronicity or reduced fecundity may adversely affect their ability to recover and repopulate degraded areas. Reproductive information on *Siderastrea siderea,* an abundant Caribbean broadcast spawning species*,* is particularly sparse. In order to track gametogenesis and identify the time of spawning, tissue samples from *S. siderea* were collected from August 2007 on a weekly basis until November, when a reduction in gametes, indicative of spawning, was observed. Estimated spawning time was compared with lunar phase as well as water temperature data obtained from permanent digital temperature recorders deployed throughout Broward County to determine if either of these environmental cues affected spawning time. Information on colony condition and presence of bleaching was obtained for each colony sampled. Tissue samples were processed for histological analysis and examined for late stage gametes. Fecundity was estimated from measurements of the volume of oocytes cm-2tissue and was compared between bleached and unbleached colonies. Initial analysis suggests that *S. siderea* spawned between November 8 and 11, 2007 which coincided with the new moon on November 9th. Samples collected on the 8thcontained both ova and spermaries extruded from the mesenteries into the gastrovascular cavity and un-spawned gametes absorbed by the gastrodermis. Further collections of *S. siderea* in 2008 will be used to corroborate spawning correlation of *S. siderea* with lunar period.

## 11.390

**Spawning Patterns Of Corals in North-Western Philippines**

**Kareen VICENTUAN*[1]**, James GUEST[2], Maria Vanessa BARIA[1], Patrick CABAITAN[1], Rommi DIZON[1], Ronald VILLANUEVA[1], Porfirio ALIÑO[1], Alasdair EDWARDS[2], Edgardo GOMEZ[1], Andrew HEYWARD[3]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom, [3]Botany Biology Building, Australian Institute of Marine Science, Crawley, Australia

The Philippines has more than 30,000 km2 of reef area and is host to some of the world's most diverse and endangered coral communities, however there is very little information on patterns of coral reproduction. Sampling to determine the reproductive state of *Acropora* species and *in situ* observations of coral spawning were conducted during March to June in 2006 and 2007 at sites close to the Bolinao Marine Laboratory in north-western Luzon. Prior to the full moon in March 2006, at least 22 *Acropora* species (96%) and 67% of colonies sampled (n = 208) contained visible white or pigmented oocytes in branches that were fractured artificially *in situ* - indicating a seasonal peak in reproductive activity. Night dives were carried out during the week following the full moons of 15 March and 14 April 2006; and 2 April, 2 May and 1 June 2007. Multi-species coral spawning was observed during all of the months of observation except in April 2007. A total of at least 36 scleractinian species belonging to 14 genera and 7 families (Acroporidae, Mussidae, Agariciidae, Faviidae, Oculinidae, Merulinidae and Poritidae) were observed to broadcast spawn, with a maximum of 13 species observed to spawn on the fifth night after the full moon in May 2007.

## 11.391

**Inferences Of Acropora Reproductive Synchrony And Spawning Phenology in The Northern Line Islands, Central Pacific**

**Jean KENYON*[1]**

[1]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

Little is known of the timing of reproduction in Central Pacific coral populations near the equator. Oocyte pigmentation and size comparison with sizes of mature eggs reported in published literature were used to infer intra-and interspecific synchrony and probable spawning phenology in 15 species of *Acropora* from Palmyra and Kingman Atolls in the northern Line Islands. Sampling at both atolls took place in March-April 2002 and 2004. Oocyte sizes were determined from microdissections of fixed, decalcified samples. The majority (91.2%) of samples (N = 209) were gravid, with high levels of fertility in most (84.3%) samples. Statistically discrete oocyte size classes could be distinguished in most taxa at each atoll in each year. These discrete oocyte size classes suggest that several episodes of spawning, involving multiple species, take place over two or three months beginning in early spring. These data, which are the first observations of coral reproductive synchrony in the Line Islands, support the results of other recent studies, suggesting that reproductive synchrony can be a feature of equatorial reef assemblages where the annual ranges of sea surface temperature and tidal amplitude are small.

## 11.392

**Reproductive Characteristics Of Scleractinian Corals Form 2002 To 2007 in A High-Latitude Coral Community At Nishidomari, Otsuki, Kochi, Japan**

**Takuma MEZAKI*[1]**, Fumihito IWASE[2], Shuu NAKACHI[2], Yoko NOZAWA[2], Tohru HAYASHI[3], Mai MIYAMOTO[4], Miho WATANABE[4]

[1]Tohoku University, Tsu-city,Shiratsuka-cho, Japan, [2]Biological Institute on Kuroshio, Otsuki town, Japan, [3]Diver, Osaka Higashisumiyoshi, Japan, [4]Tokai University, Shimizu, Japan

In previous studies, detailed reproductive data have been mainly reported from tropical and sub-tropical areas. These studies have provided information on coral sex (hermaphroditism or gonochorism), mode of reproduction (brooders or spawners), and timing of reproduction (seasonality, periodicity, and synchrony). In this study, we recorded the timing of reproduction in addition to types of bundles and type of egg-sperm clusters in situ. Field observations of spawning behavior of scleractinian corals at a high latitude coral community at Nishidomari, Otsuki, Kochi, Japan were carried out annually from early to late summer in 2002 to 2007. Spawning of 35 species from 15 genera, 6 families were observed, starting from the end of June to the beginning of September. The majority of observed species were hermaphroditic broadcast spawners except for Micromussa amakusensis (Veron, 1990) and Acanthastrea echinata (Dana, 1846). These species seemed to be releasing only egg clusters but we could not find colonies releasing only sperm. Both Montastera valenciennesi (Milne Edwards and Haime, 1848) and Goniastrea aspera Verrill, 1905 were found to have two types of releasing clusters within the same species. One type was release of a single cluster from individual corallite and the other type was, release more than five smaller clusters from a singe corallite. These types had distinguishable skeletal differences. Hence this paper reports on the reproductive information on the 35 coral species over a period of 6 years and show that the reproductive data for each coral species can be one of significant aspect in coral taxonomy to identify range of skeletal variation in a local area.

## 11.393

**Observations on the coral reproduction in Tuticorin coast of the Gulf of Mannar, Southeastern India.**

**Edward JK PATTERSON*[1]**, K. DIRAVIYARAJ[1], T. THINESH[1]

[1]Suganthi Devadason Marine Research Institute, Tuticorin, India

The pattern of reproduction was studied in the branching corals along Tuticorin coast of the Gulf of Mannar during 2006-'07. Extensive survey was conducted to monitor maturity stages and spawning. Visible gametes were observed from January onwards and the reproductive cycle ends in March when they spawn. *Acropora cytherea* showed immature colonies in January (63%) and February (71%) and matured colonies in March (73%). Likewise, the other species showed 50 to 75% of immature colonies in January and an increase of 10% to 20% in February, and matured in March. The average percentage of matured colonies was as follows, *A. formosa* 75%, *A. valenciennesi* 74%, *A. intemedia* 77%, *A. nobilis* 66%, *A. micropthalma* 59%, *A. hemprichi* 84%, *A. hyacinthus* 75%, *A. corymbosa* 64%. The gametes of *Montipora* sp. do not have a colouring pattern, but 30 to 90% colonies were with visible gametes during January to March. Spawning was observed in *A. cytherea* on 24th March 2006, 10 days after full moon and 28th March in 2007, five days prior to full moon. Approximately 30,000 bundles were observed in 1 liter of water and each bundle had 20-25 eggs. The physico-chemical parameters were believed to play lead role in coral spawning, in particular the sudden rise in temperature at the end of March.

## 11.394

**Gametogenesis Of Six Scleractinian Corals in The Celebes Sea**

**Sascha B.C. ROMATZKI*[1]**, Andreas KUNZMANN[1], Sebastian SCHMIDT-ROACH[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany

Sexual reproduction of scleractinian corals is divided into brooding and broadcast spawning species. Brooding corals are expected to be able to release planulae all year around with multiple gametogenic cycles Most broadcast spawners release their sexual products often simultaneously within a time frame of just a few days during a more specific time of a year. Broadcasting species usually breed annually but biannually is also reported in some cases. Previous studies showed that Reproduction time as although mode can be different by geographical distribution within species.

The Celebes Sea is one of the world richest areas in coral diversity. Spatial and temporal variability in reproduction of coral species from the South-East Asian region is still relatively undescribed. For this study we collected samples of branching scleractinian corals from reefs in North-Sulawesi, Indonesia. The sampling was conducted in 2-weekly intervals from March 2006 to May 2007.

We collected samples *of Seriatopora hystrix, Galaxea horrescens* and *A. brueggemanni*, which are formerly known as brooding species. *Pocillopora verrucosa, Acropora pulchra* and *A. yongei* were chosen as representatives of broadcast spawners. All collected samples were examined for their gametic cycle by using standard histological examination. The maximum egg and planula size is used for determination of the gametogenesis stage. The purpose of this study is to determine the mode and timing of reproduction in these species for an equatorial South-East Asian coral reef with a special focus on biannually spawning ability.

## 11.395

**How Depth, Polyp Position, And Colony Size Affect Fertility Among Regions**

**Andrea VANEGAS*[1]**, Alberto ACOSTA[2], Angelica BATISTA[3]

[1]Pontificia Universidad Javeriana, Bogotá, Colombia, [2]Biology, Pontificia Universidad Javeriana, Bogotá, Colombia, [3]Universidad Nacional de Colombia, Bogotá, Colombia

Two important geographical regions are recognized in the Atlantic; the Caribbean, and the South Western Atlantic, where the zoanthid *Palythoa caribaeorum* is present. Populations inhabiting different regions are an ideal condition to test how some variables may affect fertility. Is already documented, within the same region, for several colonial species, that depth, polyp position, and colony size have an important effect on fertility (percentage of polyps with gonads); however, a latitudinal or regional comparison using the same species have not been tested. 165 colonies were randomly sampled at Praia Portinho, S.P., Brazil (23°N), and at Punta de Betín, Colombia (11°S) during the peak of sexual reproduction. Fertility was quantified and the results compared between populations according to: 1. depth (shallow: 0.5-2m; deep: 2.5-4m); 2. polyp position within the colony (marginal; middle; center); and 3. colony size (small: ≤900cm2; large: ≥4,901cm2). Populations exhibited similar reproductive colonies (61-62%). Fertility was statistically different between populations for depth and polyp position; with higher values for Brazil, particularly polyps located in the center and shallow water colonies. Fertility could be related to: 1. colony size; when a threshold distance is achieved between marginal and center polyps, within large Brazilian colonies; 2. biotic factors (i.e. degree of fission, and inter-specific competition), which decrease fertility in marginal polyps when compared to the center; 3. abiotic factors (i.e. sedimentation rates, SST), which are more benign in shallow than deeper water. In contrast, fertility between populations was not significantly affected by colony size. The results suggest that local variables may affect fertility. To propose a reproductive effort pattern for any species will imply to deal with multiple synergistic factors, which act differently between regions or latitudes.

## 11.396

**Reproductive Cycle Of *montastraea Cavernosa* Linnaeus, 1767 (Cnidaria, Scleractinia) From Southern Bahia Reefs, Brazil**

**Joana SILVA*[1]**, Débora PIRES[1]

[1]Departamento de Invertebrados, Museu Nacional/Universidade Federal do Rio de Janeiro, Brazil, Rio de Janeiro, Brazil

The reproductive cycle of the coral *Montastraea cavernosa* was studied in colonies collected from southern Bahia reefs (18ºS), the richest reef area of the South Atlantic. In Brazil, it is distributed from Pernambuco (8ºS), to Espírito Santo (20ºS), also occurring in oceanic areas as the Parcel do Manuel Luís, Fernando de Noronha archipel and Atol das Rocas. Patterns of reproduction, mode of development, gametogenesis and seasonal patterns of the reproductive cycle were assessed from histological sections. The results showed that *M. cavernosa* is a gonochoric and broadcasting species, with an annual reproductive cycle which lasts for approximately 11 months. The development of the female and male gametes started at different moments. The oogenesis lasted about 11 months, starting on March and April. The spermatic cysts were first seen on preparations of material collected on January and remained up to three months later. The maximum oocyte diameter measured was 417 µm. The spawning of the species in many localities in the Caribbean occur after the full moons of July, August, September and October, during the end of summer in the northern hemisphere. In the southwestern Atlantic, spawning also occurred at the end of summer, when water temperature is the highest, and, during the first days after the full moons of February and March.

## 11.397

**Development And Substrate Preference Of Planula Larvae Of *Pocillopora Damicornis* In Thailand**

**Pataporn KUANUI*[1]**, Suchana CHAVANICH[1], Voranop VIYAKARN[1]

[1]Marine Science, Chulalongkorn university, Bangkok, Thailand

In this study, the releasing period and development of planula larvae of *Pocillopora damicornis* in Thailand were investigated. In addition, the substrate preference for settlement of larvae was conducted. Ten colonies of *P. damicornis*, approximately 15 cm in diameter, were tagged and collected for observation every month. To observe the releasing period of larvae, each colony was placed in a separated tank in a rearing system until it released the planula larvae. The results showed that *P. damicornis* released planula larvae during the day and night between 1-14 days after the new moon. However, the high numbers of planula larvae were released during 3-6 days after the new moon. The releasing rates were $0.18\pm0.05$ planula larvae per polyp. Moreover, some colony could release planula larvae monthly. The newly released planula larvae were approximately 1 mm in length. The larvae started attaching on a substrate with in 0.5 hour, and depressed their body shape in 1.5 hours. The polyp, tentacle, and hard structure were observed after 40 hours. After 4 days, a juvenile coral (one polyp) started budding and expanding its size. At the 6th month, the colony shape started uplifting. In addition, the results of the substrate preference for settlement of larvae showed that larvae preferred to settle on the substrates (tile, dead coral slide and rock slide) that had coralline algae covering than ones without coralline algae ($p<0.05$). Furthermore, planula larvae preferred to settle on the tile substrate compared to other kinds of substrates. The data from this study can be further used as baseline information for further culturing of *P. damicornis* in Thailand.

## 11.398

**Gamete And Larval Development Of Spawning Corals in The Inner Gulf Of Thailand**

**Chalothon RAKSASAB*[1]**, Suchana CHAVANICH[1], Voranop VIYAKARN[1]

[1]Department of Marine Science, Chulalongkorn University, Bangkok, Thailand

The patterns of gamete and larval development of corals were investigated in 5 species of Family Acroporidae and 3 species of Family Faviidae during October 2004 to March 2007. These corals are hermaphroditic broadcasting species, which are commonly found in the Gulf of Thailand. The developmental periods of gametes were observed directly in the field. The results from field observations showed that spawning of 8 species occurred during January to March each year. The spawning date and time of all species related to the lunar cycle, which from 5 to 11 nights after the full moon or the new moon. To investigate larval development, the gametes of each coral species were collected directly underwater using collectors during their spawning season in February 2006 and 2007. The collected gametes were carefully transferred to a fertilization tank on a land-based hatchery. In each coral species, bundles from different colonies were mixed together for fertilization, and they were maintained in a cultured system. Then, the morphological development stages of larvae were observed every hour. The first equal cleavage division was observed one hour after the eggs were fertilized. The cell then started dividing quickly, and become flatten to irregular dish shape after 8 hours. Then, the shape of fertilized eggs became thicker. The planula larvae started swimming slowly by using cilia at the 36$^{th}$ hours. After 3 days, larvae started searching for suitable areas for settling by swimming near the bottom of the rearing tank due to the negative phototaxic behavior.

## 11.399

**Planula Release, Settlement, Metamorphosis And Growth Of Deep-Sea Soft Corals**

**ZHAO SUN*[1]**, JEAN-FRANÇOIS HAMEL[2], ANNIE MERCIER[1]

[1]Ocean Sciences Centre (OSC), Memorial University of Newfoundland, St John's, NL, Canada, [2]Exploration and Valuing of the Environment (SEVE), St John's, NL, Canada

The life history of deep-sea octocorals has rarely been studied in any detail, mostly owing to the difficulty of collecting and keeping live specimens. Here we present the reproductive biology, timing of larval release and settlement, and early growth of three nephteid species, with a focus on *Drifa* sp. Specimens collected off the SW Grand Banks (eastern Canada) were brought back to the laboratory where release of planula larvae was monitored daily from July to December 2007. Planulae were emitted without any clearly defined monthly or seasonal patterns. The number of planulae released in a single event by *Drifa* sp. varied from 1 to 14 in six colonies from 500 m, and from 1 to 5 in eleven colonies from 1200 m. The large planulae (ca. 3-6 mm long) were generally expulsed one at a time from the reproductive polyps in a process that took between 20 min and up to 7 d. They exhibited cycles of contraction and expansion that allowed them to alternately sink to the bottom and float in the water column. Settlement occurred after 1 to 29 d, though a small portion of larvae took >2 mo to settle. The type of substratum clearly influenced the time and rate of settlement: for instance, only 5 of 39 planulae settled on sterile plates (after 12 to 50 d), whereas 15 of 32 planulae settled on shell fragments (after 2 to 24 d). A few planulae were observed to settle on adult colonies and other planulae. The eight primary mesenteries typically appeared within 24 h. Polyps developed eight pinnulated tentacles after 12-75 d; they had a stalk diameter of ca.1 mm and a length of ca. 5 mm after 140 d of growth.

## 11.400

**Embryogenesis in The Reef-Building *acropora* Spp.**

**Nami OKUBO*[1]**

[1]Yokohama National University (present: Kyoto University), Yokohama, Japan

Embryogenesis in the reef building corals *Acropora intermedia, A. solitaryensis, A. hyacinthus, A. digitifera, and A. tenuis* was studied in detail at the morphological level, and the relationships among the animal pole, blastopore, and mouth were investigated for the first time in coral. These species showed essentially the same sequence of development. The embryo underwent spiral-like holoblastic cleavage despite the presence of a dense isolecithal yolk. After the morula stage, the embryo entered the prawn-chip stage, which consisted of an irregularly shaped cellular bilayer. The embryo began to roll inward to form the bowl stage; the round shape observed during this stage suggests that it may be the beginning of gastrulation. However, the blastopore closed and the stomodeum (mouth and pharynx) was formed via invagination at a site near the closed blastopore. During the planula stage, a concavity formed in the aboral region in conjunction with numerous spirocysts, suggesting that spirocysts are used to attach to the substrate before the onset of metamorphosis.

## 11.401

**Breeding Experiments Of The Hermatypic Coral Galaxea Fascicularis: Partial Reproductive Isolation Between Colonies Of Different Nematocyst Types, And Enhancement Of Fertilization Success By The Presence Of Parental Colonies**

**Mariko ABE*[1,2]**, Toshiki WATANABE[3], Hideki HAYAKAWA[3], Michio HIDAKA[4]

[1]Marine and Environmental Science, University of the Ryukyus, Nishihara, Japan, [2]Okinawa ReefCheck and Research Group, Nishihara, Japan, [3]Ocean Research Institute, The University of Tokyo, Tokyo, Japan, [4]University of the Ryukyus, Nishihara, Japan

The populations of *G. fascicularis* in Okinawa, Japan are likely to consist of two cryptic species. By morphological examination, a nematocyst type macrobasic p-mastigophore (MpM) in *G. fascicularis* has been distinguished to two distinct subtypes S and H, named after soft and hard colonial morphologies, respectively.Type S MpMs had a relatively thick capsule and a shaft about a half of the capsule length, whereas MpMs of type H had a slender capsule with a shaft shorter than one third of the capsule length. In the majority of *G. fascicularis* colonies, only one of the two MpM types is found in external tentacles. Molecular analyses have shown that the MpM types are highly correlated to different genotypes in a mitochondrial intergenic region and at a nuclear microsatellite locus. Thus, this species in Okinawa is suspected to consist of two reproductive units that occur in sympatry. The present study was to examine the presence of reproductive isolation in *G. fascicularis* by performing fertilization experiments between individuals of the same or different MpM types.

Results of three years breeding experiments showed that fertilization specificity, only a cross between type H female and type S male, was found to be compatible with the MpM morphotypes with low frequencies of cross-fertilization, suggesting the presence of permeable reproductive barrier between the putative cryptic species. In addition we also found an interesting fertilization mechanism of *G.fascicularis*, fertilization could only be successful in the presence of colony fragments.

## 11.402

**Reproductive Effort Of A Brain Coral in The Abrolhos Reef Complex, Brazil**

**Marcia ALVARENGA*[1]**, Clovis CASTRO[1]

[1]Invertebrates, Museu Nacional - UFRJ, Rio de Janeiro, Brazil

Brazil has the only true coral reefs in the South Atllantic Ocean and Abrolhos is considered the largest and richest coral reef area in Brazil. Mussismilia hispida is endemic to Brazilian coast. This specie is very comon and plays an important role as one of the major reef builder along the Brazilian coast. Five colonies were collected at five sites at the inner reefs of the Abrolhos Bank, located at different distances from the coast. Reproductive effort was estimated through fecundity (number of eggs per polyp and per mesenteries). Our data show that the fecundity is variable. The specie presents a mean of 51,7 (6,0 s.d.) mesenteries per polyp. Mean fecundity per mesenteries was 28,6 (6,5 s.d.) and the higher number of eggs per mesenteries was 32. The accuracy of the fecundity per gonad obtained was correlated to sediment deposition in each site sampled. Sedimentation has previously been considered an important source of impact in coral reefs. Percentages of fertile mesenteries per polyp were similar among sites. However, the fecundity per mesenteries varied among colonies and sites, especially on the sites with high sediment deposition. We suggest that M. hispida can suffer impacts on your reproductive effort or can also invest a lot of energy in egg production to increase its chance of survival of the species in more disturb habitats. The study shows data that can be used as a tool if environment threat in the area.

## 11.403

**Reproduction of *Madracis decactis* (Cnidaria, Scleractinia) from Southern Bahia Reefs, Brazil**

**Bruna CASTRO*[1]**, Débora PIRES[1]

[1]Departamento de Invertebrados, Museu Nacional/Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

The reproductive biology of the scleractinian coral *Madracis decactis* (Lyman, 1859) was studied in southern Bahia reefs (16° to 18°S), the most extensive and richest reef areas of the South Atlantic. *Madracis decactis* is one of the most widespread zooxanthellate corals in Brazil and can be found at the edges of the reefs on exposed or cryptic areas. The objective of this study was to investigate patterns of the sexual reproduction of *M. decactis*. Information about sexuality, gonad arrangement, mode of development, gametogenesis and temporal patterns of the reproductive cycle were obtained using histological procedures. The results showed that *M. decactis* is a hermaphroditic species and probably presents a brooding mode of development in southern Bahia reefs. Reproductive cycle is annual and lasts about four months. Female and male gametes started to develop at different times, with spermaries appearing in approximately the second month of oogenesis and lasting about two months. Gametogenesis started on the summer onset (December) and was complete at early autumn (April). Mature gametes were not present in samples collected between the end of March and April. Evidences suggested that fecundation, embryogenesis and the possible planulae release occurred within this period, of approximately one month.

## 11.404

**Spawning Seasons Of Scleractinian Corals in Southern Part Of Phuket, Thailand**

**Thanongsak CHANMETHAKUL*[1,2]**, Hansa CHANSANG[3], Niphon PHONGSUWAN[3], Kumpol MEESAWAT[1]

[1]Biology, Prince of Songkla University, Songkla, Thailand, [2]Biology, Phuket Rajabhat University, Phuket, Thailand, [3]Marine and Coastal Resources, Phuket Marine Biological Center, Phuket, Thailand

This study focuses mainly on the spawning season of scleractinian corals at the southern part of Phuket Island. Spawning was monitored for the period of 15 months, from March 2000 to May 2001. A total of 12 species (*Goniastrea aspera*, *G. pectinata*, *G. retiformis*, *Favites halicora*, *F. abdita*, *Platygyra sinensis*, *Favia pallida*, *Acropora aspera*, *A. formosa*, *A. austera*, *Pectinia paeonia* และ *Mycedium elephantotus*), were investigated. Initially, egg maturation of each species was investigated in the natural habitat. Thereafter, 10 colonies of each coral species were collected and kept for monitoring in the aquaria, where spawning activities were observed and recorded. The result of this study revealed a hermaphrodite broadcasting mode of reproduction of all 12 species of corals. However, the spawning period varied depending on the species. The spawning period of all species investigated were related to the lunar cycle. Spawning took place both during the full moon and new moon periods. All species spawned during dusk, approximately 2 - 3 hours after the sunset. The spawning behavior of these 12 species of corals can be categorized into 3 types 1) slowly released from the polyps 2) rapidly expelled from the polyps. 3) attached to the mouth of each polyp. The colors of eggs also varied among each coral species.

Key words: Spawning; Scleractinian corals; Thai waters; Phuket

## 11.405

**Sexual Reproduction Of The Orange Colonial Coral *astroides Calycularis* (Scleractinia: Dendrophyllidae) in The Mediterranean Sea**

Stefano GOFFREDO[1], Giulia MARCONI[1], **Gabriella GASPARINI*[1]**, Maria Teresa PUTIGNANO[1], Francesco ZACCANTI[1]

[1]Department of Evolutionary and Experimental Biology, University of Bologna, Bologna, Italy

This study examines the sexual reproduction in a scleractinian coral living in temperate waters, in the western and central Mediterranean Sea. *Astroides calycularis* is an azooxanthellate coral that colonizes vertical walls, overhangs, cave entrances, and sea caverns with strong water movement, from the surface to 50m in depth. The colonies have been collected monthly, from April 2004 to September 2005 at Palinuro (Salerno, Campania, Italy) in the Southern Tyrrhenian Sea. This is the first in-depth investigation of the reproductive biology of this species. As expected for a member of the family Dendrophylliidae, *A. calycularis* was a gonochoric coral: colonies were sex separated. Morphological aspects of male gametogenesis were similar to those described in other dendrophylliids coral. During spermary development, spermary diameter increased from a minimum of 31 µm during the immature stages to a maximum of 673 µm during the mature stages. Female gametogenesis was characterized by the conspicuous presence of lipid droplets in the oocyte cytoplasm, which were of phagocytic origin. During oogenesis, oocyte diameter increased from a minimum of 30 µm during the immature stage to a maximum of 1529 µm when mature. Embryogenesis took place in the coelenteron indicating a brooding reproductive mode. Quantitative data on the annual reproductive cycle indicate spring fertilization.

## 11.406

**Sexual Reproduction in The Octocoral, *carijoa Riisei*, in Hawaii**

**Samuel KAHNG*[1]**, Yehuda BENAYAHU[2], Daniel WAGNER[3], Nina ROTHE[4]

[1]College of Natural Science, Hawaii Pacific University, Kaneohe, HI, [2]Tel Aviv University, Tel Aviv, Israel, [3]University of Hawaii, Honolulu, HI, [4]National Oceanography Centre, University of Southampton, Southampton, United Kingdom

Since its initial discovery on Oahu in 1966, the azooxanthellate octocoral, *Carijoa riisei* (Duchassaing and Michelotti, 1860), has spread across the main Hawaiian Islands and proliferated in abundance. To help understand the substantial ecological success of *C. riisei* in Hawaii, its sexual reproduction was examined. *Carijoa riisei* is gonochoric with a male to female ratio of one. Gametogenesis is asynchronous, continuous, and does not exhibit seasonal or lunar periodicity. *Carijoa riisei* spawns negatively buoyant eggs which suggest external fertilization and possibly benthic larvae. Under favorable conditions, *C. riisei* exhibits high polyp fecundity. Asynchronous, continuous spawning of gametes is an unusual mode of reproduction which forgoes the advantages of concentrating gametes in space and time and requires dense aggregations of male and female colonies in close proximity to ensure fertilization success. Other life history traits such as fast growth, early age of sexual maturity, vegetative propagation, and superior competitive ability enable *C. riisei* to form dense, multi-colony aggregations thereby facilitating sexual reproduction. Provided *C. riisei* can achieve a critical density, this unusual sexual reproductive strategy probably enables it to exploit the ephemeral availability of space across time with a high and continuous production of larvae.

## 11.407

**REPRODUCTIVE ASPECTS OF SEA FANS Gorgonia Ventalina (CNIDARIA: GORGONIIDAE) IN THE SANTA MARTA AREA, COLOMBIAN CARIBBEAN**

**Nelson MANRIQUE RODRÍGUEZ*[1]**, Adolfo SANJUAN[2], María Antonieta SALCEDO[2], Katrin Gisseth PERILLA[2], Carlos Edwin GÓMEZ SOTO[2]

[1]Ciencias Biológicas, Universidad de los Andes, Bogotá D.C., Colombia, [2]Biología Marina, Universidad Jorge Tadeo Lozano, Santa Marta, Colombia

As a contribution to the biological knowledge of the sea fan Gorgonia ventalina and as informative argument in order to support management and conservation strategies design for this threatened species, an investigation was done on its reproduction in two coral reefs in Santa Marta, southern Colombian Caribbean. A total of 126 histological slides of the polyps were analyzed during seven months. Reproductive structures were recognized establishing that the reproduction is gonochoric, synchronic development of ovocites and sperm sacks in different colonies, and three developmental stages for each sex. It is speculated that spawning starts at the beginning of the rainy season during August and September. However, the reproduction of these populations may be limited by local environmental and biological changes. It is recommended to rigorously design and to execute precise strategies of handling and conservation to protect Gorgonia ventalina of the area of Santa Marta, which is gradually recovering. It is important to include the human communities that use this resource in order to generate alternatives of sustainable performing culture experiments and in this way preserving the natural populations, as with other gorgonians that are used commercially for souvenirs. Additionally, the banned human activity season is priority during the reproductive peaks and no-take areas where populations of G. ventalina must be monitored. This is the case of Punta Betín, where populations stay stable and there is a continuous recruitment in spite of the anthropogenic impact generated by the maritime and carboniferous ports. Finally a tourism plan is a high priority organizing all the operators and making them understand the importance of conserving this resource and, in addition, be spokesmen of this information.

## 11.408

**A Preliminary Study On Early Life Ecology Of Blue Coral, Heliopora Coerulea (Alcynonaria: Coenothecalia) Assessed By Microsatellite Variation**

**Nina YASUDA*[1]**, Kazuo NADAOKA[2], Tsutomu TAKINO[2], Mugumi KIMURA[3], Satoshi NAGAI[4], Chunlan LIAN[3]

[1]Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan, [2]Tokyo Institute of Technology, Meguro, Japan, [3]Asian Natural Environmental Science Center, University of Tokyo, Nishitokyo, Japan, [4]National Research Institute of Fisheries and Environment of Inland Sea, Hatsukaichi, Japan

Blue coral Heliopora coerulea is one of reef-building corals, and the sole extant member of the alcyonarian order Coenothecalia. This species is well known as a living fossil and once widely distributed in tropical and subtropical regions. However, the distribution of large populations of H. coerulea is now quite limited probably due to historical climate changes. Therefore, the conservation and management of the ecosystem surrounding the coral are of great concern. To conduct the effective management of this species, understanding of the early life ecology such as the reproduction strategy and the larval dispersal is crucial. H. coerulea is known as a brooder whose fertilization and larval development take place in female polyps. However the important factors such as the brooding strategy and also the genetic connectivity within and among reefs are still unknown. To clarify the strategy, at first we conducted field observations at the surfaces of 23 female colonies. The brooding process was found to be divided into 5 stages: 1) stretching tentacles without larvae, 2) brooding larvae with tentacles, 3) only larvae left on the surface, 4) releasing larvae and 5) all larvae released. Then we determined the genotypes of a brooding female colony and its 33 larvae as well as 11 neighboring male colonies to test whether the fertilization takes place among neighboring colonies or not. Initiation of larval release was coincident with neap tide on July 23 in 2007. It took at least 4 days before  eonly larvae f stage coral began to release the larvae. Among the 33 larvae genotyped, we found 14 different alleles from those of the analyzed adults on one locus. Thus at least 7 adult males situating outside the sampling site are associated with fertilization

## 11.409

**The Desirable Invertebrates Breeding Society (Dibs): Reproduction Of Invertebrates For Education And Sustainability**

**Eric BORNEMAN*[1]**, Brian PLANKIS[2,3]

[1]Biology and Biochemistry, University of Houston, Houston, TX, [2]The DIBS Foundation, Manvel, TX, [3]The DIBS Foundation, Manvel

The DIBS Foundation is a non-profit organization dedicated to educational research, research on marine invertebrate reproduction, and educational outreach to marine aquarium hobbyists through the online community Project DIBS. The Foundation conducts formal educational research and informal educational outreach centered on ocean literacy and declining coral reefs. These efforts are specifically geared towards providing concrete ways that concerned students and citizens can make relevant connections to the ocean and take action to reduce stressors on marine environments. Past projects include high school experiments designed to test the feasibility of conducting rigorous scientific experiments, emphasizing ocean literacy, within existing NSES standards and examining the potential for technology to connect classrooms to each other, research scientists, and field observers.

The Foundation is concerned with the reliance of the marine aquarium hobby on wild collection, fragmentation techniques and the growing threat of invasive species. With over 500 members in 9 countries, Project DIBS is coordinating research efforts and providing online classes that educate hobbyists on the necessary steps needed to provide ornamental invertebrates to the marine ornamental trade. The efforts are geared towards understanding reproductive behaviors and life history traits with the goal of maximizing the number of species that can be reproduced *ex situ* to ultimately replace wild collection of inappropriate or ecologically important species that suffer high mortality.

The five year plan is to establish an interdisciplinary research center focused on field research on coral reef decline, invertebrate biology laboratory research, program evaluation of ocean literacy educational interventions and integration of technology into the K-12 science curriculum. The research center will provide internships for disadvantaged and female students interested in pursuing science careers to conduct meaningful invertebrate biology research studies and for individuals to volunteer and develop personal connections to the ocean, leading to an engaged citizenry.

## 11.410

**Long Term Reproductive Success Of Brazilian Giant Seahorses *hippocampus Cf. Reidi***

**Tim MIGAWSKI*[1]**

[1]Center for Tropical Marine Ecology, Bremen, Germany

Seahorses are endangered in their wild habitats. For conservation plans it is important to know reproduction patterns to supply information about population development. In captivity there is no seasonal non-breeding time like in the wild. The provided environmental parameters are stable throughout the year. Thus it is possible to reach a maximum birth rate which is an important factor for the commercial use.

In this study the reproductive success of fifteen *Hippocampus cf. reidi* pairs was measured over a period of eight months. Information on frequency, quantity and duration of pregnancy was collected. In addition the number, size, vitality, growth rate and mortality of the juveniles were measured. These data were linked with detailed info about the adults / pairs and compared with *in situ* data from other studies and species.

In an aquaculture fifteen pairs marked with coloured neckbands. They were characterized by different age, size and weight which were documented. Physical and chemical parameters were identical for all specimens.

According the analysis there are individual differences in frequency, quantity and duration. Pairs / individuals with a high condition factor produce more offspring than pairs with a lower condition factor. For a high reproduction success it is important that the females are in good condition otherwise, there is no males abide by the female and there is no reproduction. The height of the male respectively the pouch size is the second important factor. The largest males are nearly 20 cm and produce up to 1100 Juveniles. The number of underdeveloped young ones increases proportionately with the total number. The length of the juveniles is not correlated with the length of the adults. The collected *ex situ* data are correlated with *in situ* data of other species, showing a consistency.

## 11.411

**Pseudo-4d Visualization Of The Seahorse Larva Head During Ontogenesis**

**Tim MIGAWSKI*[1]**, Martin HEß[2]

[1]Center for Tropical Marine Ecology, Bremen, Germany, [2]BioZentrum der LMU München, Planegg, Germany

The developing seahorse larva undergoes a metamorphosis from hatching to the final seahorse morphology. At the beginning the seahorse larvae look like "normal" teleost larvae, with a voluminous yolk sack and an elongated body. During the development in the male brood pouch a metamorphosis towards an erected, fully differentiated juvenile seahorse takes place within ± two weeks.

In this study larval stages, from hatching to the differentiated juveniles, were collected from a male of *Hippocampus* cf. *reidi*. Information on the formation of the eyes, the snout and the development of internal organ systems is given, as a first demonstration of the changing seahorse head with all internal organ systems.

After fixation section series were cut through the heads of the larval stages beginning with the snout tip. Digital images of each mechanical slice were made on a light microscope, imported into 3D-rendering software (Amira$^{TM}$), converted to stacks, aligned and segmented manually. The abstracted organ contours were used to compute surface-models of several organ systems, to be displayed at any angle of view and for some morphometric analysis. The virtual 3D-models show the internal organs like brain, olfactory epithelia, jaw- and eye-muscles, cartilages and bones, lateral line system and labyrinth organ in different colours. Thus it was possible to display single or several organ systems of the seahorse larva head in any combination, transparency and angle of view at different developmental stages – sort of handling a virtual "transparent fish" in space and time. The method presented here gives detailed insight in the morphogenesis of the seahorse head during metamorphosis, e.g. the effects of eye formation and snout development to all neighbouring tissue structures involved. In further experiments biochemical effects in different live stages of seahorses will be tested in view of active bio compounds and their influence on specific cell types.

## 11.412

**Spawning Induction Method Responses Of Trochidae Gastropods in Closed System Aquaculture**

**Brian PLANKIS*[1]**

[1]Aquaculture Research, The DIBS Foundation, Manvel, TX

The marine ornamentals trade is almost exclusively dependent on wild collection of herbivores to meet commercial demand. Collection of gastropods alone is in excess of 500,000 individuals per year and could be considerably higher due to lack of reporting requirements. Removal of grazers could have a negative impact on reef resilience and developing captive breeding programs to supplant wild collection should help preserve diversity and herbivore abundance in collection locales.

The Desirable Invertebrates Breeding Society Foundation (DIBS Foundation) is a non-profit organization dedicated to testing methods of closed system aquaculture on marine invertebrates. The families Turbinidae and Trochidae contains many herbivores that are collected or are excellent substitutes for current gastropods used in the marine ornamentals trade. While flow through aquaculture systems using natural sea water have been studied for several members of the families, most notably Trochus niloticus and Turbo marmoratus, reports are rare for closed system aquaculture utilizing artificial sea water with multiple spawning attempts per individual.

The DIBS Foundation is conducting spawning induction trials on members of the Trochidae family that have not been previously reported in the literature. This presentation will report spawning induction methods utilized by The DIBS Foundation in closed system aquaculture utilizing aged artificial sea water and individuals subjected to multiple spawning inductions over a 12 month period. I will discuss the methods utilized, the response of three Trochidae members (Trochus stellatus, Trochus sp., and Tegula sp.) to the methods, and initial results of fertilizing the resulting gametes. Discussion will focus on the varied responses by the different species, the need for further study of broodstock conditioning and recovery intervals and implications for the potential of utilizing captive populations for a regular supply to the marine ornamentals trade to reduce the need for wild collection.

## 12.413

**Spatial Patterns Of Stony Coral Population And Community Demographics As An Indicator Of Resistance And Tolerance To Ambient Environmental-And Anthropogenic-Induced Stress On South Florida Reefs.**

**Rowena GARCIA*[1]**, Philip KRAMER[1]

[1]The Nature Conservancy, Sugarloaf Key, FL

The existence of natural refuges to climate stress has been widely speculated and anecdotally observed, but there are few quantitative ecosystem-wide studies documenting their distribution. A synoptic study of surviving stony coral population demographics was conducted to examine possible coral bleaching refuges within the south Florida reef system. A two-stage, spatially balanced probabilistic survey was designed to sample representative coral populations from a large domain extending 500 km from Martin County, Florida to the Lower Florida Keys. Stony corals (≥4 cm in diameter) were visually assessed within two belt transects (1 x10m) located randomly within a Reef Primary Unit (RPU), defined spatially as a 200 x 200m cell. Sampled RPU's were randomly chosen each year within 21 strata (sub-regions and cross shelf zones) using digital reef maps (0-30 m) delineating all possible RPU's (33,949). During the three years (2005-2007), a total of 21,490 colonies were sampled within 431 primary sites representing approximately 1% of the total reef area. Coral density and coral size of common species, such as *Siderastrea siderea*, were positively correlated across all strata but disproportionately distributed. Inshore and mid-channel patch reefs representing 7 of the strata had significantly higher coral densities and size-frequency distributions were skewed towards larger sizes compared to offshore and fore reef zones and all reef zones north of Miami. Corals in these inshore zones may have coped better with stress during the 1998 and 2005 bleaching years because of the highly variable environmental conditions (temperature, visibility) that persist year round, although several other factors (intrinsic and extrinsic) are currently also being tested. The spatial framework resulting from this study gives resource managers an immediate tool to incorporate representative demographics of resistant stony coral population into zoning schemes that may improve ecosystem-wide adaptation to future climate stress.

## 12.414

**Bleaching And Resilience Of Florida Keys Coral Reefs**

**James KIDNEY*[1]**

[1]Fish & Wildlife Research Institute, Florida Fish & Wildlife Conservation Commission, Marathon, FL

Elevated seawater temperatures during the summer of 2005 caused a coral bleaching event in the Florida Keys. We surveyed 2 Hawk Channel patch reefs (DPR, WTPR) and a shallow forereef (LKFR) during August and September 2005, to assess the severity of bleaching. The patch reefs are located inshore of the forereef, in closer proximity to land, and are under greater influence by waters flowing out of Florida Bay - a body of water with greater temperature extremes and dissolved nutrients. Sampling consisted of video belt-transects. Video frames were analyzed to determine abundance and percent cover of healthy and bleached coral. There were significantly more bleached coral colonies per $m^2$ at patch reefs than at LKFR. Furthermore, all species present at WTPR showed signs of bleaching, 85% of species at DPR exhibited bleaching, but only half the species at LKFR were bleached. LKFR had the highest coral cover of the sites with 33.5% cover. Bleached coral cover was 3.2 %. In comparison, DPR had 20.3% total stony coral cover and 9.2 % bleached cover. WTPR had 19.1 % total stony coral cover, with 9.5% bleached cover. Ten percent of coral bleached at LKFR, while 46 % bleached at DPR, and 50 % of the coral cover bleached at WTPR. Bleaching was more severe at the patch reefs than at the shallow forereef. Both percent cover and the percentage of species affected were greater at the patch reefs than the forereef. Surveys in 2006 determined that percent coral cover remained unchanged at LKFR and DPR, with only a slight decrease at WTPR. Although closer to land, in areas of reduced water clarity, and greater water temperatures fluctuations, the patch reefs were equally resilient to bleaching as LKFR. Further research into mechanisms by which patch reefs respond to physical stressors is warranted.

## 12.415

**Effect Of Elevated Temperature On The Settlement Success And Early Ontogeny Of A Coral-Algal Symbiosis: A Case Study in The Brooding Coral *porites Astreoides***

Andrew BAKER[1], Paul JONES[1], **John PARKINSON*[2,3]**, Wade COOPER[1]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Marine and Atmospheric Science, University of Miami, Coral Gables, FL, [3]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami

Symbiosis flexibility in coral-algal symbiosis has been a research focus for over a decade, but the majority of studies have focused on adult corals and the potential response of their symbiont communities to different environmental conditions or disturbances. Several studies have suggested that flexibility in coral-algal symbiosis might be less common in brooding corals that transmit their symbionts maternally, compared with broadcasting corals that acquire symbionts from the environment. Here we investigated the degree to which brooding corals are capable of flexibility in early ontogeny by settling larvae and rearing them at three different temperatures (28, 30 and 32°C) and three irradiance levels (using 0, 1 and 2 layers of neutral density mesh to reduce ambient light). We collected 900 larvae in April and May 2006 from each of two adult *Porites astreoides* colonies, and introduced 100 larvae per colony to each treatment. Temperature was increased at a rate of 2°C per day to reach target temperatures. *Symbiodinium* DNA was extracted periodically from both swimming larvae and settlers, to compare with the symbionts identified from samples taken from five locations across the parent colony. Settlement success and mortality rates were tracked, and chlorophyll fluorescence properties monitored using an Imaging-PAM (Walz, GmbH). Initial settlement was highest under the high light treatment (although on the undersides of tiles), but there was no clear temperature effect. Long-term survivorship of settlers was generally poor, with <3% of larvae surviving to the 7-month stage under the experimental conditions. Symbiont identifications were hampered by poor amplification success from single larvae. We plan to repeat these experiments with larger sample sizes in late spring 2007 and combine our results with the long-term (>12 months) results from the 2006 larvae.

## 12.416

**Flicker condition reduces light-induced inhibition of photosynthesis of symbiotic algae in the reef-building coral *Acropora digitifera***

**Takashi NAKAMURA*[1,2]**, Hideo YAMASAKI[1]

[1]Faculty of Science, University of the Ryukyus, Okinawa, Japan, [2]Amakusa Mar Biol Lab, Kyushu University, Kumamoto, Japan

Reef-building corals inhabit a variety of habitats with a range of light conditions. Because the host coral depends on photosynthesis by endosymbiotic algae, reef-building corals have to cope with dynamic change in irradiance level from instantaneous to seasonal time scales. In oligotrophic coral reef environments, moving patterns of interspersed light and shadows on the substrate are prominently observed on a sunny day. The high-frequency light fluctuation, known as flicker light is produced by a lens effect of moving water surface that simultaneously focuses and diffuses sunlight in the upper few meters. Although light is essential for photosynthesis of coral symbiont, excessively strong light destroys the photosynthetic apparatus, a phenomenon referred as to photoinhibition. Because flicker light potentially produces excessively strong light as well as dimmer light, such fluctuations may have profound effects on photosynthesis of shallow inhabiting corals. We conducted experiments with the reef-building coral *Acropora digitifera*, a species dominantly found in shallow reef habitats. The effects of flicker light on endosymbiont photosynthesis were evaluated with pulse amplitude modulation (PAM) chlorophyll fluorometry. At super-saturating light intensities for photosynthesis, exposure to a flicker light condition resulted in less photoinhibition of photosynthesis compared with the ones exposed to a constant super-saturating light. Reduction in photoinhibition by flicker light was pronounced at high water temperatures. These results indicate that flicker light condition would enable endosymbiont photosynthesis to withstand a period of strong irradiance and high water temperature. We suggest that the doldrums-like condition with flat water surface can lead to severe damage to the photosynthetic apparatus of endosymbiotic algae.

## 12.417

**Atypical Coral Skeletal Morphologies Under Non-Optimal Growth Conditions: Caribbean Examples From Lagoon Reefs With High Sedimentation And Turbidity**

**Iain MACDONALD*[1,2]**

[1]Qatargas, Doha, Qatar, [2]Environmental and Geographical Sciences, Manchester Metropolitan University, Manchester, United Kingdom

This study describes unusual coral colony morphologies and skeletal adaptations that are exhibited in response to conditions of high sedimentation and turbidity. The areas investigated were Columbus Park reef and Red Buoy Patch reef, which are located within Discovery Bay, north Jamaica, and which are characterised by conditions of high turbidity and moderate to high rates of sedimentation and sediment accumulation. At these sites, framework development decreases with depth, and the sediments exhibit a progressively higher proportion of material in the mud size fraction. Coral morphological responses to these conditions included 1) the occurrence of platy corals and / or closely-tiered platy growth morphologies of corals (cf. the "show shoe effect"; Thayer, 1975), 2) skeletal evidence from *Siderastrea siderea* and *Montastraea annularis* of extreme polyp tissue retraction and subsequent rejuvenation (cf. the "phoenix effect"; Krupp et al., 1992) followed by full colony morphology regeneration (cf. the "pancake stack" morphology; Hillis and Bythell, 1998), and 3) skeletal evidence from *Agaricia lamarcki* for rapid, colony wide, vertical "catch-up" growth that reduces colony weight to volume ratios, and which may facilitate coral growth in order to catch-up or surmount local sediment accumulation. A few examples comparable to Thayer's (1974) "ice-berg effect" were also noted. These observed morphological responses to turbid and high sedimentation environments may help answer the paradox of coral survival within such apparently inhospitable nearshore environments. Furthermore these skeletal morphologies have significant potential to be preserved in the fossil record and thus have application to the detailed interpretation of palaeoenvironmental conditions and life histories at the individual coral colony level providing potential criteria for interpreting coral growth strategies within fossil coral-rich sequences.

## 12.417A

**Variation in Bleaching Susceptibility Among Color Morphs in The Reef-Building Coral *acropora Millepora*, Great Barrier Reef (Gbr)**

**Allison S PALEY*[1,2]**, Caroline V PALMER[2,3], Line K BAY[2], Bette L WILLIS[1,2], Madeleine JH VAN OPPEN[4]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]School of Biology, University of Newcastle, Newcastle Upon Tyne, United Kingdom, [4]Australian Institute of Marine Science, Townsville, Australia

Color polymorphisms, a common feature among reef-building corals, are primarily determined by the relative abundances of a suite of green fluorescent proteins (GFPs). In addition to their roles in coloration, GFPs may also modify internal light environments and play roles in reducing oxidative stress, yet little is known about the variation in bleaching sensitivity among coral color morphs. Historical data indicate that the relative abundance of three color morphs of *Acropora millepora* have changed on the GBR concomitantly with an increase in sea surface temperatures and bleaching frequency highlighting the potential role of color in bleaching sensitivity. To determine the relationships among color morph variation, relative GFP levels and bleaching sensitivity we investigated the distribution and abundance of color morphs of the common coral *A. millepora* among seasons and sites in the central GBR, and the relative fluorescence of the three known pigments (cyan, green and red). We then examined the response of the three color morphs of this species during natural and experimental bleaching events. Relative abundances of color morphs were significantly different, and although some colonies appeared to change color among seasons, the green morph had consistently lower abundance across all sites, at all times. Relative fluorescence of the three fluorescent proteins associated with *A. millepora* varied significantly among color morphs. Bleaching sensitivity was variable among colonies but not color morphs during a mild natural bleaching event, suggesting that color does not influence thermal tolerance. Because of the apparent influence of microhabitat on natural bleaching, variation in color morph sensitivity was further tested in a controlled bleaching experiment. These findings are relevant in understanding potential changes in coral populations if bleaching becomes more prevalent in the future.

## 13.418

**Dispersal Without Errors: Symmetrical Ears Tune Into The Right Frequency For Survival**

**Monica GAGLIANO*[1]**, Martial DEPCZYNSKI[2], Stephen SIMPSON[3], James MOORE[4]

[1]School of Marine Biology (AIMS@JCU), James Cook University & Australian Institute of Marine Science, Townsville, Australia, [2]School of Marine Biology, James Cook University, Townsville, Australia, [3]Institute of Evolutionary Biology, University of Edinburgh, Edinburgh, United Kingdom, [4]School of Marine Biology (AIMS@JCU), James Cook University, Townsville, Australia

Vertebrate animals localize sounds by comparing differences in the acoustic signal between the two ears, and accordingly ear structures such as the otoliths of fish are expected to develop symmetrically. Sound recently emerged as a leading candidate cue for reef fish larvae navigating from open waters back to the reef. Clearly, the integrity of the auditory organ has a direct bearing on what and how fish larvae hear. Yet, the link between otolith symmetry and effective navigation has never been investigated in fish. We tested whether otolith asymmetry influenced the ability of returning larvae to detect and successfully recruit to favourable reef habitats. Our results suggest that larvae with asymmetrical otoliths not only encountered greater difficulties in detecting suitable settlement habitats, but may suffer significantly higher rates of mortality. Further, we found that otolith asymmetries arising early in the embryonic stage were not corrected by any compensational growth mechanism during the larval stage. Because these errors persist and phenotypic selection penalises asymmetrical individuals, asymmetry is likely to play an important role in shaping wild fish populations.

## 13.419

**Corallivorous Microparasites And The Potential Of Invasion From The Marine Ornamental Trade**

**Eric BORNEMAN*[1]**

[1]Biology and Biochemistry, University of Houston, Houston, TX

In recent years, many undescribed or little-known microparasites and predators of scleractinian and non-scleractinian corals have entered the marine ornamental coral trade. Because of the high degree of success in growing corals in captivity, the trading or selling of coral fragments has become commonplace and special “coral fragment trade” events are regular local, regional, and national events. Little effort is generally made to quarantine or disinfect corals harboring pest species. Consequently, numerous coral microparasites and predators have reached epizootic levels in susceptible captive genera on a national and even global scale. These pest species can be generalists or have more specific hosts, but they are able to host on both Caribbean and Indo-Pacific species within their taxonomic dietary confines.

It is now recognized that accidental or intentional release of non-native marine ornamental species has occurred, and this is primarily well-documented in Florida waters. There have also been some incursions and invasions resulting from public aquariums and culture facilities into oceanic waters. Due to the number of known and sometimes highly cryptic microparasites and the increasing number of reports of undescribed corallivorous cryptic species entering the ornamental trade, most of which reproduce asexually or by direct development, the potential for invasion and highly detrimental effects to susceptible corals poses a new risk to coastal waters.

## 13.420

**Synthesis Of Conservation Initiatives in Cagayan Ridge, Phillippines: Lessons, Gaps And Challenge**

**Vivien FACUNLA*[1]**, Sheila VERGARA[1]

[1]Sulu Sulawesi Seascape Project, Conservation International-Philippines, Quezon City, Philippines

Cagayan Ridge is one of the corridors supported by Conservation International through its Sulu Sulawesi Seascape Project. The ridge is composed of many small islands, atolls and shoals – starting from the Sultana Shoal in the north and ending at San Miguel Islands in the south (Ledesma et al., 2005) with an estimated area of about 40,637 Km² including the world heritage site-Tubbataha Reefs Natural Park (TRNP).

CI launched its marine biodiversity program in Cagayan ridge in 2005, which aim to assist the strengthening of management implementation strategy and expansion of the TRNP. At that time, encroachment of commercial fishing vessel in the park water was seen as the large scale enforcement difficulties for the park management. In order to address these evolving threats, the project identified types of support that will directly contribute to local enforcement capacities and indirectly, by communication, training and awareness campaigns directed at particular stakeholder groups.

For two years (2006-2007), SSS project conducted collaborative research among academic institution to determine the ichthyoplankton and oceanographic connectivity and recruitment pattern within MBCC to provide science-based in designing MPA. The project studied the economic valuation of coral reefs destruction and wildlife disturbance in TRNP from boat grounding to identify the monetary values and provide basis for the computation of fines/penalties for the level of violation committed in the park. Linkages and coordination with stakeholder was also done through consultation and meetings.

The information generated from these studies were feed backed to the stakeholders. Using participatory approach, the feed backing session resulted towards identification of priorities and provided basis for the continuity of the conservation effort being implemented in the Cagayan Ridge.

## 13.422

**Evolution Of Anemonefishes (Amphiprioninae, Pomacentridae): Species Boundaries in The Indo-Malay Archipelago**

**Janne TIMM*[1]**, Malgorzata FIGIEL[2], Marc KOCHZIUS[2]

[1]Biotechnology and Molecular Genetics, University of Bremen, Bremen, Germany, [2]Biotechnology and Molecular Genetics, University of Bremen, 28359 Bremen, Germany

Many species of coral reef fishes are distinguished by their colour patterns, but genetic studies have shown these are not always good predictors of genetic isolation and species boundaries. The genus Amphiprion comprises several species that have very similar colouration. Additionally, morphological characters are so variable, that sibling species can show a considerable overlap, making it difficult to differentiate them. In this study, we investigated the species boundaries between the sibling species pair A. ocellaris and A. percula and three closely related species of the subgenus Phalerebus (A. akallopisos, A. perideraion, A. sandaracinos) by phylogenetic analysis of mitochondrial control region sequences. Within the A. ocellaris/A. percula complex, five clades were found representing different geographic regions. Two major divergences both with genetic distances of around 17 % indicate the presence of three deep evolutionary lineages in this group. The species of the subgenus Phalerebus show three monophyletic clades, concordant to the morphological classification.

## 13.423

**The Origins And Fate Of Reef Island Sediments**

**Deirdre HART*[1]**

[1]Department of Geography, University of Canterbury, Christchurch, New Zealand

Low coral reef islands are constructed almost entirely of biogenic reef sediments originating primarily from surrounding reef platform ecosystems. Beaches comprise the interface between reef ecosystems and islands through which the latter are nourished, built or eroded. This research characterises functional relationships between island-beach sediments and reef-flat sources on Warraber Reef, an intertidal reef platform system in central Torres Strait, Australia.

The origins and transport pathways of beach-nourishing sediments were examined using (a) an array of wave gauges, current meters and sediment traps, (b) ecological and geomorphic surveys, and (c) textural, compositional and dating analyses of 218 samples of surface sediment.

Overall, reef flat sediments (moderately-sorted fine sands to gravels of mollusc/coralline algae/coral origin) were found to differ greatly in composition and texture from those of the island beach (mollusc-dominated moderately to very-well sorted coarse sands). Ecologic, hydrodynamic and sediment patterns reveal the mollusc and algae covered sand flats of the emergent, inner, windward reef flat as the dominant contemporary source of beach nourishing sediment. In contrast, the deeper, more-distant and leeward reef-flat zones were found to be isolated from the modern island deposit. These sediment relationships occurred despite the order of magnitude greater carbonate productivity, more-frequent submergence, and more-energetic wave environment of the latter areas but in line with reef flat sediment transport directions and the proportionately-greater sediment particle production rates of organisms living in the windward, near-island zones.

Findings reveal the sediment system of this large reef platform to be strongly compartmentalised such that the contemporary maintenance and growth of the island depends on organisms and processes operating within a small physiographic and ecological sector of the surrounding reef flat. Any change in physical conditions across the reef flat is forecast to produce major adjustments in the amount, type, and supply rates of island nourishing sediment.

## 13.424

**Recruitment Dynamics Of The Three-Spot Damselfish, Dascyllus Trimaculatus, in Moorea, French Polynesia**

**Ricardo BELDADE*[1]**, Sally HOLBROOK[2], Russell SCHMITT[2], Giacomo BERNARDI[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]Ecology, Evolution & Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

The three-spot damselfish, Dascyllus trimaculatus, is a coral reef species that spawns benthic eggs. After hatching, larvae remain in the water column for about 26 days and then recruit back on anemones. After growing to a size large enough to escape predation, the fish leave the anemone after a few months to live a demersal adult life. In order to study the recruitment dynamics of this species, we have placed two rows, of 8 anemones each. Anemones were 10 meters apart; the two rows were 100 meters apart. The two rows were parallel to shore and to the barrier reef, within the lagoon of Moorea, French Polynesia. The crest row was 50m from the barrier reef, and the channel row was 100m downstream from the crest row. Every morning the new incoming recruits were collected. Through genetic typing, a single nucleotide polymorphism (SNP) showed that the fishes from the two rows are genetically distinct (chi-square $p<0.01$): 3% of the individuals in the channel row and 6% of the individuals in the crest row carried a unique mutation called OC3. DNA sequences of the mitochondrial control region have been shown to be extremely variable in Dascyllus trimaculatus, with nearly each adult individual carrying a unique haplotype. In this study we also found identical haplotypes for several recruits that settled into the same anemone on the same day, strongly suggesting the presence of self-recruitment.

## 13.425

**Population Connectivity Of The Gulf Coney, Epinephelus Acanthistius, in The Northern Sea Of Cortez**

**Ricardo BELDADE*[1]**, Pete RAIMONDI[1], Richard CUDNEY[2], Giacomo BERNARDI[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA, [2]School of Natural Resources, University of Arizona, Tucson, AZ

The gulf coney, Epinephelus acanthistius occurs from Mexico to Peru. In the northern Sea of Cortez, from San Francisquito to the Colorado river delta, this species has been heavily fished. Connectivity between populations is nowadays recognized as a fundamental tool in spatially explicit management. To assess population structure in the northern Gulf, we sampled five locations (Puerto Lobos, Puerto Libertad, Santo Tomas, San Luiz Gonzaga, Puerto Penasco), by clipping fins of fishes obtained by local fishermen. DNA sequencing of mitochondrial (D-loop) and nuclear markers (S7) was performed. A significant number of individuals turned out to be different species, underscoring the difficulty of positively identifying this species in the field. Analyses of sequences from over 200 Epinephelus acanthistius samples showed surprisingly low levels of overall gene flow. Considering the relatively small geographic region investigated, we discuss the ecological underpinnings of our results and the potential implications for the management of the gulf coney fishery.

## 13.426

**Hybridization Dynamics in A Threatened Caribbean Coral Genus, *acropora***

**Nicole FOGARTY*[1]**

[1]Department of Biological Science, Florida State University, Tallahassee, FL

Caribbean acroporids, *Acropora palmata* and *A. cervicornis*, have experienced dramatic declines since the 1970s and are listed as threatened under the Endangered Species Act. These species form a hybrid, *A. prolifera,* which was not given protective status but its ecological and evolutionary roles may influence the fate of this reef-building genus (e.g., by spatial competition or genetic swamping through introgression). Throughout the Caribbean hybrids vary in abundance with no clear geographic pattern. This study will determine if this variation occurs as a result of differences in the strength of reproductive isolating barriers, variation in success of asexual fragmentation, or differential fitness of hybrids. Observations of overlapping spawning times and no statistical difference in conspecific and heterospecific no-choice crosses suggested a lack of isolating barriers; however, further investigation with choice crosses revealed conspecific sperm precedence (CSP). CSP is only effective when conspecific and heterospecific sperm collide with an egg simultaneously; therefore, the decline in the parental species may lead to increased hybridization. Hybrid ramet abundance varied across sites; however, this was a poor indicator of hybrid genetic diversity. Hybrids were often found in extremely shallow habitats where disturbances generated fragments and encouraged asexual propagation. Hybrids persisted in this habitat by fast reattachment rates and their ability to withstand thermal and irradiant stress, possibly as a result of a unique clade of zooxanthellae found in some hybrids. The prevalence of the typical afflictions that plague acroporids (e.g., bleaching, disease, parasitism, and predation) was comparable in the parental species and hybrid. Even if subtle costs to hybridization exist, increases in hybrid offspring production in the absence of competing conspecific sperm, may result in and select for increased introgression. Decreases in parental species' abundance might increase introgression and the likelihood of reticulate evolution or adaptive evolution, both of which have important conservation implications.

## 13.427

**Genetic Links Between Adult Size And Larval Quality in A Coral-Reef Fish**

**Darren JOHNSON*[1]**, Flower MOYE[1], Mark CHRISTIE[1], Mark HIXON[1]

[1]Zoology, Oregon State University, Corvallis, OR

Wild populations of fish may evolve in response to direct selection on traits such as adult size and growth rate. However, some traits may evolve indirectly through genetic correlations with traits that are under direct selection. We evaluated the degree to which traits that affect the survival of larval fish (size at hatching and swimming performance) may evolve in response to selection on adult size in bicolor damselfish (*Stegastes partitus*) in the Bahamas. To estimate the genetic covariance between adult size and larval quality, we combined mark-recapture demographic studies with quantitative genetic analyses. Using standard quantitative genetic methods, we compared the asymptotic size of adult males to the size and swimming performance of their larval offspring. Results from both natural breeding and a cross-fostering experiment (demersal eggs reared by either fathers or non-fathers) indicated that size of the male parent was strongly and positively correlated with both the size and swimming performance of larval offspring. Based on this information, we could predict how quickly larval quality may change in response to selection on adult size. For example, removing the largest 10% of adults would reduce average larval size by 0.107 SD per generation. Such a change is estimated to reduce the relative rate of post-settlement survival by 6% in one generation. Because the dynamics of many fish populations are sensitive to changes in survival of early life history stages, these results suggest that even moderate rates of selection on adult size can have substantial consequences for population viability.

## 13.428

**Application Of The Neutral Theory To Reef Fish Trophic Groups**

**Elizabeth H. M. TYLER*[1]**, Andrea MANICA[1]

[1]Department of Zoology, University of Cambridge, Cambridge, United Kingdom

One of the key questions in ecology is what controls community structure and biodiversity. The Unified Neutral Theory of Biodiversity (UNTB) proposes a simple model in which community structure is the result of stochastic processes with all species behaving in an identical manner. The theory has sparked controversy, with most effort being devoted to testing whether a few communities (most notably trees and corals) follow a neutral dynamic. We take a novel step forward by comparing how several communities from the same taxon vary in their fundamental characteristics (i.e. speciation rate and migration) according to the neutral theory. Coral reef fish provide an ideal study system, as they allow the comparison of several communities (different trophic groups) within one taxon, that only obviously differ in the type of resources (food) they use. We sampled the relative abundance of all fish species at three islands in the Lizard Island Group, Great Barrier Reef, using four sites per island and 16 samples per site (n = 192). We divided species into trophic groups based on the relative dominance of different components in their diet from published sources. We estimated values of $\theta$ (speciation rate) and $\nu$ (migration rate) for each community. Speciation rate changed systematically with trophic level, with higher speciation rates at lower trophic levels. Migration rates, on the other hand, were relatively similar across communities, as we might expect from communities from the same taxon. Overall, our results imply that trophic groups differ in their community structuring rules. Understanding the intrinsic ecological and evolutionary processes governing trophic groups could help to predict their response to perturbation. This may allow conservation actions to be targeted to specific trophic groups for the management of coral reef health.

## 13.429

**The Introduction of Lutjanus kasmira to the Hawaiian Islands: Using genetics to investigate an invasion**

**Michelle GAITHER*[1]**, Serge PLANES[2], Rob TOONEN[1], Ross ROBERTSON[3], John CHOAT[4], Vanessa MESSMER[2], Brian BOWEN[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]University of Perpignan, Perpignan, France, [3]Smithsonian Tropical Research Institute, Washington DC, DC, [4]James Cook University, Townsville, Australia

Here we use molecular techniques to characterize the introduction of the blue-lined snapper *Lutjanus kasmira* (Lutjanidae) to the Hawaiian Islands. *L. kasmira* inhabits coral reefs throughout the Pacific and Indian Oceans; however, it is not native to the Hawaiian archipelago. In the 1950's the Hawaii Division of Fish and Game introduced a total of 3,163 *L. kasmira* from Moorea and the Marquesas Islands to the Hawaiian Island of Oahu. Following their introduction, *L. kasmira* quickly spread throughout the archipelago at a rate of approximately 60 km/year. Analysis of mitochondrial cytochrome *b* and 2 nuclear introns have shown little genetic structure across the Indo-Pacific range with the exception of the Marquesas Islands. This population is highly divergent from the rest of the Pacific and Indian Ocean populations. When comparing the two source populations we observe a 5.5% divergence in the mitochondrial control region and strong population structure in the nuclear genome (Fst = 0.49). Based on the high level of genetic divergence between the two source populations we have demonstrated that descendents of fish from both Moorea and the Marquesas are present throughout the archipelago and have colonized with seemingly equal success. We found no indication of a loss of genetic diversity either during the initial introduction or during the subsequent spread and establishment of this species.

## 13.430

**Communities And Nature Bond – "adopt The Coral" in Les Village, Bali-Indonesia**

**Fransiska PRIHADI*[1]**, Cipto Aji GUNAWAN[2]

[1]Adopt the Coral, Denpasar, Indonesia, [2]Adopt the Coral, Sanur, Indonesia

When the term community is used, the first thing that usually comes to mind is a place in which people know and care for one another. The word community it self means a mixture of living things that share an environment. The individual living beings can be plant or animal; any species; any size. Sharing interaction in various ways is the character of a community. The best force of community is that all individual subjects in the mix have something in common.

"Adopt the Coral" is a community based strategy for coral conservation. The main goal is to encourage the main idea of Taking Care environment and have more direct people's involvement (fisherman, supporters/adopters).

It allows individuals to adopt coral by contributing an initial adoption and annual fee. Adopters are given coral image reports to monitor the growth of the corals four times a year. The coral transplantation method was chosen amongst other available method (example: Reef balls) because it is easier and require no advance technology. This method also involve a lot of people in the process, therefore it support community empowerment and provide alternative livelihood.

The program started first in Les Village, Bali since 2005. It is now run by an independent team collaborating with Mina Bhakti Soansari fishermen group that coordinate and conduct the Coral Transplantation - Maintenance process.

"Adopt the Coral" becomes a foundation for other positive development which is:

- environment rehabilitation
- other livelihood resource: ornamental fish
- underwater tourism potential

In this paper we provide "Adopt the Coral" initiative as a tool in mass advocating to reduce activities that will damage corals. This strategy will give more time for coral to recover naturally.

## 13.431

**Ancestral Foundations and Geomorphology in Conserving Habitats and Communities of the Ningaloo Reef, Western Australia**

**Emily TWIGGS*[1]**, Lindsay COLLINS[1]

[1]Applied Geology, Curtin University of Technology, Perth, Australia

Ningaloo Reef is the fifth in a series of shoreline reef platforms developed as a response to tectonics and sea-level fluctuations. This research aims to characterise the growth history, geomorphology and surficial sediments of the reef and identify evolutionary characteristics relevant to the maintenance of marine biodiversity and conservation. Coring, coastal outcrop interpretation and shallow seismic lines provide the data on antecedent foundations and reef growth. GIS mapping using aerial and acoustic remote sensing alongside groundtruthing techniques have been used to characterise geomorphic zonation, 3D structure and benthic habitat distribution.

A number of geological foundations played a major role in the establishment of Holocene reef development (7.57 ka). These foundations are the primary physical controls on present reef morphology and benthic habitat distribution, and include the Last Interglacial reef (125 ka) and alluvial fans. The Last Interglacial reef was developed during a period of higher sea-level and is expressed as the Tantabiddi terrace, coastal scarps and rock platforms. Alluvial fans composed of carbonate gravels encroached onto the shelf during periods of lower sea-levels and today form part of the modern reef system. Coral, encrusting coralline algae and macroalgae communities thrive in geomorphic zones of the back-reef. Ancestral karst has created distinct collapse structures within the reef framework influencing community composition. On the shallow fore-reef slope there is a thin veneer of coralgal growth on multiple backstepping spur and groove systems. Hard corals are rapidly replaced by rhodolith beds at the transition from the lower slope-inner shelf, which provide the substrate for deeper-water sessile benthic communities. On the open mid-outer shelf, sediment plains are interrupted by karstified ridge systems, drowned reefs and paleo-shorelines colonised by sponges, gorgonians and bryozoans. An understanding of reef evolution and the strong spatial relationships between ancestral foundations, geomorphology and contemporary ecology is essential for the ongoing conservation of the Ningaloo Reef.

## 14.432

**Gene flow of *Symbiodinium* on the Great Barrier Reef is limited and primarily mediated by sea circulation patterns**

**Emily HOWELLS*[1]**, Madeleine VAN OPPEN[2], Bette WILLIS[1]

[1]Australian Research Council Centre of Excellence and School of Marine and Tropical Biology, James Cook University, Townsville, QLD, Australia, [2]Australian Institute of Marine Science, Townsville, QLD, Australia

The resilience of *Symbiodinium* types harboured by corals depends on population genetic diversity and inter-reef connectivity. This study presents genetic analyses of Great Barrier Reef (GBR) populations of clade C *Symbiodinium* hosted by the alcyonacean coral, *Sinularia flexibilis*. Allelic variation at 4 microsatellite loci demonstrated that 12 reef populations of *Symbiodinium* were genetically differentiated at spatial scales from 16 to 1,300 km (mean pairwise ΦST = 0.21). For 11 of 12 populations, genetic differentiation was strongly related to geographic distance between populations ($r$ = 0.77), indicating that gene flow is restricted for *Symbiodinium* hosted by *S.flexibilis* on the GBR. Patterns of population structure reflect longshore circulation and limited cross-shelf mixing on the GBR, suggesting that passive transport by currents is the primary mechanism by which low levels of dispersal occur in *Symbiodinium* types acquired horizontally. Genetic diversity of *Symbiodinium* populations was on average 1.5 to 2 times higher at mid to outer shelf reefs than on inner-shelf reefs. Patterns of genetic diversity were consistent with immigration of *Symbiodinium* genotypes to the northern GBR which have been spread to mid and outer shelf reefs via longshore currents. Additional factors that may have shaped cross-shelf differences in diversity are historical sea-level fluctuations and recent bleaching events. *Symbiodinium* populations hosted by *S.flexibilis* are suggested to be susceptible to losses of genetic diversity, such as those likely to occur with increased threats to coral reefs. There is little opportunity for lost genetic diversity to be replenished by migration or for beneficial alleles potentially involved in adaptive processes to be spread beyond local reefs.

## 14.433

**Testing Natural Markers in Otoliths From Known-Origin Larvae Of Coral Reef Fish**

**Michael BERUMEN*[1]**, Harvey WALSH[1], Serge PLANES[2], Geoffrey JONES[3], Simon THORROLD[1]

[1]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA, [2]Ecole Pratique des Hautes Etudes, Université de Perpignan, Perpignan, France, [3]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

Analysing the chemical composition of otoliths from fish is a commonly employed technique to search for a signal indicative of a particular habitat at some point in a fish's environmental history. In connectivity studies, this method frequently runs into a problem as the origin of most larval fish is unknown, reducing the ability of the technique to definitively identify a source location among locations with subtle water mass differences. Following an intensive self-recruitment study on an isolated island in Kimbe Bay, Papua New Guinea, genetic parentage analysis (genotyping) confirmed the origin of about 50% of 110 new recruits of the orange clownfish, *Amphiprion percula,* on Kimbe Island. Known-origin larvae were those confirmed to have been spawned by parents on Kimbe Island, while the remainder would have been spawned by parents on other reefs (with the nearest reef ~10km away). Using standard otolith composition analyses (laser ablation inductively coupled mass spectrometry, LA-ICPMS), we were able to compare the known-origin (self-recruiting) larvae against those known to have originated from reefs at least 10km away, testing for differences in elemental composition of their otoliths. We will discuss these findings and the implications for future studies attempting to use natural markers in studies of connectivity in coral reef fish populations.

## 14.434

**Temporal Variations of Mangroves, Soft Bottoms and Coral Reefs Shorefishes Assemblages within a Lagoon Seascape, New Caledonia**

**Laurent WANTIEZ*[1]**, Michel KULBICKI[2]

[1]University of New Caledonia, Noumea, New Caledonia, [2]IRD, Perpignan, France

The shorefishes of St Vincent Bay (New Caledonia) were studied on a monthly basis during one year in three adjacent habitats: coral reefs, mangroves and soft bottoms. The objectives were to analyze the overlap and compare the temporal variations of the fish communities between the three habitats. Coral reefs were sampled using visual census, mangroves using gill nets and fyke net, and soft bottoms using a shrimp trawl and a fish trawl. In total, 485 species were censused in all three habitats. The species richness was significantly higher on coral reefs (300 species) than on soft bottoms (200 species) and in the mangroves (126 species). The number of families was not significantly different between habitats. Only 16 species and 19 families were observed in all three habitats. The species overlap was higher for mangroves, which shared 61.9% of its species with the other habitats, than soft bottoms (50.0%) and coral reefs (29.3%). The similarity (Kulczinski Index) was higher between mangroves and soft bottoms ($I_k$=34.3%) than between soft bottoms and coral reefs ($I_k$=23.1%), mangroves and coral reefs being the most different ($I_k$=16.7%). The monthly variations of the species richness were significantly different between habitats and the monthly variations of the standardized density and biomass indices were not correlated, indicating different temporal patterns between habitats. The monthly variations of the number of overlapping species between habitats were not significant. Only four species were successively present as juveniles in the mangroves and as adults on the soft bottoms. Our results suggest that the links between the coral reefs and the mangroves, and to a lower extend the coral reefs and the soft bottoms, are limited and lower than in the Caribbean.

## 14.435

**Are Montastraea Faveolata Populations Connected Along The Mesoamerican Barrier Reef System?**

**Isabel PORTO*[1]**, Camilo SALAZAR[2], Tonya SHEARER[3]

[1]Department of Biology, Universidad de los Andes, Bogota, Colombia, [2]Department of Biology, Genetics Institute, Universidad de los Andes, Bogota, Colombia, [3]School of Biology, Georgia Institute of Technology, Atlanta, GA

For benthic sessile coral reef dwellers, the larval stage is very important for dispersal. There has been controversy between larval retention versus long distance dispersal as the main life history strategy for marine organisms. There is limited information concerning coral reef larvae dispersal in the Caribbean where coral reefs are widespread and sustain a huge diversity of marine organisms. Understanding levels of biological connectivity between and among reefs has important ecological and management implications. It is necessary to determine the potential resources of reef recruits in order to successfully create Marine Protected Areas (MPA) and assess the efficacy of already established MPAs. Montastraea faveolata has widespread distribution on Caribbean reefs and is considered one of the major reef-builders in the area. Using eight variable microsatellite loci, the population structure of M. faveolata was discerned to answer the following questions with regard to the Mesoamerican Barrier Reef System: What is the biological connectivity among M. faveolata over time and space? Have larvae sources or patterns of connectivity changed over time? Are M. faveolata generally self-seeding or dependent on non-local larval source populations? Locations included in this analysis are Mexico (Puerto Morelos and Cozumel), Belize (Glover's reef, Columbus reef, Turneffe and Ambergris), Guatemala (Punta Manabique) and Honduras (Cayo Cochinos, Roatan and Bahia Cortes).

## 14.436

**Zoanthid Connectivity At Different Spatial Scales**

**Alberto ACOSTA*[1]**, Natalia MANRIQUE[2], Maria VARELA[2], Manuel RUIZ[1]

[1]Biology, Pontificia Universidad Javeriana, Bogotá, Colombia, [2]Pontificia Universidad Javeriana, Bogotá, Colombia

Successful conservation, management and restoration strategies require knowledge about the spatial scale of coral reefs connectivity. This is particularly important for species that share similar life histories, and where dispersal is greatly influenced by physical factors (e.g. currents and rivers). For these reasons the gene flow among four populations of the zoantharian *Palythoa caribaeorum* was estimated at local (~100Km) and regional scale (~700Km). The study was conducted in two regions, oceanic (San Andres and Providencia locations, 94Km apart) and continental island (Grande and Fuerte, influenced by large rivers) locations, in the Colombian Caribbean. These regions (aprox. 715Km apart) are located within the Panama-Colombian gyre sub-region, and are considered to be largely isolated from the rest of the eastern and western Caribbean. ITS2-rDNA sequences (138pb) were used to assess diversity, genetic structure, isolation by distance, and connectivity. The population′s results indicated high genetic diversity (ΠIJC=0.0345), absence of genetic structure and no isolation by distance. However, slight differentiation among San Andres and other populations was detected (FST=0.0626; p<0.01). This could be explained by an excess of clones in the San Andres population, or a higher probability to receive larvae from nearby islands (larvae importation). Moderate to high values of gene flow (Nm=3.7-6.8) were detected at both spatial scales. Strong currents (Panama-Colombia Gyre) during the spawning season (May-June) may carry larvae between the four connected reefs, in a bidirectional manner. Due to the cyclonic and anticyclonic eddies acting in the Southern Colombian Basin, Colombian reef populations could act as an important source of larvae for the western Caribbean. Future management strategies should consider the high connectivity found in this annual broadcaster species, and additional research should be conducted to explain why the genetic flow seems to not be limited by the influence of larger rivers.

## 14.438

**Using Species Assemblages to Define Reef Fish Populations in the Bohol Sea, Central Philippines**

**Brian STOCKWELL*[1]**

[1]Silliman University Angleo King Center for Research and Environmental Management (SUAKCREM), Dumaguete City, Philippines

No-take marine reserves have been shown to be valuable fishery management tools especially for hard to manage multiple-species fisheries typical of coral reefs. Knowledge gaps pertaining to connectivity and population boundaries are the main cause of the inappropriate placement of MPAs. The species assemblages encountered on a reef are the product of both larval supply and survival resulting in successful connectivity, thus reefs with similar assemblages may represent a population connected through larval supply. The specific goals were to, compare species assemblages at the regional level in the Philippines (500km), to compare species assemblages at the local/site level within the Bohol Sea to determine fine (100 km) cluster and compare clusters with population genetic studies in the area. Surveys were conducted on 44 reefs throughout the Philippines wherein species from four families (Chaetodontidae, Pomacathidae, Pomacentridae, and Labridae,) comprising 303 species were analyzed using a Hierarchical Cluster Analysis and Principal Components Analysis (PCA) bi-plots. The analysis indicated that the Bohol Sea had a distinct species assemblage from other sites in the Philippines. Within in the Bohol Sea three distinct clusters were shown to occur in the west, central, and eastern portions. Species assemblage clusters coincided with clusters determined by previous genetic and current modeling projects in the area. Populations of reef fish at this scale is much smaller than assumed in the past, however recent studies are highlighting the prevalence of larval retention. Management therefore needs to focus more locally than regionally to successfully protect coral-reef fishery resources.

## 14.439

**Genetic Connectivity Of Coral Reef Fish Populations In The Red Sea**

**Tawfiq FROUKH*[1]**, Marc KOCHZIUS[2]

[1]Biotechnology, Faculty of Agricultural Technology, Al-Balga Applied University, Salt, Jordan, [2]Biotechnology and Molecular Genetic, University of Bremen, Bremen, Germany

The study aimed to reveal the genetic population structure and the demographic connectivity of the cleaner wrasse *Larabicus quadrilineatus* (endemic in the Red Sea and Gulf of Aden), the blue green chromis *Chromis viridis*, and the sea goldie *Pseudanthias squamipinnis* in the Red Sea. Fish samples were obtained from five locations in the Red Sea. Partial sequences of the mitochondrial control region were used as a molecular marker. The study showed dissimilar genetic structure in these fishes throughout the same basin. While panmixing was revealed for *C. viridis*, significant genetic structure was disclosed for *P. squamipinnis* (between the Red Sea proper and the Gulf of Aqaba) and *L. quadrilineatus* (between northern and central/southern Red Sea). Different ecological and oceanographic factors seem to play a role in shaping the genetic population structure of theses species. The ecological differences between northern and southern Red Sea, such as increase of turbidity and decrease of coral variety and reef development in the south, which led to differences in fish communities at about 20 N°, was only congruent to the genetic differentiation between northern and southern populations of *L. quadrilineatus*. The circulation pattern and the water exchange between the Gulf of Aqaba and northern Red Sea drive only the genetic structure for *P. squamipinnis*. The geographic distance was only a factor for the genetic structure in *L. quadrilineatus*. The studied fishes showed that their population size was reduced, most probably as a consequence of the worse ecological conditions in the Red Sea during sea-level low stands. The data on *P. squamipinnis* give signatures supporting the hypothesis that part of the Red Sea fauna survived during the Pleistocene.

## 14.440

**Twenty years of measured exposure. The duration and extent of anthropogenically polluted plume waters and consequences for the Great Barrier Reef, Australia.**

**Michelle DEVLIN*[1]**, Jon BRODIE[1], Mirjam MAUGHAN[1]

[1]Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, Australia

This paper presents a historic assessment of river plume waters in the Great Barrier Reef, Australia, identifying areas most likely to be impacted by anthropogenic materials discharging in high flow (flood) events. A suite of tools were employed to identify risk areas of exposure to nutrient enriched plume waters, including aerial surveillance, satellite remote sensing and targeted water sampling during and after key events. Areas adjacent to high intensity landuse, such as cane farming, and receiving annual episodic inputs from rivers in high rainfall regions (e.g. wet tropics) were identified as being most at risk from exposure to enriched plume waters. Areas adjacent to and north of the larger dry tropics rivers were also found to be at some risk from enriched waters during the larger, less frequent river discharge events. Areas adjacent and north of the low intensity landuse areas, with low population and limited agriculture were found to be at lowest risk from exposure to enriched and polluted waters.

Information was integrated into a1-d model consisting of the river water loads and concentrations, the frequency and volume of flow and mapping of the extent and direction of riverine plumes discharging into GBR waters. From the outputs of the model, a risk area map was constructed for ecosystems within the Great Barrier Reef, identifying a high risk region located between Cooktown and Mackay.

## 14.441

**Population Genetics Of Spotted Seahorses (*hippocampus Kuda*) in Thai Waters**

**Thadsin PANITHANARAK*[1]**, Ratima KARUWANCHAROEN[1], Uthairat NA-NAKORN[2], Thuy NGUYEN[3]

[1]Institute of Marine Science, Burapha University, Chonburi, Thailand, [2]Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand, [3]Network of Aquaculture Centers in Asia-Pacific, Bangkok, Thailand

Population genetics of spotted seahorse (*Hippocampus kuda*) was studied in order to investigate genetic diversity, level of genetic differentiation and evolution of the species in Thai waters derived from the analysis of mtDNA control region. The study was also carried out to identify the populations of Thai waters for effective conservation and management of this vulnerable coral reef species. The spotted seahorses were collected from four populations of Eastern and Western Coast of the Gulf of Thailand and one population of the Andaman Sea (101 individuals collected). Of all mtDNA sequences analyzed (353 bp), seven haplotypes were found. Five haplotypes were observed and shared between Eastern and Western Coast of the Gulf of Thailand while the others were found only in the Andaman Sea with 13-17 nucleotide differences compared to the formers. Genetic differentiation was observed in pairs of their populations (*F*ST *P*-value < 0.0001) in consistent with high percentage of genetic variance observed between two groups of the populations (95.56%) using the analysis of molecular variance (AMOVA). Neighbour-joining trees showing relationship among seahorses from Thai waters and other regions suggested that populations of the Gulf of Thailand and the Andaman Sea were phylogenetically different and placed in separated evolutionary groups. The populations of the Gulf of Thailand had a close relationship with populations of the Pacific Ocean (Philippines, Taiwan and Fiji, 84% bootstrap support). In contrast, the population of the Andaman Sea was grouped with populations from the Indian Ocean and closely related with populations of Indonesia. All results indicated that populations from the Gulf of Thailand and the Andaman Sea should be treated as separate conservation units. However, more specimens would be needed to confirm the differentiation between the populations, especially, the specimens from the Andaman Sea.

## 14.442

**Population Genetic Study Of *acropora Digitifera* Using Microsatellite Markers in Sekisei Reef**

**Yuichi NAKAJIMA*[1]**, Akira NISHIKAWA[2], Kazuhiko SAKAI[1]

[1]University of the Ryukyus, Motobu-cho, Japan, [2]James Cook University, Townsville, Australia

For understanding maintenance and recovery mechanism of coral populations, it is essential to elucidate the genetic connectivity among the local populations. In Sekisei Reef that is the largest coral reef in Japan, K. Nadaoka (in a report by Ministry of Environment of Japan) estimated dispersal range of coral larvae from several local populations by a computer simulation of seawater flow, and suggested that larval dispersal of broadcast spawning corals may be limited among local populations in Sekisei Reef. We examined the possibility suggested by K. Nadaoka by estimating gene flow of *Acropora digitifera* among local populations in Sekisei Reef.

We selected six sites in Sekisei Reef, and collected small flagments of *A. digitifera* at each site. Distances between sites were ranged from 6 to 25km. We used six microsatellite markers for analyzing genetic difference among colonies. Our results indicated that genetic differentiation of *A. digitifera* populations was very small in Sekisei Reef. FST values among sites were ranged from 0.05 to 0.012. These values are much lower than those reported for *Seriatopora hystrix* in Western Australia using microsatellite markers; FST values were ranged from 0.045 to 0.187 in 3 to 23km spatial scales in *S. hystrix*. This difference may be due to difference in mode of reproduction between the two species; *A. digitifera* is a broadcast spawning coral and *S. hystrix* is a planula brooding coral. If disturbance of coral communities occur patchily in several km spatial scale, recovery of broadcast spawning coral populations such as *A. digitifera* at disturbed reefs will be faster than that of brooding coral populations such as *S. hystrix*.

## 14.443

**Coral Recruits To Settlement Plates At Remote Locations Throughout The U.s. Pacific**

**Jean KENYON*[1]**

[1]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI

The world-wide decline of coral reefs necessitates improved understanding of their intrinsic capabilities for replenishment. The capacity of scleractinian corals to maintain or renew genetically diverse populations through sexual reproduction is a key attribute of reef resilience. Documenting the density, taxon, and size of coral recruits to settlement plates during known time intervals is a widely used method of quantifying coral recruitment. Four deployments of arrays of terra cotta settlement plates were made at six locations in the Northwestern Hawaiian Islands at annual or biennial intervals between 2001 and 2006. Similar arrays were deployed at four additional locations in the U.S. Pacific (Baker, Rose Atoll, Palmyra, Kingman) for two consecutive, two-year periods, and a single deployment of two years' duration was made at Jarvis and at Swains, American Samoa. Most locations with multiple deployments showed substantial temporal variability in the density of coral recruits. In the Northwestern Hawaiian Islands, lowest average recruitment rates (9.0-11.3 recruits/m2/yr) were found at Midway and Pearl and Hermes Atoll, respectively, and highest average rates were found at Maro (332.2 recruits/m2/yr). The taxonomic composition of the recruits (96.2% Pocilloporidae, 2.7% Acroporidae, 1.1% Poritidae) did not reflect the composition of mature coral communities, where the genus *Porites* dominates in all locations. No recruits were found at Rose Atoll or at Swains, though arrays were emplaced in coral-rich habitats. Annual rates at the other four near-equatorial locations ranged from 3.3 to 4.7 recruits/m2/yr. The taxonomic composition of the recruits similarly was disharmonic with the composition of the mature coral communities at these locations. The largest recruits were found at Baker (*Pocillopora*, 5.5 cm) and Kingman (*Acropora*, 5.2 cm), but most recruits measured less than 2.5 mm. These results reveal the need for further study of coral reproductive and recruitment processes in these remote areas, where little data exist.

## 14.444

**Variation in Spatial And Temporal Coral Recruitment Patterns On Fijian Reefs**

**Norman QUINN*[1]**, Barbara KOJIS[2]

[1]St Croix East End Marine Park, Frederiksted, Virgin Islands (U.S.), [2]University of the Virgin Islands, St Thomas, Virgin Islands (U.S.)

Community structure and recruitment patterns of scleractinian and milleporan corals were investigated at Suva Harbour, Great Astrolabe Reef, and Taveuni in Fiji. Seventy five coral species were recorded surveys with percentage coral cover ranging from 8% in polluted Suva Harbour to 26% at Great Astrolabe Reef. Acroporids were the most dominant genus. The density of coral recruits ranged from a mean of 20 to 1845 recruits m2. The lowest recruitment rate occurred at Suva Harbour while the highest recruitment occurred on a reef periodically disturbed by high rates of sedimentation. Larval settlement was >7 times greater in the "summer" than the "winter". The recruitment rate was greater than rate in the Mariana Islands in the western Pacific, but lower than the highest settlement rates observed on the Great Barrier Reef. The highest recorded recruitment rate in the Caribbean Sea is less than 1/3 of the settlement observed in the best site in Fiji. The greatest variation in recruitment rates between sites occurred within the Acroporidae. Recruits of the Pocilloporidae, Poritidae, Faviidae and other species preferred settling in deeper water while Acroporidae preferred settling in shallow waters. The high acroporid recruitment rate was probably related to the high frequency of occurrence of the family. The high levels of recruitment of *Acropora* planulae in Fiji contrasts with the paucity of *Acropora* recruitment in the Caribbean. This high recruitment rate of an important shallow water coral family results in a greater resilience to natural disasters.

## 14.445

**The Swimming Ability And Behaviour Of Coral Larval: How These Affect Retention And Dispersion?**

**Valeria PIZARRO*[1]**, Jeremy C. THOMASON[2]

[1]Universidad de Bogota Jorge Tadeo Lozano, Bogotá, D.C., Colombia, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom

In general, marine larvae have a free-swimming phase before settling. This phase could be playing an important role on retention, dispersion, and connectivity between populations between others. Until recently, it was thought that coral larvae swimming capabilities were so poor that currents advected them as passive particles. Nowadays it is accepted that coral larvae can control their position in the water column avoiding advection. This study aims to describe Montastraea annularis and M. faveolata larvae swimming capabilities and changes in swimming behaviour with age, and how these could affect retention and/or dispersion from parental reefs. Coral larvae observations were made following Stake and Sammarco (2003) methods. Three planulae from each species were observed daily, and vertical position, swimming velocity, and qualitative observations of swimming behaviour were recorded every five minutes. GLM ANOVA analyses were used to determine the effects of the age on the velocity and depth for each response variable. The effect of age on planulae behaviour a binomial logistic regression analysis was performed. Obtained results shown the capability of larvae to alternate swimming pattern, velocity and depth which then enables them to explore suitable substrata for settlement. This capability also contributes to dispersal away from natal reefs by controlling their position in the water column, and may determine adult distributions on reefs. Additionally, we found, for the first time 1) swimming velocity and depth varied with age only for M. annularis; and, 2) the probability of settlement increased with age for M. annularis and M. faveolata

## 14.446

**Population Structure Of The Mediterranean Solitary Coral *balanophyllia Europaea***

**Jillian MANSFIELD*[1]**, Stefano GOFFREDO[2], Mary Alice COFFROTH[3]

[1]University at Buffalo, Oswego, NY, [2]University of Bologna, Bologna, Italy, [3]University at Buffalo, Buffalo, NY

Balanophyllia europaea is a simultaneous hermaphroditic, brooding coral species, and is endemic to the Mediterranean Sea. The population structure and biogeography of B. europaea were determined for eight populations found in the Mediterranean Basin around Italy. Population genetic theory predicts that if B. europaea is a hermaphrodite, it will self-fertilize frequently leading to inbreeding and a significant deficit of heterozygotes in the populations. Three microsatellite loci were used to test this hypothesis; and the hypothesis that the swimming, pelagic larvae of this brooder coral will produce significant gene flows within small spatial scales causing populations at large scales to be genetically structured. Preliminary results of this study do seem to support these hypotheses; however, more analyses and the creation of several new polymorphic loci are required to fully support these hypotheses and will be carried out in the near future and reported in a subsequent paper.

## 14.447

**Strong Genetic Structure Of The Widespread Coral *acropora Hyacinthus* in The Peripheral Region Of Indo-Pacific Reefs**

**Go SUZUKI*[1,2]**, Takeshi HAYASHIBARA[3], Yoshihisa SHIRAYAMA[2], Hironobu FUKAMI[2]

[1]Division of Applied Biosciences, Graduate School of Agriculture, Kyoto University, Kyoto, Japan, [2]Seto Marine Biological Laboratory, Field Science Education and Research Center, Kyoto University, Wakayama, Japan, [3]Ishigaki Tropical Station, Seikai National Fisheries Research Institute, Ishigaki, Japan

Genetic variations in marine organisms with high dispersal potential of larvae are generally low especially within a region subject to strong ocean current. However, a difference in the genetic composition of the temperate and subtropical populations of tabular coral *Acropora hyacinthus* (one of the most common corals in the Indo-Pacific reefs) was found, despite the presence of the Kuroshio current in this region. Phylogenetic analysis using a mitochondrial DNA marker showed that intra-specific genetic variations were as large as that among 14 other congeneric species, and the variations were classified into four haplotype groups (Hya A–D). Notably, each group was disproportionately distributed: HyaA and B were mainly distributed in the temperate region, HyaD was mainly distributed in the subtropical region, and HyaC dominated in both regions. Crossbreeding experiments showed no gametic isolation among the colonies with these haplotype groups, simultaneous spawning was observed during the experiments, and sympatric distribution of all groups was verified in the field, indicating the four haplotype groups belong to a single species with high genetic polymorphism. Nested clade analysis revealed the existence of a geographical association between HyaA and D. Considering the geological and genetic data, we hypothesize that a vicariant event such as a lowering of the sea level during glacial periods may have isolated peripheral (temperate) *A. hyacinthus* populations from the core subtropical ones. Recent connection between the populations (based on the presence of HyaC) may be due to the Kuroshio current, which would transport *A. hyacinthus* larvae from subtropical to temperate populations. Focusing on peripheral/temperate populations has the potential to improve our understanding of the evolutional history of corals.

## 14.448

**Population Structure Of The Redbelly Yellow Tail Fusilier, Caesio Cuning, (Perciformes, Lutjanidae)**

Sinta PARDEDE[1], **Paul BARBER*[2]**, Kent CARPENTER[3]

[1]Indonesia Marine Program, Wildlife Conservation Society, Bogor, Indonesia, [2]Biology, Boston University Marine Program, Boston, MA, [3]Biological Sciences, Old Dominion University, Norfolk, VA

Studies examining patterns of regional genetic subdivision in Indonesia report many regional barriers to gene flow. However, these have focused on species with pelagic or demersal life history. *Caesio cuning* is a mid-water reef fish that combines aspects of demersal and pelagic life histories. This study examines genetic connectivity among *C. cuning* populations throughout Indonesia to understand the genetic impact of its intermediate life history. A total of 380 base pairs of the mitochondrial control region were collected from 323 individual fish, representing 18 study sites in Indonesia. Results from AMOVA indicated pronounced genetic structure among populations east and west of the Sunda Shelf ($F_{ST}$=0.4827 ($p < 0.0001$), suggesting Pleistocene vicariance between Indian and Pacific Ocean populations. Although pair-wise analysis of gene flow shows similar results with Medan and Raja Ampat exhibiting limited genetic exchange with most of the other populations. fine-scale genetic structure was also found throughout the Indonesian Archipelago, suggesting additional limits to genetic connectivity. In particular, results suggest that populations from the Java region are significantly isolated from populations in Northern Sulawesi and most of Eastern Indonesia. Overall, genetic patterns in *C. cuning* are more similar to demersal reef fish than to pelagics, suggesting that this species does not disperse broadly.

## 14.449

**Mitochondrial Phylogeography of *Acanthaster planci*) (L.) Across the Indo-Pacific Region: Does the Strong Genetic Break Reveal an Ongoing Speciation?**

**Karin GÉRARD*[1]**, Nina YASUDA[2], Kazuo NADAOKA[2], Satoshi NAGAI[3], Jean-Pierre FÉRAL[4]

[1]CNRS DIMAR, Université de la Méditerranée, Marseille, France, [2]Tokyo Institute of Technology, Tokyo, Japan, [3]National Research Institute of Fisheries and Environment of Inland Sea, Hiroshima, Japan, [4]CNRS DIMAR, Marseille, France

The crown-of-thorns-starfish, *Acanthaster planci* (L) is one of the most devastating corallivorous asteroids, which unstable population dynamics rapidly switches from low density to outbreak. Although the biology of this species is well illustrated, information about the origin and mechanisms of outbreaks is scarce. Most of genetic studies on *A. planci* populations were conducted in Pacific and East Indian Oceans from allozyme polymorphism, highlighting strong dispersal abilities across the Indo-Pacific region. Here, to complete the nuclear genetic structure, the relationships of *A. planci* populations from West Indian and Pacific Oceans were analysed with two mitochondrial loci: *16S rDNA* (*16S*) and *cytochrome oxydase subunit I* (*COI*).

The populations of *A. planci* from the Indian and Pacific Oceans did not share any haplotype of both mitochondrial loci. The divergence of these populations reached 9% (*16S*), which was particularly strong given that the inter-specific divergence within the genus *Acanthaster* is about 12%. These two populations have been isolated for long enough to reach the reciprocal monophyly. Molecular clock calculations led to estimate the divergence time at 1.56 million years.

Within the Pacific region, a genetic differentiation among populations from Japan, North central Pacific (Pohnpei and Majuro) and French Polynesia is highlighted. The star-like network of the *16S* haplotypes together with mismatch distributions and negatives values of neutrality tests, suggested that the Japanese group has suffered a population expansion −however not recently− while samples from Pohnpei Majuro and French Polynesia show characteristics of stable populations. The populations from West Indian Ocean displayed both lower nucleotide and haplotype diversities than Pacific populations and no genetic structure has been proved.

Populations of *A. planci* from both oceans may actually be on their way to speciation, but in order to prove it, the putative contact zone of the two genetic entities remains to be analysed: the Indo-Malayan region.

## 14.450

**Tracking Multiple Fish Species' Movements Among Multiple Habitats: The Florida Atlantic Coast Telemetry Array (FACT).**

**Samantha WHITCRAFT*[1,2]**, Craig FAUNCE[3], Eric REYIER[4], David SABIN[5], Christina CONRATH[6], John LAMKIN[7], Craig LAYMAN[8]

[1]Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL, [2]Bilogical Sciences Dept., Florida International University, North Miami, [3]Florida Fish and Wildlife Conservation Commission, Tequesta, FL, [4]DYNAMAC Corporation - NASA, Kennedy Space Center, FL, [5]Loxahatchee River District, Jupiter, FL, [6]Florida Museum of Natural History, University of Florida, Gainesville, FL, [7]Early Life History Lab, NOAA Southeast Fisheries Science Center, Miami, FL, [8]Biological Sciences, Florida International University, North Miami, FL

The Florida Atlantic Coast Telemetry Array (F.A.C.T.) is a regional coordination of multiple acoustic telemetry projects aimed at tracking the movements of multiple species' within and between ecosystems. The array is composed of two portions: the northern array in the Mosquito/Indian River Lagoons, and the southern array of St. Lucie and Loxahatchee estuaries and adjacent reefs. The northern array comprises 34 VEMCO VR2 receivers that span over ~256 km2 of lagoonal habitats, and tracks 44 tagged red drum (*Sciaenops ocellatus*), and 50 rays (*Dasyatis sp., Gymnura sp.*). The southern array combines 67 VR2 receivers, stretching over ~13 km from river to reef, and is currently tracks 44 tagged juvenile and 33 adult mangrove snappers (*Lutjanus griseus*), 6 common snook (*Centropomus undecimalis*), and lemon sharks (*Negaprion brevirostris*). Comparisons of nocturnal/diurnal movement patterns suggest that some daily movement patterns are conserved in both juvenile and adult *L. griseus* in two different habitats – estuarine and coral reef. The FACT collaboration addresses and demonstrates the importance of considering ecosystem-scale fish movements in subtropical coastal research and management.

## 14.451

**Comparative Phylogeography Of Three Endangered Giant Clam Species Across The Coral Triangle**

**Timery DEBOER*[1]**, Matthew SUBIA[2], Pak AMBARIYANTO[3], Mark ERDMANN[4], Katie KOVITVONGSA[5], Paul BARBER[1]

[1]Biology, Boston University, Boston, MA, [2]College of Science, Media Arts, and Technology, Cal State University Monterey Bay, Seaside, CA, [3]Diponegoro University, Semarang, Indonesia, [4]Conservation International Indonesia Marine Program, Bali, Indonesia, [5]Boston University, Boston, MA

The Coral Triangle is the global center of marine biodiversity. Phylogeography seeks to explain such contemporary distributions of taxa in the context of both species-specific biological factors and geologic and climatic factors that are common to all species in a single geographic area. To determine the relative importance of biological characteristics and environmental conditions, it is necessary to know whether groups of taxa with similar distributions share the same history of diversification. This study employed mitochondrial DNA sequence data to examine patterns of genetic connectivity in three sympatric species of giant clams (Tridacna species) in an effort to investigate the underlying cause of differentiation and speciation within this group and to guide conservation efforts across the Coral Triangle. An approximately 485 base pair fragment of mitochondrial DNA cytochrome c oxidase 1 (CO1) was collected from a total of 700 Tridacna crocea, 350 T. maxima, and 350 T. squamosa individuals at 35 sites across Indonesia. Intraspecific genetic structure revealed three divergent clades within each species. Clades were geographically distributed in three primary regions across Indonesia from west to east: Sumatra, central Indonesia, and Papua New Guinea. However, the exact boundary between each region varied by species. Times of separation between clades was broadly concordant for all three species, indicating a common timing of divergence during Plio-Pleistocene sea level fluctuations. Estimates of migration rates between populations varied by species. The identification of deeply divergent lineages that are likely cryptic species, combined with evidence for limited gene flow across portions of the Coral Triangle, has important consequences for conservation planning and restocking efforts for these endangered marine species.

## 14.452

**Population Analysis of the Hermatypic Coral *Galaxea fascicularis* in Southwestern Japan**

**Toshiki WATANABE*[1]**, Yuta SUZUKI[1], Hirohiko TAKESHIMA[1], Mutsumi NISHIDA[1], Mineo OKAMOTO[2], Mariko ABE[3], Michio HIDAKA[3]

[1]Ocean Research Institute, The University of Tokyo, Tokyo, Japan, [2]Faculty of Marine Science, Tokyo University of Marine Science and Technology, Tokyo, Japan, [3]Faculty of Science, University of the Ryukyus, Okinawa, Japan

A significant part of the coral reefs in the Ryukyu Archipelago (southwestern Japan) consists of fringing reefs formed around islands and patch reefs near islands. Corals in reefs around inhabited islands are subject to anthropogenic impacts. In this study, the genetic diversity in populations of the coral *Galaxea fascicularis* (a broadcast spawner) was evaluated at three locations around highly populated Okinawa Island, and comparison was made to populations around remote islands. Connectivity between the local populations was also studied. Prior to the population analysis, the question was addressed whether *G. fascicularis* is a single biological species. Based on the genotypes in a mitochondrial intergeic region, this species was distinguished to two types (*mt-L* and *S*). These two types were highly different in the frequencies of morphotypes of a nematocyst type macrobasic p-mastigophore, and alleles at a nuclear microsatellite locus. These observations argue that *G. fascicularis* in the Ryukyu Archipelago consists of two sympatric cryptic species that rarely inter-breed. For the population analysis, four polymorphic microsatellite loci were identified in a *mt-S* individual, and the four-locus genotype was determined in a toal of 256 *mt-S* colonies (only two of these markers turned out to be useful for the *mt-L* group). The genetic diversity (indicated by expected heterozygosity and allelic richness) in three local populations around Okinawa I. was lower than four other locations near remote islands. Pairwise *F*ST analysis showed significant genetic differentiation between nearby populations (approx. 10 km apart) around Okinawa I., but not between the populations in remote areas even beyond 350 km. Although *G. fascicularis* are still found in large numbers around Okinawa I., human impacts such as coastal development and pollution presumably fragmented the habitats into smaller sub-populations, resulting in reduction of genetic diversity.

## 14.453

**Genetic Diversity And Clonal Structure Of The Cold-Water Coral *lophelia Pertusa* in Ne Skagerrak**

**Mikael DAHL*[1]**, Carl ANDRÉ[1]

[1]Department of Marine Ecology, Göteborg University, Strömstad, Sweden

*Lophelia pertusa* is a scleractinian cold-water coral. It is very likely the most widespread coral and in the northeast Atlantic it is the main reef building species. The main depth distribution is between 200 and 1000 meters, but due to special conditions in fjords it can be found shallower than 100 meter. In northeast Skagerrak between Sweden and Norway there are five reefs at 120-70 meters depth. These reefs have been sampled with a remotely operated vehicle. A previous genetic analysis of *Lophelia pertusa* revealed a moderate gene flow between the populations distributed along the European continental margin and genetically isolated fjord populations. This study complements with a description of genetic diversity and structure at a fine-scale.

A major difference between shallow-water and cold-water corals is the number of species that build-up the reef structure. Whereas tropical reefs usually are composed of many different corals species, are deep-water reefs often built-up by one single species. *Lophelia pertusa* is therefore regarded as an autogenic engineer or a key structural species. The largest reef, the Tisler reef, 1200 meters in length has been extensively sampled in order to generate a clone map. No one has to my knowledge never made an attempt or been able to shown how genetic individuals are distributed throughout a cold-water coral reef.

## 14.454

**Regional Specific Relationships Of Species in The Genus *favia***

**Hironobu FUKAMI*[1]**, Keiichi NOMURA[2], Kenji IWAO[3], Takeshi HAYASHIBARA[4], Go SUZUKI[5], Fumihito IWASE[6], Nancy KNOWLTON[7]

[1]Seto Marine Biological Laboratory, Kyoto University, Nishimuro, Japan, [2]Kushimoto Marine Park, Higashimuro, Japan, [3]Akajima Marine Science Laboratory, Zamami, Japan, [4]Seikai National Fisheries Research Institute, Ishigaki, Japan, [5]Kyoto University, Nishimuro, Japan, [6]Kurohio Biological Research Foundation, Otsuki, Japan, [7]Smithsonian Institution, Washington, DC

The genus *Favia* as conventionally defined, is globally one of the most important reef-building corals, although it is now recognized that Pacific and Atlantic members of the genus are not closely related. Pacific *"Favia"* have not been well studied, despite their diversity. One important obstacle is the difficulty of species identification due to the high intra-specific morphological variation and probably hybridization. In this study, to define the species boundaries, evaluate the possibility of hybridization, and examine regional differences and connectivity, we analyzed *Favia* through the subtropical to the temperate region in Japan using molecular techniques. Most species we analyzed were genetically distinct from one another and regional differences within species were not observed. However a few species including *F. speciosa* and *F. palida*, were genetically indistinguishable. Therefore, we treated them as the *F. speciosa* complex and investigated their reproductive biology (spawning time and possibility of hybridization in laboratory crosses) in both subtropical and temperate regions. The crossing experiments revealed the existence of two to three groups with incomplete reproductive isolation in each region. Moreover, species forming these groups were likely different in each region although species identification is difficult due to the non-typical morphological characters. Also these crossing groups strongly reflected the differences in spawning times. Thus, the situation of some *Favia* species is quite complicated, with the possibility of regionally specific complexes of partially isolated taxa and cryptic species.

## 14.455

**Population Genetic Structure Of The Crown-Of-Thorns Starfish, Acanthaster Planci (L.) Across Indo-Pacific: Genetic Evidence For The Secondary Outbreaks?**

**Nina YASUDA*[1,2]**, Satoshi NAGAI[2], Masami HAMAGUCHI[2], Lian CHUNLAN[3], Ken OKAJI[4], Karin GERARD[5], Kazuo NADAOKA[6]

[1]Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan, [2]National Research Institute of Fisheries and Environment of Inland Sea, Hatsukaichi, Japan, [3]Asian Natural Environmental Science Center, University of Tokyo, Nishitokyo, Japan, [4]CoralQuest Inc, Atsugi, Japan, [5]Université de la Méditerranée, Marseille, France, [6]Tokyo Institute of Technology, Meguro, Japan

Outbreaks of the crown-of-thorns starfish, Acanthaster planci, have been one of the major management issues in coral reefs throughout Indo-Pacific region. Since it produces numerous eggs and pelagic larvae, sudden increase in the survival rate of its larvae may result in the abrupt increase in adult population called primary outbreaks, whereas propagation of the outbreaks to other reefs, from the primary outbreaks via larval dispersion is assumed secondary outbreaks. Although the nearly co-occurrence of recent population outbreaks in the western Pacific supports this idea, the paucity of information on the genetic structure of this species has hindered the understanding of the extent of connectivity. In this study we examined the genetic structure of 24 populations across the Indo-Pacific using seven loci of highly polymorphic microsatellites. A UPGMA dendrogram using Nei fs genetic distance (1978) detected seven genetically distinct groups, i.e. the East African group (Kenya, Mayotte and Madagascar), North Western Pacific group (Japan and Philippines), Palau, North central Pacific group (Majuro & Pohnpei), South Western Pacific group (Great Barrier reefs), Fiji, South Central Pacific (French Polynesia), with large genetic break between the Indian and Pacific Oceans. A significant isolation by distance pattern was found across overall populations ($p<0.05$, $r=0.85$, $n= 276$, Mantel test), indicating that the genetic isolation according to the geographic distance and the restricted gene flow has occurred among the populations. Both F-statistics and genetic admixture analysis supported strong gene flow within the East African, the North Western Pacific and the South Western Pacific groups suggesting larval dispersal via the strong currents; i.e. by Kuroshio Current along the Philippines to throughout Japan, East Australian Current along GBR and East African Coastal Current along Madagascar, Mayotte and Kenya. These data suggest that the secondary outbreaks can occur within these regions through the major ocean currents.

## 14.456

**Genetic Connectivity Of Acropora Palmata Across The Mesoamerican Reef System, Panama, Puerto Rico And Venezuela.**

**Ainhoa LEON ZUBILLAGA*[1]**, Tonya SHEARER[2], Carolina BASTIDAS[1]

[1]Biologia de Organismos, Universidad Simon Bolivar, Caracas, Venezuela, [2]School of Biology, Georgia Institute of Technology, Atlanta, GA

In the Caribbean, the recent decline of reef builders, including Acropora cervicornis and A. palmata, has contributed to the rapid deterioration of coral communities. In only three decades, many populations of both species were wiped out by white band disease, hurricanes, and/or eutrophication. Since the current status of A. palmata is in debate, studies of connectivity and genetic diversity, together with monitoring programs are crucial to assess the status of this species on a regional basis. The integration of this information will be useful in assessing management and designing better conservation strategies for acroporids in the Caribbean. Population genetic analysis of A. palmata will test the following hypotheses: (A) gene flow is restricted between the southern (Panama and Venezuela) and northern Caribbean (Puerto Rico) and Mesoamerican barrier reef system (MBRS), which are highly connected; (B) levels of genetic connectivity in this species vary between size classes; and (C) the relative importance of sexual versus asexual reproduction varies across spatial scales. A. palmata colonies were sampled from multiple sites within the MBRS (Mexico and Belize), Panama, Venezuela and Puerto Rico. At each site, 30-50 colonies of each of the two size classes (10-20 cm and < 50 cm in height) were sampled along one km of reef extension. Multilocus microsatellite genotyping was utilized to characterize the genetic diversity of each size class at each site and to provide information on biological connections among reefs in the region. Results from this study will contribute in understanding of the actual status of A. palmata in terms of its distribution, patterns of genetic diversity and connectivity, and the actual role of sexual reproduction for recovery at different spatial scales.

## 14.457

**Undirect Evidences On The Connectivity Of Coral Reefs Of The Gulf Of Mexico**

**Alejandra CHÁVEZ-HIDALGO*[1]**, Gustavo DE LA CRUZ-AGÜERO[1], Ernesto A. CHÁVEZ[1]

[1]Pesquerías, Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN), La Paz Baja California Sur, Mexico

Details of connectivity among coral reefs of the Gulf of Mexico and adjacent Mexican Caribbean coast are mostly unknown, despite the need of having evidence to support decision making, addressed to preserve priority sources of larval stages of reef species. Indirect evidence to support management decisions is provided on the basis of analyzing patterns of similarity of 56 species of stony corals and 383 fish species from 22 reef locations. Data on species richness suggest that the highest biodiversity of stony corals is located around the Sian Kaan reefs on the Caribbean, with 42 species, whilst at the Triángulos reef on the Campeche Bank, only ten species have been recorded. The highest fish species richness was found at Alacran reef, Campeche Bank, with 287 species, and the lowest one with 24 species corresponds to Punta Allen on the Caribbean coast. With this initial exploration of data, the communities were analyzed in reference to species dominance and ecological diversity. Similarity between locations was undertaken with reference to fish and coral records and results were compared against the geographic distances amongst locations. Advection patterns are used trying to explain the most likely patterns of larval dispersion and to identify sources of recruitment and dispersion pathways of coral and fish larval stages with reference to reef locations.

## 14.458

**The Molecular Population Structure of the Crown-of-thorns starfish, *Acanthaster planci*, across the Hawaiian Archipelago and the two Closest Island Neighbors, Johnston Atoll and Kingman Reef**

**Molly TIMMERS*[1,2]**, Robert TOONEN[3], Misaki TAKABAYASHI[4], Marta DEMAINTENON[4]

[1]Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, HI, [2]University of Hawaii at Hilo, Hilo, [3]Hawaii Institute of Marine Biology, University of Hawaii, Honolulu, HI, [4]University of Hawaii at Hilo, Hilo, HI

*Acanthaster planci* infestations can decimate the ecology and economic value of coral reef ecosystems. Therefore, understanding *A. planci* dispersal and recruitment mechanisms is imperative not only for mitigation purposes but for monitoring outbreak impacts on reef structure. The Hawaiian Islands are the most biogeographically isolated island group on earth. The two closest neighbors to the archipelago are Johnston Atoll and Kingman Reef. Recorded *A. planci* populations in the Hawaiian Islands and subsequent coral predation have been very low compared to other locations in the Indo-Pacific, presumably because of the islands' extreme insularity. However, populations around the main Hawaiian Islands appear to have increased in recent years. Furthermore, *A. planci* densities have been at outbreak levels in localized areas around Kingman Reef since 2001, and densities at Johnston Atoll have also increased within the past three years. Using a mitochondrial DNA marker (660 bp of the control region), patterns of gene flow and connectivity of *A. planci* were assessed along the Hawaiian Archipelago and compared to populations at Johnston Atoll and Kingman Reef to determine whether Kingman Reef and/or Johnston Atoll might serve as a larval transport vector to the Hawaiian Islands. Understanding the population connectivity of this fecund corallivore may provide a basis for predicting potential aggregation patterns in the Hawaiian Islands. The knowledge gained from this research likely has direct implications to Hawaiian coral reef management.

## 14.459

**Seagrass-Coral Reef Connectivity: A Case Study On Reef Fishes Migration in North Sulawesi, Indonesia**

**Augy SYAHAILATUA*[1]**, Jemmy SOUHOKA[2]

[1]Research Centre for Oceanography LIPI, Jakarta, Indonesia, [2]Research Centre for Oceanography LIPI, Bitung, Indonesia

Seagrass beds and coral reefs are important coastal ecosystems for fish fauna in the tropic. They can be functioned as a nursery and feeding ground, permanent habitat and shelters for fish species. The species diversity and abundance of fish are usually greater in seagrass beds than those in unvegetated habitats. However, many studies revealed that only few fish species inhabit in seagrass beds, while most of them are resident only during juvenile stage or migration from surrounding ecosystems (mangrove, coral reefs, estuarine or pelagic system) for feeding and /or shelter. So far, only few studies in the tropic explain clearly the role of seagrasses in fish productivity of their neighbourhood ecosystems. This research aims to understand the relationship of fish assemblages between seagrass beds and coral reefs in term of their ecological functions. Several techniques were applied to provide a good information on fish migration between seagrass and coral reef including beachseine, gillnet, and visual sensus. The results show that 3 reef species, such as *Cheilinus trilobatus, Scarus niger* and *Sargocentrum cornutum* usually migrate between 03:00 – 18:00 hours for feeding. The results could be relevant for management of coral reef and its associated ecosystems, especially seagrass beds.

## 14.460

**Phylogeography Of The Endemic Scleractinian *cladocora Caespitosa* (L., 1767) in The Northern Mediterranean Sea**

**Fabrizio STEFANI*[1]**, Francesca BENZONI[1], Paolo GALLI[1]

[1]Dept. of Biotechnology and Biosciences, University of Milano-Bicocca, Milan, Italy

*Cladocora caespitosa* (L.,1767) is the principal endemic bioconstructor coral of the Mediterranean Sea. Despite recent episodes of mortality have been documented all over the Mediterranean and a significant knowledge about the ecology, paleoecology and conservation status of this species exists, no description of its phylogeny and phylogeography is available.

In order to supply this information, essential for any conservation plan, the genetic variability of some populations of *C. caespitosa*, collected in the northern Mediterranean Sea, has been evaluated. A 790 bp fragment of the ribosomal DNA has been amplified and cloned prior to sequencing. The genetic variability has been estimated at intraindividual, intraspecific and interspecific levels.

An elevated degree of intraindividual polymorphism has been detected, but the presence of a clear phylogenetic divergence with the congener species excludes the retention of ancient phylogenetic lines, predating the origin of the species. At the intraspecific level more clades are described, yet the presence of a significant spatial genetic structure is excluded. The data also suggest a recent demographic expansion.

Patterns of isolation due to biogeographic barriers within the Mediterranean Sea do not currently appear consistent for *C. caespitosa*, although the presence of past vicariance events is likely. This can be justified hypothesizing wide phenomena of secondary gene flow, following past divergences in few refugia areas.

## 14.461

**On The Trail Of A Voracious Predator – The Phylogeography Of *acanthaster Planci***

**Catherine VOGLER*[1]**, Paul BARBER[2], John BENZIE[3], Gert WÖRHEIDE[1]

[1]Courant Research Center Geobiology, University of Göttingen, Göttingen, Germany, [2]Boston University, Boston, MA, [3]Moana Technologies, Aiea, HI

Due to their high dispersal potential and the apparent lack of barriers in the marine realm, widespread marine organisms have long been expected to display little genetic structuring. Yet recent studies on marine invertebrates challenge this belief. Distributed throughout the Indo-Pacific, and as such an ideal model for understanding patterns influencing its genetic structure, the conspicuous crown-of-thorns starfish *Acanthaster planci* has drawn much public and scientific attention over the last 40 years. Despite being a natural predator of corals, it is notoriously infamous for its dramatically destructive oubreaks that have devastated coral reefs throughout its distribution range. However, until today, little is understood about its larval dispersal patterns, the connectivity among populations, and the spread of outbreaks among reefs - all essential elements to appreciate the scale of *A. planci*'s threat to coral reefs and devise appropriate management plans.

Previous studies on *A. planci* have allowed uncovering substantial gene flow among populations over large distances; nonetheless a major genetic differentiation between the Indian and Pacific Oceans was also detected. However, the lack of resolution of the markers used in these studies limited the interpretability of the data at a finer scale. By investigating *A. planci*'s phylogeography using sequences of the mtDNA control region, and increasing the sampling to its whole distribution range, this study allowed distinguishing several differentiated clades - probably influenced by past geo-tectonic events and sea level changes, as well as current oceanographic patterns - and understanding more about the dispersal patterns of this ecologically important corallivore.

## 14.462

**The Smell Of Leaves Helps Coral Reef Clownfish Find Island Homes**

**Danielle L. DIXSON*[1]**, Geoffery P. JONES[1,2], Serge PLANES[3], Morgan S. PRATCHETT[1,2], Maya SRINIVASAN[1,2], Craig SYMS[1], Simon R. THORROLD[4]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia, [3]Laboratoire Écosystèmes Aquatiques Tropicaux et Méditerranéens, Université de Perpignan, Perpignan, France, [4]Biology, Woods Hole Oceanographic Institution, Woods Hole, MA

Coral reef fish larvae can potentially use a range of stimuli to locate and orientate towards natal reefs. While a high proportion of juvenile clownfish *Amphiprion percula* settle on natal reefs, how they find their way home is unknown. In Kimbe Bay (Papua New Guinea), *A. percula* is most abundant on the shallow reef flats and in lagoons associated with isolated vegetated islands and is rare on reefs without islands. Here we used a series of pair-wise choice experiments to investigate the role of water-borne olfactory cues potentially used to find islands. Recently settled juvenile *A. percula* preferred: (1) Water collected near islands instead of offshore water; (2) Water taken from reefs with islands instead of water from reefs without islands; and (3) Natal lagoon water instead of water from another lagoon. In addition, (4) juveniles preferred water treated with rainforest leaves compared to untreated offshore water. We hypothesize that *A. percula* use a cocktail of olfactory stimuli to locate vegetated islands, which may explain the high levels of self-recruitment on island reefs. This previously unrecognised link between coral reefs and island vegetation argues for the integrated management of these pristine tropical habitats.

## 14.463

**Reef Connectivity Of Marine Reserves in Central Philippines As Determined Using Fish Mitochondrial Dna**

**Amida Diwata MACANSANTOS*[1]**, Hilconida CALUMPONG[1], Ma. Rio NAGUIT[1], Jacinta LUCAÑAS[1], Janet ESTACION[1], Adonis FLOREN[1]

[1]Silliman University Institute of Environmental and Marine Sciences, Dumaguete City, Philippines

A patchwork of Marine Reserves have been established in central Philippines as a means of conserving and enhancing its marine resources. However, these reserves were established without any particular design or consideration of their ecological connectivity which is so important for their sustainability. The objective of this study was to determine the connectivity of marine reserves in the central Philippines to assist coastal managers in determining priority areas for protection and in site selection to enhance productivity. Mitochondrial DNA of fish collected from the vicinity of twelve marine reserves found throughout central Philippines was used to compare genetic variation and infer genetic structure. Two fish species, *Dascyllus trimaculatus* and *Pterocaesio pisang* were used because they exhibit extreme differences in pelagic larval duration and mode of dispersal. Water current patterns from each site was determined using the drogue method. Preliminary analysis using PAUP* 4.0 showed three subgroups of more similar haplotypes that correspond to three levels of geographic distance. *Dascyllus trimaculatus* exhibited a stronger genetic structure compared to *P. pisang* which is a more mobile species. The genetic structure obtained is supported by the water current patterns.

## 14.465

**Genetic Structure Of The Giant Clam, *tridacna Crocea* As Indicator Of Connectivity Among Mpas in Central Philippines**

**Maria Rio NAGUIT*[1,2]**, Hilconida CALUMPONG[2], Janet ESTACION[2], Amida Diwata MACANSANTOS[3]

[1]Jose Rizal Memorial State College, Katipunan, Zamboanga del Norte, Philippines, [2]Institute of Environment and Marine Sciences, Silliman University, Dumaguete, Philippines, [3]Institute of Environment and Marine Sciences, Silliman University, Dumguete, Philippines

The genetic structure of five populations of the giant clam, *Tridacna crocea* from reefs in the Central Philippines was determined using mitochondrial cytochrome oxidase 1 (CO1). Samples from the Spratly group of islands were included for comparison. Results showed a remarkably high level of haplotypic diversity but low nucleotide diversity. Analysis using Molecular Analysis of Variance (AMOVA) revealed significant homogeneity which indicates geneflow among the five populations. This translates to MPA connectivity and highlights the importance of each MPA sampled as both source and sink of *T. crocea*.

## 14.466

**South East African, High-Latitude Coral Communities, A Canary For Western Indian Ocean Coral Reefs?**

**Angus MACDONALD*[1]**, Michael SCHLEYER[1], Jennifer LAMB[2]

[1]Oceanographic Research Institute, Durban, South Africa, [2]University of KwaZulu-Natal, Durban, South Africa

Coral reefs are important to coastal communities throughout the western Indian Ocean (WIO). Coral reef health is deteriorating in this region and resources associated with reefs are thus dwindling. In order that reef resources are sustained for future generations, intervention, in the form of management, is necessary. Effective management of human behaviour associated with coral reef use must incorporate realistic information on coral population dynamics. In this study, stony coral population diversity and relatedness were investigated at several scales using molecular methods. Genetic diversity may be used as a proxy to gauge both the population dynamics and resilience of a community. Genetic variability was thus measured in two corals with different reproductive modes, larval dispersal capabilities and life history strategies. The corals Acropora austera and Platygyra daedalea were chosen as molecular markers were available for these species. We used intron regions in the nuclear DNA of A. austera and the ITS region of the ribosomal DNA of P. daedalea to compare population genetic variability and to separate phylogenetic history from phylogeography. There appears to be regular genetic exchange between populations of both corals in the region. The local oceanography would indicate that northern reef systems may be considered source populations and southern systems, sink populations. This is corroborated by greater genetic diversity in the north. Considering this information, southern reef coral genetic diversity may be a valuable gauge of reef deterioration in the true accretive coral reef systems in the north.

## 14.467

**Using A Multi-Locus Technique To Assess Population Genetic Structure And Infer Dispersal Patterns in Adult Populations Of The Temperate Coral Oculina Arbuscula.**

**Daniel BRAZEAU*[1]**, Daniel GLEASON[2]

[1]Pharmaceutical Sciences, University at Buffalo, Buffalo, NY, [2]Department of Biology, Georgia Southern University, Statesboro, GA

The population structure of adult corals is determined by the genetic diversity of the settling larvae each season and subsequent recruit survivorship. On hard-bottom reefs of the southeastern U.S., the broadcast spawning temperate coral, Oculina arbuscula, exist within a patchwork of rocky outcrops surrounded by large expanses of soft substrate. These "live bottom" reefs provide topographic complexity and serve as critical habitat for fish and invertebrate communities. In this paper we employ highly polymorphic genetic markers to assess the genetic structure of adult populations of O. arbuscula on 5 reefs within the vicinity of Gray's Reef National Marine Sanctuary off Georgia, USA. Juveniles were also collected from recruitment plates at one of the sites and assessed for likely origin. A total of 143 adults and 28 juveniles were studied using 85 polymorphic AFLP markers. The overall frequency of markers was 0.23 (SD = 0.17), ranging from 0.05 to 0.81. Two assignment-based analyses (AFLPOP and Structure) were used to assess the genetic heterogeneity of adults and recruits. Both AFLPOP and Structure showed significant structure among adult populations though there was no relationship between allele frequency divergences between sites and geographic distance. Genetic heterogeneity among adult populations was sufficient to allow either analysis to correctly assign randomly chosen individuals back to the populations they were collected from with probabilities from 41% to 72%. Based upon adult frequencies, AFLPOP and Structure identified the natal reef as the most likely source for 57% and 61% respectively of the juveniles. The next site with the highest probabilities of recruit origin accounted for 21% to 25% of the recruits. This site was not the next nearest site to the reef where the juveniles were collected. These limited data suggest significant structure among adult populations for this broadcast spawning species perhaps driven in part by self seeding.

## 14.468

**Genetic structure of the giant barrel sponge Xestospongia muta in Northern Caribbean**

**Susanna LOPEZ-LEGENTIL*[1]**, Joseph PAWLIK[2]

[1]Center for Marine Science, University of North Carolina Wilmington, Wilmington, NC, [2]Center for Marine Science, University North Carolina Wilmington, Wilmington, NC

Sponges play key functional roles in coral reef ecosystems. In the Caribbean, the giant barrel sponge, *Xestospongia muta*, is a dominant reef constituent. In recent years reports of sponge bleaching, disease and subsequent mortality have alarmingly increased. Population recovery may strongly depend on colonization capabilities of the affected species. However, little is known about population structure and gene flow among sponge populations. The mitochondrial gene Cytochrome Oxidase subunit I (COI) fragment amplified with Folmer's universal primers is frequently used for population genetic and phylogeography studies in marine taxa, but this fragment presents very low nucleotide variability in sponges. In this study, we tested the usefulness of the I3-M11 partition of COI to determine the genetic structure of *Xestospongia muta* in the Northern Caribbean. 116 sequences of 544 bp were obtained corresponding to four haplotypes. The nucleotide diversity found for the I3-M11 partition ($\pi$ = 0.00386) was higher than the one found for Folmer's, indicating better resolution at lower taxonomic levels. Pairwise tests for genetic differentiation among geographic locations based on $F_{ST}$ values showed significant genetic divergence between most populations. However, this genetic differentiation was not due to isolation by distance. While limited dispersal may have led to differentiation among some of the populations, the patterns of genetic similarity appear to be most strongly related to patterns of ocean currents. As determined for other marine invertebrates, our results suggest that geographic barriers play a major role in sponge colonization in the Caribbean and need to be considered in existing and future plans for management and conservation of coral reef ecosystems.

## 14.469

**Pelagic Larval Durations And Settlement Size in The Western Atlantic *lutjanus Spp.***

**Benjamin VICTOR*[1]**

[1]Ocean Science Foundation, Irvine, CA

The pelagic larval duration for all of the eight shallow-water snappers from the Western Atlantic is three to four weeks with remarkably little variation. Divergent reports of PLDs in the literature probably reflect different interpretations of the otolith microstructure near the center and at the settlement mark. I estimated larval durations from the otoliths of settling larvae from several sites in the Caribbean. Both inter and intra-specific variation in PLD was very low, especially considering some inevitable counting error. In contrast to the consistency in PLD, the size at settlement varied greatly between species, with grey snappers settling at particularly small sizes (10-15 mm SL) and mahogany snappers settling at the largest sizes (17-22 mm SL). There was less variation in size at settlement within species. Given the consistency of the larval duration, the variation in size at settlement is due primarily to varying growth rates while pelagic. This indicates that there are species-specific growth trajectories in the open ocean that likely reflect species-specific larval ecology amongst the snappers in the region.

## 14.470

**Recent Invasion Of The Tropical Western Atlantic By An Indo-Pacific Deep-Sea Snapper**

**Tonatiuh TREJO-CANTWELL*[1]**, Brian W. BOWEN[1]

[1]University of Hawaii, Hawaii Institute of Marine Biology, Kaneohe, HI

Deep-sea snappers (Lutjanidae) in the genus *Etelis* are represented by 3 species (*E. carbunculus*, *E. coruscans*, *E. radiosus*) in the Indo-Pacific Ocean, but only a single species (*E. oculatus*) in the Atlantic. Many other marine organisms exhibit evolutionary connections between the Indo-Pacific and Atlantic oceans, but the pathway and timing of these connections remain largely unknown. Phylogenetic analyses of 507 bp of the mtDNA cytochrome b gene indicate a close affinity (approximately 1.5% divergence) between Indo-Pacific populations of *E. coruscans* and western Atlantic populations of *E. oculatus*, two morphologically similar snappers. These data indicate a colonization pathway from the Indo-Pacific around South Africa and directly into the tropical western Atlantic, a pattern also observed in recent studies of gobies (genus *Gnatholepis*) and angelfishes (genus *Centropyge*). During recent interglacial periods, relaxation of the cold Benguela Current along the coast of Africa may have allowed fish larvae in the tropical Agulhas Current to enter the southern Atlantic and be transported by the South Equatorial Current directly into the western Atlantic. The goby and angelfish data indicate invasions of Indo-Pacific reef fishes into the western Atlantic occurred approximately 145,000 and 250,000-500,000 years ago, respectively. Using conventional mtDNA molecular clock estimates for marine fishes (approximately 2% per million years between lineages), our data for *E. coruscans* and *E. oculatus* suggest an Atlantic founder event occurred approximately 750,000 years ago. Collectively these findings demonstrate a novel biogeographic pathway for colonization between ocean basins that clearly enhances Atlantic reef biodiversity.

## 14.471

**Glass Sponge Reefs On The Canadian Continental Shelf: Population Structure And Reproduction**

**Andia CHAVES-FONNEGRA*[1]**, Sally P. LEYS[1]

[1]Biological Sciences, University of Alberta, Edmonton, Alberta T6G 2E9, Canada, Edmonton, AB, Canada

Glass sponges are unusual animals that have the ability to form massive reefs. Sponge reefs reached their maximum during the Jurassic, declined during the Cretaceous, and were thought extinct until several were discovered in the early 1990s at depths of 100 to 250 m on Canada's Pacific coast. Glass sponges have a siliceous skeleton that is fused into a rigid framework. Compared to coral reefs, sponge reefs have a lower richness of framework species; only three hexactinellid sponge species form the reef framework: *Aphrocallistes vastus*, *Farrea occa* and *Heterochone calyx*. But, like corals, they can form patches or mounds where they tend to grow very close to each other, thus forming a net three-dimensional structure. Sexual reproduction by larvae has only been documented in one individual, suggesting that sustainability of the reef could be by asexual reproduction. To determine the extent to which sponge reefs might be clonal, and bud to form massive single colonies of the same genotype, tissue compatibility experiments were carried out with different individuals (non-self) and with pieces of the same individual (self). The remote operated vehicle ROPOS was used to survey and collect tissue samples from reefs located in the Strait of Georgia, Canada. Initial results suggest that 10/15 (67%) pairs of self fragments stayed adhered to one-another, whereas only 3/23 pairs (13%) of non-self fragments remained adhered to one-another after 12 hrs. These results suggest that reefs are not formed exclusively by clones, implying that recruitment must occur by larval dispersal. A total of five patches of live sponge reefs are found in the Galiano Ridge reef complex and eight at Fraser Ridge reef. Microsatellite markers are being designed to confirm these preliminary results and to determine whether the reef complexes of framework hexactinellid sponges constitute different populations.

## 14.472

**Understanding Potential Patterns Of Larval Dispersal From Grouper Spawning Aggregations – Drifter Vial Studies From Raja Ampat Islands, Eastern Indonesia**

**Joanne WILSON*[1,2]**, Peter MOUS[2], Chris ROTINSULU[2], Andreas MULJADI[2]

[1]Indonesia Program, The Nature Conservancy, Sanur, Indonesia, [2]The Nature Conservancy, Sanur, Indonesia

Raja Ampat Islands in Eastern Indonesia contain the world's highest coral reef biodiversity and are a global priority for conservation. Recently, a network of 7 Marine Protected Areas (MPAs) covering an area of 900 000 ha was declared in this area. The Nature Conservancy and partners are supporting local governments and communities to develop a zoning system within these MPAs. Understanding and incorporating biological patterns of connectivity is one of the fundamental principles used in the design of MPA networks. Grouper spawning aggregations are a key target for inclusion in no-take areas. Understanding the patterns and scale of larval dispersal from these sites will inform MPA design. Biological patterns of connectivity result from a combination of biological and physical factors. As a first step, drifter vials were used to determine local and regional scale current patterns. Vials were released from two spawning aggregation sites, one during the spawning season in 2005 (1000 vials) and another in 2006 (5000 vials). Between 15-30% of vials were recovered. The majority were recovered within the first month and within 20 km of the release sites which is within the MPA network. However, a small number of vials traveled over 500 km with one vial traveling to Papua New Guinea 'against' major equatorial currents. This study demonstrates the potential importance of these sites for local and regional replenishment and hence the importance of protecting spawning aggregations in no-take areas. It also demonstrates the importance of understanding local currents when interpreting the role of large scale current features in connectivity. The next step is to compare these data with the extensive database on marine genetic connectivity available for this region.

## 14.473

**Scale-Dependent Variability in Larval Supply in Coastal Kenya: Towards Estimating Connectivity Of Reef Sites**

James MWALUMA[1], **Boaz KAUNDA-ARARA*[2]**, Melckzedeck OSORE[1], Vidar ORESLAND[3]

[1]Kenya Marine & Fisheries Research Institute, Mombasa, Kenya, [2]Fisheries and Aquatic Sciences, Moi University, Eldoret, Kenya, [3]Marine Insitute, Fisheries Board, Stockholm, Sweden

Reef fishes are known to be demographically open with pelagic larval phase that reseeds distant populations. The dispersal of larvae to reef sites is therefore a function of hydrodynamics, larval behaviour and interactions thereof. Metacommunity models have either been based on local communities connected to a regional pool or on a set of spatially segregated communities connected by individual inputs. In this study we examined the levels of connectivity of local and regional fish assemblies based on an estimate of larval supply to reef sites covering a span of > 100 km and across habitat patches spanning a distance of < 10 km on the Kenyan coast. Larval supply was quantified using plankton tows when peak larval abundance is expected along the coast during 2006 and 2007. Results show species-specific differences in larval supply on a south-north gradient, with the presence of more spatially truncated dispersal in some species (e.g. Lethrinidae, Scaridae and Apogonidae). This is contrasted to species with medium (Siganidae) and long distance dispersal regimes (e.g. Holocentridae). Models of dispersal for the dominant larvae show differences in kurtosis. The results indicate differences in dispersal distances of larvae along the Kenyan coast. Patterns of distribution indicate possible differences in spawning sites and times and existence of mechanisms that truncate dispersal. These results have implications for setting outer spatial limits for stock management, connectivity of reef sites and for siting of marine reserves.

## 14.474

**Population Genetic Structure of the Scleractinian Coral *Seriatopora hystrix* on the Great Barrier Reef as Revealed by Microsatellites: Patterns of Reproduction and Dispersal**

**Elke MAIER*[1]**, Ralph TOLLRIAN[2], Beate NÜRNBERGER[1]

[1]Department Biologie II, Ludwig-Maximilians-Universität München, Munich, Germany, [2]Lehrstuhl für Evolutionsökologie und Biodiversität der Tiere, Ruhr-Universität Bochum, Bochum, Germany

Pelagic dispersal of larvae is a fundamental process in coral population dynamics and evolution because it affects the rate and pattern of adaptation and determines the dynamics of local extinction and re-colonisation. Thus it is critical for the persistence of populations and a central issue for the design of marine reserves. We present a microsatellite study on the brooding coral *Seriatopora hystrix* from the Great Barrier Reef, sampled at nine locations from two geographical regions (Lizard and Heron Island, max. distance: ~1200 km). We employed traditional population genetic analyses together with recent Bayesian approaches to evaluate within-site genetic structure as well as connectivity patterns on different spatial scales. Specifically, we aimed to 1) infer reproductive mode, 2) identify causes of heterozygote deficits that occurred at all sites, 3) evaluate migration patterns and 4) detect immigrants. Within-site genetic structure revealed evidence for low levels of clonal propagation at several locations. Observed heterozygote deficits were best explained by a combination of null alleles and population processes (e.g. Wahlund effects, sampling of close relatives). Levels of genetic differentiation were low (Lizard Island) to moderate (Heron Island) within regions whereas marked differentiation between regions indicated little genetic exchange. At Heron Island, cluster analyses revealed pronounced substructure within sites which allowed us to identify individual immigrants. In contrast, Lizard Island sites appeared highly homogeneous, consistent with low levels of immigration. Furthermore, we investigated the occurrence of within-colony heterogeneity. We found that both allogeneic fusions and somatic mutations occurred. Our results imply that restricted dispersal and local adaptation should be regarded as critical factors for the conservation of *S. hystrix*.

## 14.475

**Race To The Reef: Tracking Reef Fish From Open Ocean To Nursery Habitats To Coral Reefs And Back Again…**

**Samantha WHITCRAFT*[1]**, John LAMKIN[2]

[1]RSMAS - Cooperative Institute for Marine and Atmospheric Studies, Miami, FL, [2]NOAA - Southeast Fisheries Science Center, Miami, FL

The Early Life History Team at NOAA's Southeast Fisheries Science Center is a multi-disciplinary team of scientists dedicated to excellence in early life history research to support applied fisheries management and habitat conservation in the Southeast Atlantic, Gulf of Mexico, and Caribbean ecosystems. To that end, we study the dynamics of how specific fish species use a variety of habitats during their life-cycle. For example, adult gray snappers (*Lutjanus griseus*) tend to spawn in deeper coastal waters, usually in association with coral reefs or hard-bottom substrate while coastal mangroves provide the intermediate juvenile habitat for gray snappers that recruit to seagrass beds. To study spawning and larval transport in pelagic waters we conduct large-scale survey cruises that sample, quantify, map, and model the distribution of specific fisheries species. To study smaller-scale estuarine and inshore habitat use and movements of snappers we use acoustic tagging and tracking to determine site fidelity and habitat requirements. Understanding this dynamic ecosystem connectivity is vital to essential coastal habitat conservation planning and fisheries management.

## 14.477

**Zonation of Mesophotic Reefs in the Bahamas**

**John REED*[1]**, Shirley POMPONI[2], Robert GINSBURG[3]

[1]Harbor Branch Oceanographic Institute, Fort Pierce, FL, [2]Harbor Branch Oceanographic Institute, fort Pierce, FL, [3]University of Miami, Miami, FL

Fore-reef escarpments, margins of carbonate platforms, and island slopes provide an expansive zone for mesophotic reefs throughout the Caribbean and Bahamas that may exceed 24,000 linear km at depths of 30->100 m. Mesophotic reefs occur where there are suitable combinations of geomorphology (steep, rocky slope), low sedimentation, light and temperature, that often result in biological diversity that may rival shallow water reefs. Shallow reef species that extend into the mesophotic zone provide potential connectivity and resilience to emerging threats such as rising sea-surface temperatures. Submersible dives document the macrobenthos at various sites within the mesophotic zone throughout the Bahamas using video-transects, benthic samples, and CTD. Video images from these dives analyzed by pointcount software (CPCe) reveal percent cover of habitat: rock (pavement, boulders, wall), sediment, and rubble; benthic macrobiota: coral (scleractinia, gorgonacea), sponge, and algae (red, brown, green); and percentage of corals with apparent disease and/or bleaching. Temperatures are more stable and cooler at mesophotic depths, ranging from 22-28$^{o}$C at 60-150 m with 1-3$^{o}$C thermocline common at 50-100 m. Moderated maximum temperatures on mesophotic reefs result in reduced coral bleaching compared to shallow reefs. Previous studies indicate that certain scleractinians are restricted to the deep reef zone, such as *Agaricia grahamae* (115 m maximum depth) and *Leptoseris cucullata* (108 m), whereas other species are ubiquitous to the entire reefal depth range (*Monastraea cavernosa*, 3-113 m). Likewise, some algae and sponges are either restrictive in their zonation or occupy broad and contiguous ranges from shallow to deep. Our historical records from submersible dives throughout the Bahamas and Caribbean extend nearly 30 years and are invaluable resources for marine managers for tracking natural and anthropogenic changes in these diverse deep reef ecosystems, and also for assessing their potential to mitigate losses in shallow water areas.

## 14.478

**Geographic Differentiation And Mass Mortalities Of A Mediterranean Symbiotic Gorgonian: *eunicella Singularis***

**Jérôme CATANÉO*[1]**, Paola FURLA[1], Denis ALLEMAND[2], Didier FORCIOLI[1]

[1]ECOMERS, Nice-Sophia Antipolis University, Nice cedex2, France, [2]Scientific Centre of Monaco, Monaco, Monaco

Over the past decade, Mediterranean seawaters have undergone important warming events which led to episodic but massive mortalities of many marine invertebrates. Among these, *Eunicella singularis*, the only symbiotic Mediterranean gorgonian, has been particularly affected. However the observed mortalities varied locally in this species. Such heterogeneity could be due to a genetic differentiation of the holobiont.

Geographical differentiation among the Mediterranean populations of a non-symbiotic gorgonian has already been found (Costantini *et al.,* 2007) and could occur also for *Eunicella singularis*. Unlike tropical corals, and despite a broad bathymetric distribution, *Eunicella singularis* harbours only one *Symbiodinium* sp. sub-clade (A').

The aim of this work was then to find if the heterogeneity in mortality could be linked to geographical and/or bathymetric differentiation of *Eunicella singularis*, in both the host and its symbionts at an intra-clade level. We also determined the impact of the recent mortalities on the genetic diversity of *Eunicella singularis*.

To study these issues, we identified a dozen of microsatellite loci from the genomes of *Eunicella singularis* and of its symbionts. New loci had to be developed as it has not been possible to use microsatellites found in other cnidarian or symbiotic clades. More than two hundred individuals collected on half a dozen sites at different depths were genotyped. Geographic differentiation was explored by bayesian analysis.

This work, through a better understanding of the adaptive mechanisms within this symbiosis, is a key step in the development of a conservation program for this patrimonial specie.

LITERATURE CITED

Costantini, F *et al.* – 2007 – Marine Ecology Progress Series (340) – pp109-119

## 14.479

**Underwater Corridors As An Option To The Fragmentation Of Marine Natural Spaces**

**Evelio VALEIRAS*[1]**, Evelio VALEIRAS[1]

[1]Natural and Environmental Resources, Goverment, San Juan, Puerto Rico

This work identifies and analyzes important aspects of the approved Planning Board (PB) natural reserves delimitations used by the Deparment of Natural and Environmental Resources (DNER). The delimitation process between the marine and terrestrial areas are compared using the legal descriptions issued by the (PB) through its resolutions.The study revealed that the limits of the marine reserves have fragmented natural spaces of the sea floor of identified sensitive marine ecosystems. Interconnecting underwater corridors could be created to assure their protection through zoning.

## 14.480

**Corridors And Recruitment Of Coral Reef Fishes**

**Ethan MACHEMER*[1]**, John WALTER[2], David KERSTETTER[3]

[1]Nova Southeastern University, Hollywood, FL, [2]NMFS Southeast Fisheries Science Center, Miami, FL, [3]Nova Southeastern University, Dania Beach, FL

Ontogenetic shifts in habitat utilization from mangroves to coral reefs are known to occur in several species of tropical fishes. If such habitat shifts are important for reef fish production then identifiable linkages between the two habitats should exist in the form of migration corridors. A corridor in this case is defined as an area of specific bathymetry and salinity that links accessible mangrove habitats to the reefs through breaks in the outlying barrier islands. Investigation of this connection will provide information about a transition stage in the life history of reef fishes that is not well known. This is especially pertinent given the ongoing encroachment of human populations in Southeast Florida resulting in loss of suitable mangrove habitats. Dredging and other operations that alter bottom topography or flow regimes could also prove harmful. Data for this study comes from the Mangrove Visual Census (J. Serafy, NOAA Fisheries) and the Reef Visual Census (J. Bohnsack, NOAA Fisheries) in which field observations were taken of several reef fishes over a multi-year period. Utilizing ubiquitous species as examples (*Scarus guacamaia*, *Haemulon parra*, *Lutjanus apodus*, *Lutjanus griseus, Gerres cinereus*, and *Abudefduf saxatilis*), we will explore a correlation between the distance from island channels and the relative abundances of these species on the reefs. To assess proximity and accessibility of mangroves, measures of through-the-water distance, distance from shoreline, hypothesized migratory routes, and channel viability will be used. With this information, more informed policy and conservation decisions can be made in order to preserve the areas that are most critical to the continued survival and health of tropical fishes.

## 14.481

**Seasonal Variation And Spatial Distribution Patterns Of Echinodermata Larvae in La Parguera, Puerto Rico, With An Emphasis On Diadema Antillarum Larvae**

Stacey WILLIAMS[1], Jorge GARCIA-SAIS[1], **Brandi TODD*[1]**

[1]Marine Science, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico

This study describes the abundance and distribution of echinoderm larvae in La Parguera, Puerto Rico, with an emphasis on *Diadema antillarum* larvae. The temporal larval distribution of echinoderm larvae was characterized by a series of monthly tows that were scheduled between the new and full moon of each month from April 2005 to July 2006, and September 2006. In this study, echinoids exhibited the greatest reproductive output. Out of a total of 8,182 larvae collected, 69.7 % were echinopluteus (of those 22% were *Diadema* larvae), 29.7% were ophiopluteus, 0.3% auricularia/doliolaria and 0.3% bipinnaria/brachiolaria. There was a significant peak in echinoderm larval abundance in July 2005 and two lesser peaks during October 2005 and March 2006 (Kolmogorov-Smirnov, $p<0.01$). The observed peaks in larval abundances in the water column may be indicative of higher reproductive activity during these months. In order to assess the spatial distribution of echinoderm larvae, oblique tows were taken on five separate cruises (two during May 2005, one during February, June and October 2006) at random locations within the shelf, at the shelf-edge, and offshore. There was a significant difference in larval abundances between the different shelf locations (Kolmogorov-Smirnov, $p<0.01$). The distribution of Echinodermata larvae was primarily within the shelf. Although not significant, Asteroidea larvae were found in greater abundances at the shelf-edge and oceanic stations compared to the other echinoderm larvae. A large patch of *Diadema* larvae was collected within the shelf in May 2005 (203,380,413 ind/100m3± SD 1,867,481). However, no *Diadema* larvae were collected in nearby oceanic waters, suggesting that the early larval stages of these larvae are mainly distributed within the insular shelf. The inconsistent patterns of echinoderm larvae at the different spatial stations during this study reflect the patchiness in their distribution.

## 14.482

**Microsatellite Analysis Of Population Structure in Coral *montastraea Faveolata* From Mexican Caribbean**

**José Héctor LARA ARENAS*[1]**, Renata Bárbara RIVERA MADRID[2], Jesús Ernesto ARIAS GONZÁLEZ[1]

[1]Laboratorio de Ecología de Ecosistemas de Arrecifes Coralinos, Centro de Investigación y de Estudios Avanzados (CINVESTAV), Mérida, Mexico, [2]Departamento de Bioquímica y Biología Molecular de Plantas, Centro de Investigación Científica de Yucatán (CICY), Mérida, Mexico

Molecular genetic techniques, particularly DNA microsatellite markers, have contributed substantially to understand connectivity patterns of marine populations in recent years. In this work, variation at five nuclear loci of *Montastraea faveolata*, one of the more widely distributed and major reef builder corals in the West Atlantic Sea, is evaluated in order to assess genetic structure at regional scale in Mexican Caribbean. A total of 393 samples were collected from 13 sites located on five reefs (Puerto Morelos, Cozumel, Boca Paila, Mahahual, and Chinchorro). Five nuclear loci were amplified using fluorescent-labelled microsatellite markers and genotyped by mean a DNA analyzer system. After a $F_{IS}$ analysis, significant departures from Hardy-Weinberg Equilibrium were found on every population, meaning that inbreeding occurs at these reefs. Although Factorial Correspondence Analysis revealed a subtle population structure, AMOVA demonstrated that no significant genetic differences exist among reefs, and that a considerably high proportion of variation resides within populations. Weir and Cockerham's $F_{ST}$ values and Nei's unbiased distances showed that weak genetic differences exist between Mahahual, which has been characterized as having geomorphological particularities, and the other four reefs. Mantel test based on Nei's unbiased distances of the whole set of 13 samples suggested that a stepping-stone model may underlie the restricted gene flow in this case ($R^2$= 0.21, $p$ = 0.043). In accordance with this study, dispersion levels of *M. faveolata* larvae could be relatively low at regional scale in Mexican Caribbean. This results shall provide useful information to properly focus conservation strategy efforts.

## 14.483

**Influences Of Wind-Wave Exposure On The Distribution And Abundance Of Recruit Reef Fishes On Back Reefs At Kure And Pearl & Hermes Atolls, Nwhi**

**Brian J. ZGLICZYNSKI*[1]**, Edward E. DEMARTINI[2], Raymond C. BOLAND[3], Alan M. FRIEDLANDER[4]

[1]Coral Reef Ecosystem Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Fishery Biology and Stock Assessment Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, [3]Ecosystems and Oceanography Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, [4]National Centers for Coastal Ocean Science-Biogeography Program, NOAA, National Ocean Service, Waimanalo, HI

In situ surveys of recruit (≤ 5 cm total length, TL) and resident piscivore (> 5 cm TL) reef fishes and benthic habitats were conducted at Kure (KUR) and Pearl and Hermes (PHR) atolls in the Northwestern Hawaiian Islands (NWHI) during July-August 2007. Totals of 30 and 57 stations were surveyed at approximately 0.5 km spacing around the entire back reef perimeters of the two atolls (KUR: 23 km; PHR: 65 km). ANCOVAs were used to evaluate the effects of resident piscivore biomass density (biomass) and a benthic habitat metric on the numerical densities of recruit fishes on windward (exposed to prevailing NE trade winds) versus leeward (protected from trade winds) sectors of back reefs at the two atolls. The piscivore covariate and recruit densities were positively related but the habitat covariate explained little observed variation in recruits (mean coral cover ranged from 6 to 7 % among atoll-exposures). Five species of Hawaiian endemic fishes (four labrids: *Stethojulis balteata*, *Thalassoma duperrey*, *Macropharyngodon geoffroy*, *Coris venusta*, and one scarid: *Scarus dubius*) comprised 90-95% of all recruits throughout windward and leeward sectors. Recruit densities were generally greater overall at PHR and lower at the windward sectors of each atoll. Small (≤ 2 cm) recruits of each of four of the five top-ranked species, moreover, were disproportionately less abundant (by 44-81 %) along leeward versus windward PHR. These observations suggest that the windward barrier reef at PHR, the atoll with the 3-fold larger perimeter, has a more prominent physical lee that affects the advective transport and settlement of reef fishes at this atoll.

## 14.484

**Community-Based Mpa in Fiji Affords Reasonable Protection To Lethrinids**

**Rikki GROBER-DUNSMORE*[1]**, Victor BONITO[2], Team KABATIA[3]

[1]NOAA, National Marine Protected Areas Center, Santa Cruz, CA, [2]Reef Explorers, Votua, Fiji, [3]Votua Village, Korolevu District, Votua, Fiji

Acoustic tagging was used to assess the effectiveness of a community-based MPA in Votua village, Fiji for protecting targeted reef fishes. In collaboration with local communities, research evaluated whether Lethrinids captured at common village fishing areas are part of the same population as those intended for conservation within the adjacent MPA. Lethrinids were caught within and outside the MPA, implanted with acoustic tags, and their movements tracked for up to 5 months. Fishes tagged from disparate habitats exhibited different temporal and spatial diurnal patterns of movement. Fishes tagged in the channel were detected predictably inside the channel during the day, but at night left the channel and were detected on adjacent reef flat habitat, though not within the MPA. Fishes tagged on the reef flat moved primarily during the night within reef flat habitat, and were detected periodically in the channel. These fishes crossed MPA boundaries moving freely across the continuous fringing reef-flat habitat, travelling distances up to 1 km. Although the entire home range of Lethrinids does not appear to be incorporated within the present MPA design, the MPA may afford considerable protection of Lethrinids, since fishing pressure is almost exclusively during the day. Fishes generally left the MPA during the night, and consequently may derive temporal refugia from fishing pressure. Comprehensive diurnal habitat requirements may be met with minor adjustments in MPA boundaries. Finally, fishes that reside primarily outside the MPA may be afforded benefits by the MPA, since the reef flat area appears to be used for foraging. Landscape ecology can assist in understanding interactions between movement behavior and the spatial patterning of the seascape, ultimately leading to more ecologically-meaningful decisions for designing MPAs and identifying essential fish habitat.

## 14.485

**Mesophotic Coral Reefs (30-100m), A Frontier Of Reef Exploration**

**Robert GINSBURG*[1]**, John REED[2]

[1]University of Miami, Miami, FL, [2]Harbor Branch Oceanographic Institution, Fort Pierce, FL

Mesophotic reefs (30-100m) have surprising luxurious communities of hermatypic corals, gorgonians, sponges, and algae that occur extensively on steep slopes, terraces and submerged banks throughout the Tropical North Atlantic (TNA: Caribbean, Gulf of Mexico, Florida, Bahamas). Their high structural complexity provides habitats for exploitable fish and shellfish and settling juvenile fish, spawning sites for commercial reef fish, potentially useful bioactive compounds and the focus of deep scuba diving. Furthermore, these reefs, isolated from natural and anthropogenic near-surface impacts, may serve as refugia for fish, corals and invertebrates that could repopulate degraded shallow reefs.

Steep slopes extending some 24,000 km are the most extensive habitat for mesophotic reefs in the TNA. Among the largest of these are around Bahama Banks (5,300 km), Central America including the Mesoamerican Barrier Reef (4,900 km) and Cuba (3.200 km). In addition, several small submerged banks and shelves at depths of 30-50+ m also have luxurious mesophotic coral communities (Tortugas Bank, Flower Garden Bank, Saba Bank and the Nicaragua Rise). The tools to explore and characterize these mesophotic reefs are readily available: side-scan sonar, ROVs, AUVs, multibeam, technical diving using mixed gas and closed circuit rebreathers. Initial research on mesophotic reefs has been limited but surprisingly productive; results include:

Coral cover of 50% or more

Maximum depth -130 m.

Large carnivores locally abundant.

Shallow reef fish species and juveniles to 60 m

Accreting steep slopes preserved by rapid cementation.

That so much has been discovered with relatively little efforts indicates how many new findings are expectable; for example about the biotic composition its zonation and trophic structure as well as the history of accumulation of mesophotic reefs as related to established changes is sea level.

## 14.486

**Patterns Of Genetic Variation Of The Corallimorpharian, *ricordea Florida***

Luis RODRIGUEZ[1], **Hernan TORRES-PRATTS*[2]**, Tania LADO-INSUA[3], Nikolaos SCHIZAS[4]

[1]Marine Science, University of Puerto Rico Mayaguez, Ponce, Puerto Rico, [2]Marine Science, University of Puerto Rico Mayaguez, Hormigueros, Puerto Rico, [3]University of Vigo, Spain, Lajas, Puerto Rico, [4]Marine Sciences, University of Puerto Rico Mayaguez, Lajas, Puerto Rico

The long-distance dispersal potential of marine larvae is crucial to the maintenance of populations. We examined the genetic variation of the corallimorpharian, *Ricordea florida*, in order to identify the connectivity patterns among populations. *Ricordea florida* is distributed throughout the Caribbean region and is heavily harvested in the marine aquarium trade. Samples were collected from three geographically distant Caribbean locations (Curaçao, Florida, and Puerto Rico). Our DNA data consisted of two mitochondrial introns and the nuclear rDNA interspacer regions ITS-1 and ITS-2. Our preliminary analysis revealed several haplotypes with the mitochondrial markers, however we did not identify genetic differentiation between locations. In contrast, all of our Curaçao samples were characterized by a very distinct ITS-1/ITS-2 haplotype, found twice in Puerto Rico and never in Florida, so far. Even though our mitochondrial data suggest no significant population structure, our nuclear interspacer regions suggest two distinct lineages. We are in the process of adding more locations and specimens to uncover the genetic population history of *Ricordea florida*.

## 14.487

**Fine-Scale Population Structure Of *symbiodinium* Associated With The Common Caribbean Sea Fan *gorgonia Ventalina* in The Florida Keys**

**Nathan KIRK*[1,2]**, Jason ANDRAS[3], Mary Alice COFFROTH[4]

[1]Biology, Auburn University, Auburn, AL, [2]Biology, Auburn University, Auburn, [3]Ecology & Evolutionary Biology, Cornell University, Ithaca, NY, [4]Geology, State University of New York at Buffalo, Buffalo, NY

Many marine cnidarians form endosymbiotic relationships with dinoflagellates in the genus *Symbiodinium*. Although high levels of genetic diversity have been described within the genus, the common Caribbean sea fan, *Gorgonia ventalina*, has been previously shown to associate specifically with a single "type" (*Symbiodinium* ITS "type" B1). Here, we elucidated the population structure and biogeography of this *Symbiodinium* "type" in *G. ventalina* along the Florida Keys reef tract. Six polymorphic microsatellite loci, three dinucleotide and three trinucleotide repeats, were utilized to examine 16 populations in the Upper, Middle, and Lower Florida Keys, which span a range of ~200 km. In spite of alleles being shared among reefs, significant genetic structure was observed in 84 out of 120 pairwise population comparisons, suggesting *Symbiodinium* has limited dispersal. In addition, significant population structure was found between *Symbiodinium* populations at deep and shallow sites of the same reef. Although populations of *Symbiodinium* tended to cluster by reefs in close proximity to each other, tests of isolation by distance were not significant. Two Lower Keys sites having similar population structure as sites in the Upper Keys potentially explain this discrepancy. Lastly, a population of *G. ventalina* collected from a man-made reef established in 1986 in the Middle Keys harbored *Symbiodinium* populations not significantly different from a nearby natural population. These data imply that recruitment of *Symbiodinium* into a new host population occurs at localized geographic scales.

## 14.488

**Genetic Structure of the Massive Coral Porites panamensis (Anthozoa: Scleractinia) from the Mexican Pacific**

**David Arturo PAZ-GARCÍA*[1,2]**, Francisco CORREA-SANDOVAL[2], Héctor Efrain CHÁVEZ-ROMO[1,2], Hector REYES-BONILLA[3], Ramón Andres LÓPEZ-PÉREZ[4], Pedro MEDINA-ROSAS[5], Martha Patricia HERNÁNDEZ-CORTÉS[6]

[1]Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico, [2]Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Ensenada, Mexico, [3]Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico, [4]Instituto de Recursos, Universidad del Mar, Puerto Ángel, Mexico, [5]Centro Universitario de la Costa, Departamento de Ciencias, Universidad de Guadalajara, Puerto Vallarta, Mexico, [6]Laboratorio de Bioquímica, Centro de Investigaciones Biológicas del Noroeste., La Paz, Mexico

Genetic structure was studied on the brooding coral species *Porites panamensis* at three areas of coral development from the Mexican Pacific (MP): Gulf of California (GC), Bahia de Banderas and Bahias de Huatulco. The collections were realized in: Bahia de Los Angeles (BLA), Bahia Concepcion (BCO), south of Bahia de La Paz (BLP) inside of the GC; two zones at the entrance of the GC, Punta Arenas de la Ventana (PAV) and Isla Redonda (IRD), and one location at south of MP, La Entrega (LET). The study was conduced by allozyme electrophoresis using polyacrilamide gels. Five loci were detected using four enzyme systems. We observed exclusive genotypes from the populations of BLA (*LGG-1*$^{DE}$ and *LGG-1*$^{EE}$) and LET (*EST-1*$^{AA}$ and *EST-1*$^{AB}$). The highest genetic variation was observed on BLA and the lowest on IRD. Most of populations presented significant deviations of Hardy-Weinberg equilibrium in deficits of heterozygotes. These deficits could be for 1) different recruitment events of cohorts and mixes of adult colonies of diverse coral communities; 2) different temporal events of larvae expulsion along the MP; 3) high local recruitment and endogamy for limited dispersion of larvae; and 4) different mortality events by natural disturbances. The dendrogram of genetic distance showed three groups: the populations from inside of the GC, two populations from the entrance of the gulf, and the population of the south of MP as other cluster. Mean significant FST value (FST = 0.104) reveled a genetic structure on the populations of the coral *P. panamensis* from the MP. The oceanic patterns coupled with restricted dispersion of this brooding coral species could be the principal factor that generating the genetic structure observed on the populations of *P. panamensis* from the MP.

## 14.489

**Genetic Structure Of A Scleractinian Coral, Pocillopora Damicornis, in The Mexican Pacific**

**Héctor Efraín CHÁVEZ-ROMO*[1,2]**, Francisco CORREA-SANDOVAL[2], David Arturo PAZ-GARCÍA[1,2], Hector REYES-BONILLA[3], Ramón Andrés LÓPEZ PÉREZ[4], Pedro MEDINA-ROSAS[5], Martha Patricia HERNÁNDEZ-CORTÉS[6]

[1]Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico, [2]Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Ensenada, Mexico, [3]Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico, [4]Instituto de Recursos, Universidad del Mar, Puerto Ángel, Mexico, [5]Centro Universitario de la Costa, Departamento de Ciencias, Universidad de Guadalajara, Puerto Vallarta, Mexico, [6]Laboratorio de Bioquímica, Centro de Investigaciones Biológicas del Noroeste, La Paz, Mexico

Genetic structure was studied on the coral *Pocillopora damicornis* in three principal areas of coral development of the Mexican Pacific (MP). Specimens of *P. damicornis* were collected from six localities: El Portugues (POR), Punta Gaviotas (PGA) and Punta Arena de la Ventana (PAV) located inside the Gulf of California (GC), La Isla Redonda (IRD), in Bahia de Banderas (BDB), Las Dos Hermanas (LDH) and La Entrega (LET), Oaxaca (OAX). The samples were examined using allozyme electrophoresis in polyacrilamide gels. Six loci were scored from four enzyme systems. Exclusive genotypes were observed in the populations of PGA (LGG-1BC), LDH (LGG-1BC y LGG-1CD) and LET (LGG-1CD). We detected a high genetic variation in LDH, PGA y LET, while it was low in PGA, PAV and IRD. Most of the populations presented heterozygous deficits and they are not adjusted the model of Hardy-Weinberg. These deficiencies can be due to the predominance of the asexual reproduction by fragmentation, different mortality events by natural disturbances, inbreeding and/or Wahlund effect among localities. The UPGMA dendrogram based on Nei's unbiased genetic distance showed clear three groups: I) two populations inside the GC (POR and PGA), II) those located in the entrance of the gulf (PAV and IRD) and III) the two populations located to the south of the MP (LDH and LET). Mean significant FST value (FST = 0.153) indicates a genetic structure in the populations of *P. damicornis* of the MP. Differences in sexual (spawning gametes) and asexual (fragmentation) reproduction among the localities of the MP, local recruitment and currents patterns are possibly generating the genetic structure in the populations of *P. damicornis* in the MP.

## 14.490

**Genetic Variation in Two Morphotypes Of Porites Panamensis From The Gulf Of California, Mexico**

**David Arturo PAZ-GARCÍA*[1]**, Hector REYES-BONILLA[2], Martha Patricia HERNÁNDEZ-CORTÉS[3]

[1]Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, Mexico, [2]Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico, [3]Laboratorio de Bioquímica, Centro de Investigaciones Biológicas del Noroeste., La Paz, Mexico

Genetic variation was studied in order to clarifying the taxonomic position between two morphotypes of *Porites panamensis* from four sites in the Gulf of California, Mexico. The study was conduced by allozyme electrophoresis using polyacrilamide gels. Ten loci were detected using four enzyme systems. No fixed alleles were detected between morphotypes. The number of alleles per locus (columnar 1.9-2.4 and massive 2.1-2.3) and heterozigosity was similar between morphotypes (columnar 0.331-0.486 and massive 0.331-529), and most were close to the Hardy-Weinberg expectations. The ratio of number of observed genotypes to the number of individuals (*Ng:N* 0.76-1.00) and the ratio of observed to expected genotypic diversity ($G_o$:$G_e$ 0.71-1.00) for both morphotypes indicate high sexual reproduction. The AMOVA indicated a greatest and significant genetic variation within populations (97.85%) and among populations within morphotypes levels (2.63%), but not among morphotypes (-0.47%, p = 0.6826). The dendrogram of genetic distance showed three groups by geographical proximity, north populations of both morphotypes, central massive populations, and central-southern populations as other cluster. Mean significant FST values for columnar (FST = 0.024) and massive (FST = 0.043) suggest that both morphotypes had a moderate to low genetic structure within their populations. The number of migrants per generation (*Nem*) showed differences within morphotype populations (columnar 4.65-31 and massive 2.65-9.75). The lower genetic differentiation among morphotypes indicates that represent the same species and the variation observed may depend to a combination of morphotypes intrinsic factors in combination with the predominant oceanographic conditions.

## 14.491

**Distributions And Diversity Hot-Spots Of Gobies And Blennies Throughout The Tropical Western Atlantic: Implications For Managing Caribbean Reef Fish Diversity**

**Christy PATTENGILL-SEMMENS*[1]**, Peter AUSTER[2], Brice SEMMENS[3,4]

[1]Reef Environmental Education Foundation (REEF), Key Largo, FL, [2]University of Connecticut, Groton, CT, [3]NOAA Fisheries, Seattle, WA, [4]NOAA Fisheries, Seattle

We took advantage of a large database of reef fish presence and abundance to assess the biogeographic patterns of Gobidae and Blennidae, two families of reef fishes that are often over-looked in community assessments. Over the past decade the Reef Environmental Education Foundation (REEF) Volunteer Survey Project has generated over 95,000 visual surveys of reef fish assemblages from 5,800 sites throughout the tropical western Atlantic. Because these surveys exhaustively characterize fish taxa, they provide a unique set of information on rare and cryptic species. Previous studies of species ranges have found little support for a relationship between larval duration and range size. On the other hand, members of Gobidae and Blennidae tend to have variable larval stages and exhibit greater habitat specificity than other reef fish families. We found Gobidae and Blennidae diversity to be disjointed across the Caribbean basin. Moreover, a small number of disparate locations exhibited surprisingly high levels of diversity. These areas of high diversity may have resulted from: a) oceanographic bottlenecks or entrainments that yield high recruitment, b) high habitat diversity , or c) both. Regardless of the mechanism, these areas should be given special consideration in regional conservation efforts aimed at biodiversity.

## 14.492

**Genetic Connectivity in The Branching Vase Sponge (*callyspongia Vaginalis*) Across The Florida Reef Tract And Caribbean**

**M. B. DEBIASSE*[1]**, V. P. RICHARDS[1], M. S. SHIVJI[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL

The Porifera constitute a substantial fraction of the biomass on coral reefs and frequently have higher species diversity than corals and algae, making this phylum an important model for the investigation of reef connectivity. We examined genetic connectivity in the common branching vase sponge, *Callyspongia vaginalis*, by analyzing DNA sequence variation in 511 bp of the mitochondrial cytochrome oxidase I (COI) gene in 401 individuals sampled from 16 locations throughout the Florida reef tract and Caribbean. Populations of *Callyspongia vaginalis* were highly genetically structured over the study area ($\Phi ST = 0.48$, $P < 0.0001$), including over distances as short as tens of kilometers within the Florida reef tract, and had a significant overall pattern of isolation by distance ($P = 0.0002$). However, nonsignificant pairwise ΦST values were also found between a few Florida sampling sites suggesting that long distance dispersal, perhaps by means of fragmentation, may occur over continuous, shallow coastlines. Indeed, sufficient gene flow appears to occur along the Florida reef tract to obscure a signal of isolation by distance ($P = 0.164$), but not to homogenize haplotype frequencies over 465 km from Palm Beach to the Dry Tortugas. Statistical parsimony analysis revealed two highly divergent haplotypes from Honduras suggestive of cryptic speciation. Inferences from a nested clade analysis supported the pattern of restricted gene flow and isolation by distance in the Caribbean, and suggested a northward range extension of *C. vaginalis* from a hypothesized Central American ancestral population into the Gulf of Mexico and Florida. The extensive genetic structuring in this common reef sponge is consistent with expectations based on typically short sponge larval durations, suggesting that sponge recruitment to coral reefs may be largely local source driven.

## 14.493

**Stuck in A Hole: Extreme Differences in Genetic Differentiation Between Closely Related Caribbean Tube Blennies**

**Ron I. EYTAN*[1]**, Michael E. HELLBERG[1]

[1]Department of Biological Sciences, Louisiana State University, Baton Rouge, LA

*Acanthemblemaria spinosa* and *A. aspera* are closely related species of tube blennies inhabiting coral reefs in the tropical Western Atlantic. Both are obligate dwellers of vacated invertebrate holes in corals and hard substrates and co-occur across much of their ranges. They have similar life histories and pelagic larval durations, and as such should be expected to show similar levels of genetic differentiation among populations. Instead, an initial survey of mitochondrial sequence variation (741 bp of *cytb*) revealed extreme differences between the two species in their degree of population subdivision. While both species rarely share mitochondrial DNA (mtDNA) *cytb* alleles among populations, the genetic distance between alleles is over 10-times greater within *A. spinosa* than *A. aspera*. The objective of this study was to determine whether ecology, mutation rates, or taxon age underlies the difference between these species. To establish which of these mechanisms are responsible, sequences were collected from two single copy nuclear DNA markers (scDNA). *A. spinosa* has more specialized habitat requirements than *A. aspera* and more specialized species are expected to share fewer alleles among populations than generalists. On the other hand, if the species have the same propensity to share alleles between populations but the genetic distances among those alleles are greater for one species than the other, and that species is not much older, differences in mutation rates may be responsible. The scnDNA sequences show a pattern similar to that for mtDNA, with far greater genetic distances within *A. spinosa* than *A. aspera*. Phylogenetic comparisons with other *Acanthemblemaria* species show that species age is not a factor. This suggests that a higher mutation rate in *A. spinosa*, rather than greater ecological specialization, is responsible for the extreme differences in genetic subdivision between these two species. However, demographic differences may also be a contributing factor.

## 14.494

**Ichthyoplankton Assemblages in Atolls Along Cagayan Ridge, Sulu Sea, Philippines**

**Wilfredo CAMPOS*[1]**, Pacifico BELDIA[1]

[1]Division of Biological Sciences, University of the Philippines Visayas, Miag-ao, Iloilo, Philippines

The Sulu Sea possesses unique hydrographic features which result in high endemicity and biodiversity in the basin. It is believed that the atoll reefs of the Cagayan Ridge form a major corridor through which planktonic (fish) larval dispersal is facilitated. To examine this, ichthyoplankton surveys were conducted in April 2006 to determine the abundance, composition and distribution of fish eggs and larvae in the immediate vicinity of the Tubbataha Reefs and Cagayancillo Island. In general, egg and larval densities were highest inside the atolls and decreased with distance from the reef margin. Densities in Cagayancillo were 2.9 eggs/$m^3$ and 49.7 larvae per 100$m^3$. These were comparable to observations in Tubbataha (2.2 eggs/$m^3$ and 35.2 larvae/100$m^3$). Larvae of coastal fishes dominated the assemblages in both reef systems, although the proportion of larvae of deep water groups (e.g., myctophids and gonostomatids) was much higher in Tubbataha. The distribution of larval assemblages corresponded somewhat with the formation of island wakes. The potential role of these atoll reefs as sources of propagules for downstream reef systems is examined further through results of short-term drift experiments.

## 14.495

**Crisis Of Coral Metapopulations in Okinawa, Southern Japan**

**Kazuhiko SAKAI*[1]**

[1]Tropical Biosphere Research Center, University of the Ryukyus, Okinawa 905-0227, Japan

Coral communities on coral reefs are declining worldwide by global climate change and local degradation of coral reef environment. In Okinawa Prefecture, southern Japan, coral communities have been declining, but the status of the community varied greatly among islands. After the 1998 mass-coral bleaching, percent cover of corals was decreased by 80% around Okinawa I., but the cover remained relatively high at Kerama Is., which is located at 30 km west of Okinawa I. Coral communities are more healthy at Sakishima Is., which are at >300 km southeast of Okinawa I. I obtained the following results from ecological studies that I have been conducting since 1980 in Okinawa I.

1) Recovery of coral communities in Okinawa I. was reduced greatly after the bleaching; 2) For broadcasting spawning corals, Kerama Is. was the source area of larval supply to Okinawa I.; 3) The reduced resilience of coral communities in Okinawa I. was caused by decreased larval supply during two years after the bleaching and low survival rate of juvenile corals that were recruited abundantly in 2001; 4) Settlement of coral larvae in Okinawa I. decreased greatly after *Acanthaster* outbreak that started in Kerama Is. in 2001; 5) Coral metapopulations are likely to be separated between Okinawa-Kerama and Sakishima regions even for spawning corals whose larvae disperse long distance. The observed great reduction in supply of coral larvae in Okinawa I. may indicate that whole coral communities within the area of larval dispersal (coral communities with in connected reefs) lose the recovery potential rapidly when global climate change and local degradation of coral reef environment progress simultaneously.

## 14.496

**Distribution Of The Hermatypic Corals in Dongshan, Fujian Province, China And The Possible Link To The Tropical Warm Current Kuroshio**

**Jiansheng LIAN*[1]**, Hui HUANG[1], Jianhui YANG[2], Xiubao LI[1]

[1]LMB, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of, [2]South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of

Along mainland China's coast, the northmost marginal distribution of the hermatypic coral community was found in Dongshan, Fujian Province (23.5°N~23.8°N). Dongshan is located in the southern tip of the Taiwan Strait, facing Luzon Strait to the east. It is interesting to observe an unusual phenomenal that there is no hermatypic corals distribution below Dongshan until Daya Bay (22.5°N~22.9°N). The distance between Dongshan and Daya Bay is about 330 km and 1 degree in terms of latitude. We carried out an extensive and systematic survey of the hermatypic coral status in Dongshan using line transect method from 2005 to 2007 to study the distribution range and try to find out why the marginal distribution of the hermatypic coral community can reach to Dongshan. A total of 58 stations were surveyed. Six 10 meters transect lines were completed for each station with two depth contours.

Five species of the hermatypic corals was recorded: *Favia speciosa*, *Cyphastrea serailia*, *Turbinaria peltata*, *Leptastrea* sp., *Goniopora* sp. , ordered by the extent of their distribution range. The first three are dominant species. Comparing the earlier survey conducted from 1995 to 1997, two species *Porites lutea* and *Acropora pruinosa*,was disappeared, however, a new species *Goniopora* sp. was recorded and the three dominant species were the same. This indicated fast species turnover rate by species colonization. In terms of the live coral cover, the highest total coral cover was 33%, and *Turbinaria peltata* was the most dominant (its coral cover can reach to 31%).

We also observe that the water mass along Dongshan area is high salinity and high temperature compare to that of nearby area and the lowest water temperature is 14 degree Celsius.

Combined evidences suggested the water mass along Dongshan area is strongly influenced by the tropical warm current Kuroshio.

## 14.497

**Genetic Population Structure in A Widely Distributed Tropical Species Of Sea Cucumber, *holothuria (Halodeima) Atra.***

**Timothy WERNER*[1,2]**, Derek SKILLINGS[3], Benita CHICK[4]

[1]Biology, Boston University, Boston, MA, [2]New England Aquarium, Boston, [3]University of Hawaii, Kaneohe, HI, [4]Boston University, Boston, MA

*Holothuria atra* has one of the widest geographic distributions for any sea cucumber, ranging longitudinally from the Red Sea and Western Indian Ocean to the Panamaic region of the eastern Pacific. Typically it is locally abundant throughout its range, although this may be affected by the extent to which it is exploited as part of the international food trade. *H. atra* is capable of reproducing both sexually and asexually, a trait that it shares with only a small percentage of holothurians. We performed a population genetics analysis using 411 nucleotide bases of CO1 mitochondrial DNA from more than 600 individuals of *H. atra* sampled throughout its range, with the majority drawn from Indonesia and the Hawaiian Islands. Data were analyzed to determine evidence for population structure at multiple geographic scales, such as between regions separated by long distances and well-defined biogeographic barriers, and within sub-regions that included principally the Indonesian and Hawaiian archipelagoes. Based on an analysis of molecular variance (AMOVA) from Indonesian populations, most of the genetic variability (~80%) was explained by variation within local populations, and no obvious phylogeographic patterns were observed. In contrast, there was a significant genetic break between the Northwest Hawaiian Islands and the main Hawaiian Islands, even though the east-west geographic extent of this island chain is approximately two-thirds that of the Indonesian islands. Our results are discussed in the context of long-distance larval dispersal, physical barriers to gene flow, and reproductive strategy.

## 14.498

**Human Exploitation Of Invertebrates in Seagrass Meadows in East-Africa**

**Lina NORDLUND*[1]**, Johan ERLANDSSON[1], Martin GULLSTROM[2]

[1]Department of Systems Ecology, Stockholm, Sweden, [2]Department of Zoology, Stockholm, Sweden

Seagrasses form dense vegetative meadows which are dominating habitats of the coastlines around the world. Seagrass meadows are of ecological importance providing high biodiversity and production of both plants and animals. They are vital for fish as well as invertebrates, since they use these habitats for foraging, protection against predators, and as nursery grounds. The seagrass meadows play a significant role in the coastal environment as they often function as a link between mangroves and coral reefs. They provide protection against coastal erosion and many commercially important species use seagrass meadows as their habitat, which gives the meadows great economical value. Due to the high productivity and the significant role for coastal fisheries, seagrass meadows constitute a great direct value for humans in many tropical rural communities.

The study objective is to investigate how collection of invertebrates in seagrass meadows influences the seagrass ecosystem in East-Africa. The study was performed by collecting biological data and interviewing invertebrate collectors in Mozambique and Tanzania. Abundance, biomass, and community structure of invertebrates, as well as seagrass characteristics have been compared between exploited and unexploited sites.

The results show that invertebrate collection negatively affects abundance, biomass, and community composition of invertebrates in the seagrass meadows. Since seagrass and coral reef ecosystems are closely linked, there is a high possibility that the associated coral reef also will be affected by decreasing quantities of migrating invertebrates as well as less available feed for reef associated animals entering the seagrass ecosystem to forage.

## 14.499

**Do Mangroves And Seagrass Beds Contribute To Coral Reef Fish Productivity in The Indo-Pacific?**

**Richard UNSWORTH*[1]**, Pelayo SALINAS DE LEON[2], James BELL[3], Samantha GARRARD[4], David SMITH[5]

[1]SKM Consulting, Brisbane, Australia, [2]School of Biological Sciences, Victoria, University of Wellington, Wellington, New Zealand, [3]School of Biologica Sciences, Victoria, University of Wellington, Wellington, New Zealand, [4]Plymouth University, Plymouth, United Kingdom, [5]University of Essex, Colchester, United Kingdom

Coastal marine ecosystems are increasingly threatened across the indo-pacific region; yet the faunal interactions that exist between the different component habitats of these ecosystems remain poorly understood. This information is vital as stress on one inter-connected habitat may have cascade effects on other habitats. Promoting and raising the conservation importance of biodiverse yet unappealing habitats such as seagrass beds and mangrove forests requires a better knowledge of their connections to coral reefs and their use as fishing grounds. By extensively examining the fish assemblages of seagrass beds, mangroves and coral reefs within Eastern Indonesia we have developed a greater understanding of the usage of these habitats by fish assemblages and individual fish species. Our research found that seagrass beds were an important feeding habitat and nursery ground for many species and families of reef fish, this nursery role was found to be highly influenced by the presence of mangroves and the link with nearby coral reefs. Fish abundance and species richness in seagrass beds in close proximity to mangroves was at least twice that found in seagrass beds that were distant from mangrove habitats. We also found data to suggest that individual coral reef fish species may preferentially utilize certain environmental zones within those habitats at different stages of their development. Although indirectly important to seagrass and reef fish, mangroves are not an important juvenile reef fish habitat but harbor juveniles of many fish species of economic and subsistence importance across the indo-pacific. Our study indicates that Indo-Pacific seagrass beds play an enhanced role as fish nurseries, but this is influenced by the availability of nearby reef and mangrove habitats, and provides information to support the use of ecosystem level management of coral reef and associated fisheries within the Indo-Pacific region.

## 14.500

**Genetic Connectivity Of *siganus Fuscescens* Populations Along The Northwest Luzon Coast Based On Microsatellite Data**

**Rachel RAVAGO GOTANCO*[1]**, Candice LUMIBAO[2], Ma. Josefa PANTE[1]

[1]The Marine Science Institute, Quezon City, Philippines, [2]The Marine Science Institute, Quezon CIty, Philippines

Estimating the rates, extent, and patterns of connectivity among populations is important in the study of the population biology of marine organisms, and assumes critical importance in the design of spatially explicit management and conservation schemes. This study employs molecular genetic techniques to examine levels and patterns of connectivity among populations of the mottled rabbitfish, Siganus fuscescens, a valuable fishery species widely distributed in seagrass-dominated reef flats. Samples were collected from six sites along the northwest Luzon coast: Currimao, Ilocos Norte ; San Fernando, La Union; Bolinao, Pangasinan; Masinloc, Zambales; Morong, Bataan; and Padre Burgos, Quezon. Individuals were genotyped at 10 microsatellite loci. Population genetic diversity estimated from multilocus genotypes indicated high levels of heterozygosity (ranging from 0.66 to 0.79) among the six populations. Significant genetic differentiation was observed over all six populations (Fst = 0.047; P < 0.0001), spanning a distance of ~650 km. An analysis of molecular variance (AMOVA) was performed to test the significance of various hypothetical spatial genetic structures. AMOVA results suggest the most likely partitioning of the six populations into three genetically distinct groups broadly consistent with geographical location: (1) Currimao (north); (2) San Fernando-Bolinao-Masinloc-Morong (central); and (3) Padre Burgos (south), with 16% of the total variance accounted for by among-group variation. There was no significant correlation between genetic distance and geographic distance. Relatively high levels of connectivity among samples from San Fernando to Morong (~250 km) were inferred, with these samples apparently constituting a single panmictic population. Connectivity between this central group and a southern site (Padre Burgos) appears to be greater than connectivity between the central group and a northern site (Currimao), which may be influenced by hydrographic features (current flow) and habitat availability.

## 14.501

**Genetic Evidence Supports Larval Retention in The Western Caribbean For An Invertebrate With High Dispersal Capability (*ophiothrix Suensonii*: Echinodermata, Ophiuroidea)**

**Vince RICHARDS*[1]**, Mahmood SHIVJI[1]

[1]The National Coral Reef Institute, Oceanographic Center, Nova SE University, Florida 33004 USA, Dania Beach, FL

Understanding connectivity at various spatial and temporal scales can aid in reef management. Here we report on the dispersal dynamics and demographic history of a coral reef invertebrate with high dispersal potential (up to 49 days larval duration in culture): the brittle star *Ophiothrix suensonii*. Mitochondrial COI sequences from 266 individuals collected from 10 locations throughout the Florida reef tract and Caribbean showed high overall connectivity ($\Phi ST = 0.05$). However, pairwise comparisons revealed three significantly differentiated regions: Florida, Honduras, and the remaining Caribbean, with Honduras showing substantially higher differentiation. A Bayesian analysis of migration was concordant with the AMOVA showing the lowest migration between Honduras and the remaining Caribbean. In contrast, migration rates between Honduras and Florida, and the Caribbean and Florida were considerably higher (19 and 45 times respectively). Despite long-range dispersal of *O. suensonii* throughout the wider Caribbean, the Honduras population appears isolated, and the persistent eddy current over the Meso-American Barrier Reef could be a major factor contributing to larval retention in this region. The phylogeographic pattern among haplotypes indicated a population expansion (confirmed by mismatch distribution) and coalescence analysis estimated that the expansion commenced approximately 300,000 years ago. A derived lineage dominated by Florida and virtually all Honduran haplotypes supports a colonization of Honduras from Florida. The large number of private haplotypes in Honduras and similar levels of molecular diversity for Honduras and Florida, suggest that Honduras has been genetically isolated for an extended period of time, likely predating the region wide population expansion. Finally, three widely distributed haplotypes formed a highly divergent lineage; the genetic distance between this lineage and the remaining haplotypes was comparable to other echinoderm congeners, suggesting cryptic speciation. The genetic isolation detected in Honduras, possibly due to local current patterns, highlights the need for independent management of reefs in this region.

## 14.502

**Contribution Of Mangrove Nursery Habitats To Replenishment Of Adult Reef Fish Populations in Southern Florida**

**David JONES*[1]**, John WALTER[2], Joe SERAFY[2]

[1]CIMAS, University of Miami - RSMAS, Miami, FL, [2]NOAA Fisheries, Miami, FL

The idea that connectivity between mangrove forests and coral reefs, mediated by ontogenetic migrations of reef fishes that use mangroves for nursery habitat, is crucial for the replenishment of adult populations on the reef has recently received renewed attention. However, direct evidence of this linkage and an understanding of the influence variability of juveniles within mangrove nurseries has on the dynamics of adult reef fish populations is still lacking for many species. The present work is part of a larger study integrating two long-term and on-going efforts in southern Florida using visual survey methods to monitor fishes inhabiting (1) the Florida Keys reef tract and (2) adjacent inshore mangrove nursery habitats in Biscayne Bay. Our objective was to synthesize both data sets to establish the nature and extent of the linkage between mangrove and reef habitats and construct predictive models of recruitment dynamics, based on the mangrove survey data, that account for environmental variation and allow estimation of reef fish stock size. Length and abundance data of eleven species of fishes from nine families collected during >1000 mangrove survey transects over a nine year period (1999-2007) form the basis of the analysis. Data were partitioned according to one spatial (mainland vs. key) and two temporal (season, year) treatments and a variant of MANOVA appropriate for ecological data was used to identify significant effects, establish the influence of five environmental variables (salinity, temperature, depth, dissolved oxygen, and proximity to freshwater discharge), and derive an index of recruitment (IR). Significant differences in length and abundance due to spatial, temporal, and interaction effects were present but varied with species. Examining the concordance between the mangrove-based IR and reef fish population size forms the basis of future work.

## 14.503

**Genetic Structure in Coral Recruitment: Evidence Of Extreme Patchiness in Settlement.**

**Daniel BRAZEAU*[1]**, Paul SAMMARCO[2], Amy ATCHISON[2]

[1]Pharmaceutical Sciences, University at Buffalo, Buffalo, NY, [2]Louisiana Universities Marine Consortium, Chauvin, LA

Many sessile marine benthic invertebrates live out their entire lives at a point determined at settlement. Thus relatedness among individuals at settlement may play an important role in determining the genetic structure of adult populations. Here we employ highly polymorphic AFLP markers to assess the micro-scale heterogeneity of Agaricia agaricites coral recruits onto to settlement plates within the NOAA Flower Garden Banks National Marine Sanctuary on the West Flower Garden Bank. Three blocks of racks were implanted at the study site at a depth of 21 m in a radial pattern. Each block contained three racks, implanted haphazardly as the substrate permitted within several meters of each other. Each rack held five settling plates. AFLPs were used to generate the necessary polymorphic markers to assess micro geographic structure among recruits to each plate. A total of 203 recruits from 28 plates were examined using 4 sets of AFLP primers that yielded 164 polymorphic markers with an overall marker frequency 0.28 (SD = 0.11), ranging from 0.05 to 0.54. The assignment-based program, STRUCTURE, was used to assess patterns of genetic structure among recruits on the plates on each rack, among racks at each block and among the 3 blocks. Rates of self-assignment of recruits collected from each block back to the same block ranged from 74.4% to 63.3%, indicating genetic heterogeneity at the scale of 10's of m's. In looking at racks within the blocks rates of self assignment ranged from 96.5% to 32.5%. Finally at the smallest spatial scale, plates within each rack rates of self assignment ranged from 53.7% to 96.5%. These data suggest a high level of genetic relatedness among recruits collected from individual plates indicating that recruitment, at least for that year, was due to the reproductive success of colonies in the immediate area.

## 14.504

**First Description Of A Southwestern Gulf Of Mexico Reefs**

**Horacio PÉREZ-ESPAÑA*[1]**, Juan Manuel VARGAS HERNÁNDEZ[2], Sarahi GÓMEZ VILLADA[3], Jacobo SANTANDER MONSALVO[1], Miguel Ángel LOZANO ABURTO[1], Alexandra ALVAREZ DEL CASTILLO CÁRDENAS[4], Miguel Ángel ROMÁN VÍVES[5]

[1]Centro de Ecología y Pesquerías, Universidad Veracruzana, Boca del Río, Mexico, [2]Facultad de Biología, Universidad Veracruzana, Xalapa, Mexico, [3]Universida Nacional Autonoma de Mexico, México, Mexico, [4]Universidad Autonoma de Baja California Sur, La Paz, Mexico, [5]Acuario de Veracruz A. C, Veracruz, Mexico

Reports of the existence of other reefs located southeast of the Veracruz Reef System (VRS) have been known for years, but due to difficult access research has, up to now, focused primarily on the area within VRS boundaries. We report the first quantitative evaluation of these reefs, which we named La Perla del Golfo Reefs. These reefs form a large structure measuring 13 kilometers along the coast line, with a maximum width of 0.5 kilometer and an approximate area of 137 ha. The land access to the reefs is severely limited by a narrow, rough dirt road. There are small villages near the reefs, whose people use it for fishing activities. Three sampling sites were selected (North, Center and South). Modified AGRRA was used to describe the benthic components of the reef. Coral coverage was 14.6% being *Diploria clivosa*, (10%) the most abundant species. Other important components were coralline algae (22%), turf (19.5%), *Dictyota* sp. (11.6%) and *Palythoa caribaeorum* (8%). Species list includes eight stony coral, two gorgonians, five urchins, four sponges, and nine algae. Non-metric Multi Dimensional Scaling (MDS) analysis was applied. Results suggest that North and South sites are similar among them and different from Center; which has fewer species. From the urchin censuses we found that *Echinometra lucunter* (89%) and *Echinometra viridis* (6.4%) were the more abundant species. Even when the La Perla del Golfo Reefs shows low coral coverage and species diversity, it is important because of their localization, between two reef systems – the VRS and the Campeche reefs-, thus contributing to the connectivity of species among these reefs.

## 14.505

**The Contribution Of Coastline Complexity And Embayment Attributes To Larval Dispersal Patterns in Several Areas Around Philippine Waters**

Cesar VILLANOY[1], **Marites CANTO*[1]**, Erlinda SALAMANTE[1]

[1]Marine Science Institute, University of the Philippines Diliman, Quezon City, Philippines

Basin shapes and other physical attributes of bodies of water partly determines hydrodynamic characteristics. Hydrodynamic models were used to describe these characteristics and were also used to drive dispersal models of larvae of reef organisms. The range of basin types varies from shallow and wide basins to deep embayments; and shallow barrier reefs, or large atoll systems. The dispersal patterns varies significantly for different types of embayments. Two similarly-sized bays in southern Mindanao, Philippines but with very different bathymetry features show larger dispersal scales for the shallow bay compared to the deep bay. Comparisons between simulated larval dispersal patterns from eight sites in the Philippines show that in some areas like Danahon Bank, Bohol there is a higher degree of self recruitment or retention compared to Bongao, Tawi-Tawi where dispersal transport is largely influenced by coastal jet passing through Sibutu Passage. Results obtained from these studies have also provided relevant information critical in the development of proper management approach of marine resources in these areas.

## 14.506

**Preliminary Characterization Of The Deep Reef Fish Communities And Their Connectivity With Shallow Water Reefs in Southwest Puerto Rico**

**Ivonne BEJARANO*[1]**, Richard S. APPELDOORN[1], Michael NEMETH[1], Héctor RUÍZ[1], Clark SHERMAN[1], Milton CARLO[1]

[1]Marine Sciences, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico

Mesophotic coral reefs are characterized by having a few species of light limited corals, but abundant species of sponges, soft corals, tunicates, and algae. The complexity and topographic relief provided by these sessile communities support a diverse reef fish community; for species depleted in shallow coral reefs, these may serve as a refuge. Critical to understanding the role of mesophotic reefs is the degree and direction of their connectivity to shallow reefs. Are deep reefs important genetic reservoirs with the potential of helping depleted shallow reef fish populations to recover, or are they relict populations dependent on inputs from shallow areas? Currently, a multidisciplinary study is being conducted at the University of Puerto Rico-Mayagüez to examine the biology, geology and ecology of deep-reef habitats between 50 and 100 m depth along the insular slope. Key to the capabilities of this study is the use of closed circuit rebreather diving for *in situ* surveying and experimental manipulations. Within this study, the fish fauna is being identified, counted and lengths estimated along 10-m long belt transects with the primary objective to characterize the fish communities associated with deep reefs in Puerto Rico, and to assess the connectivity between deep and shallow reefs. Fifty species have being identified with a mean of 13 per transect. The most abundant fishes are *Chromis insolata* and *Coryphopterus personatus*. Species of commercial value include *Lutjanus analis*, *Lutjanus apodus*, *Lutjanus jocu*, *Ocyurus chrysurus, Epinephelus fulvus*, *and Mycteroperca venenosa*. Except for *C. isolata*, the species most frequently observed in deep reefs are also common inhabitants of shallow reefs. However, *Centropyge argi*, *Chaetodon aculeatus*, *C. isolata*, and *Liopoproma sp.* are common on deep reefs while they are rare on shallow reefs.

## 14.507

**Genetic variation of the hydrocoral *Millepora alcicornis* across the Caribbean**

**Dannise RUIZ RAMOS*[1]**, Nikolaos SCHIZAS[1]

[1]Department of Marine Sciences, University of Puerto Rico at Mayagüez, Lajas, Puerto Rico

The hydrozoan genus *Millepora* is an important component of tropical reef contributing to the carbonate structure. Virtually nothing is known about the genetic polymorphism and divergence within and between *Millepora* species in the Caribbean. In a region where the alarming decline of scleractinian corals has attracted the attention of the scientific community, research in *Millepora* biology is limited. The objective of this work is to make a molecular characterization of the *Millepora* populations in the Caribbean region.

Samples of *Millepora alcicornis* were collected from 11 localities across the Caribbean; Honduras, Panama, Grand Cayman, Mona, Desecheo, Puerto Rico, Vieques, Culebra, St. Thomas, Bahamas, Curaçao and Bermuda. We sequences approximately 550 base pairs of the mitochondrial COI gene. Preliminary results from the COI analysis suggest high variability within the populations (87.95%), an elevated number of haplotypes (98 out of 238 sequences) and lack of population structure ($F_{ST}$ = 0.12). The single locus analysis indicates a high degree of genetic connectivity between Caribbean wide populations of *Millepora alcicornis* suggesting high dispersal rates. However, the medusa stage of *Millepora* lasts just a few hours in the water column, limiting the dispersal potential of *Millepora*. The absence of population structure contradicts our predictions stemming from the early life history of *Millepora*.

## 14.508

**Population Structure in The Brown Tube Sponge (*agelas Conifera*) in The Florida Reef Tract And Caribbean**

**J.M. HESTER*[1]**, V.P. RICHARDS[1], K. FELDHEIM[2], M.S. SHIVJI[1]

[1]National Coral Reef Institute, Oceanographic Center, Nova Southeastern University, Dania Beach, FL, [2]The Field Museum, Chicago, IL., Chicago, IL

Sponges are broadly distributed, occur in a wide range of habitats, and comprise a substantial amount of the biomass and macro-biodiversity on coral reefs. Despite their ubiquity in reef ecosystems, their dispersal dynamics are largely unknown. Here we report on gene flow and population structure for the common brown tube sponge, *Agelas conifera* (Demospongiae, Poecilosclerida) in the Florida reef tract and Caribbean. Over 300 samples collected from ten geographically distinct locations throughout Florida and the Caribbean are being analyzed for variation at eight microsatellite loci. Preliminary results from screening four loci in 295 individuals from eight locations indicated significant population structure overall (FST = 0.072; P = 0.0018) with a significant heterozygosity deficit (FIS = 0.310; P = 0.001). Lower FST values occurred within the Florida reef tract sites compared to those between Caribbean island locations suggesting relatively greater gene flow within the Florida reef system. Significant isolation by distance was not found to occur Caribbean-wide (r = 0.25; P = 0.14), nor within the Florida reef tract (r = 0.39; P = 0.10). Fine scale population structure occurred among sites separated by <1 km around the islands of Utila (Honduras) and St. Croix (USVI) suggesting *A. conifera* recruitment in these areas is highly local source dependant. In contrast, no structure was observed among sites around Grand Cayman (Cayman Islands). Only populations within St. Croix showed a significant isolation by distance pattern (r = 0.74; P < 0.001). The strong overall and in some instances even highly localized genetic structure observed is consistent with the typically short larval durations known for sponges generally; suggesting recruitment in these important reef biomass components may be driven mainly from local sources.

## 14.509

**Corals From Sisal Reefs System, Northwest Campeche Bank, Mexico: A Potential Role On The Caribbean-Gulf Of Mexico Connectivity?**

**Catarina CÚCIO*[1]**, Maite MASCARÓ[2], Xavier CHIAPPA[2], Nuno SIMÕES[2]

[1]Biology, Universidade Lusófona de Humanidades e Tecnologias, Lisbon, Portugal, [2]Universidad Nacional Autónoma de México, Mexico City, Mexico

A species checklist, biogeographical analysis, abundance and composition of the soft and stony corals of 3 reefs from the northwestern Campeche Bank, Yucatan, México, are presented. The Sisal reefs system is composed of three distinct Pleistocene reefs: Sisal, Madagascar and Serpiente. They range between 70m$^2$ and 0.5km$^2$, presenting a structural complexity that evidences coral accretion in the past, but little hexacoral growth since then. The reefs range from 3-20+ meters depth and are 20, 40 and 60km from shore, representing an interesting terrestrial influence gradient. Sampling was done using 10m transects with ten 25x25cm quadrants per transect, as an adaptation from the A.G.R.R.A. methodology. Six different sites per depth range (7-11 and 12-16m) were observed.

Species composition of the Sisal reefs is similar to other reefs from the Campeche Bank, although some of the species found are not reported for the large oceanic Alacranes reef (main coral larvae provider into the Gulf). Biogeographically, these reefs cluster with the Veracruz and other Campeche Bank reefs. Large gorgonian gardens were observed at Madagascar and Serpiente. Soft and stony coral's abundance is significantly different between Sisal and the other two reefs (p<0,001). A positive correlation between algal cover and the most abundant species of soft corals was found (p<0,01), although it's negative for stony corals (p<0,001). Madagascar is the reef with the highest richness (20,7) and Sisal the lowest (16,9), whilst Serpiente is the most diverse reef (Shannon-Wiener H'=3,065) and Madagascar the less (H'=2,956), due to its low evenness (0,264). There was no significant zonation in the coral's abundance relative to the depth ranges measured. It is hypothesized that these reefs play an important role in the connectivity between Caribbean and inner Gulf of Mexico reefs.

## 14.510

**Contrasting Phylogeography in Three Endemic Hawaiian Limpets (Cellana Spp.) With Similar Life Histories**

**Christopher BIRD*[1]**, Brenden HOLLAND[2], Brian BOWEN[1], Robert TOONEN[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [2]Center for Conservation and Research Training, University of Hawaii, Honolulu, HI

The marine environment offers few obvious barriers to dispersal for broadcast-spawning species, yet population genetic structure can occur on a scale much smaller than the theoretical limits of larval dispersal. Comparative phylogeographic studies of sympatric sister species can illuminate how differences in life history, behavior, and habitat affinity influence population partitioning. Here we use an mtDNA marker (612 bp of COI) and a suite of nDNA microsatellite markers to investigate the population structure of three endemic Hawaiian broadcast-spawning limpets (*Cellana* spp.) with planktonic larvae that are competent to settle within three days. All three species exhibit significant population structure and isolation by distance, but the spatial scales of partitioning differ among the species. *Cellana talcosa* exhibits strong population structure between Kauai and the other main Hawaiian Islands (MHI) where the maximum channel width is 117 km, and no shared haplotypes were observed ($\Phi$CT=0.30, P<0.001). In contrast, populations of *C. exarata* and *C. sandwicensis* (*n*=109) exhibit weaker population structure within the MHI ($\Phi$ST=0.03-0.04, P<0.05), and between the MHI and the Northwestern Hawaiian Islands ($\Phi_{ST}$ =0.03-0.09, P<0.01), where the maximum channel width is 260 km. Biogeographic range and microhabitat use were correlated with estimates of dispersal, while phylogenetic affiliation and minimum pelagic larval duration were poor predictors of population partitioning. Despite similar life histories, these closely-related limpets have contrasting patterns of population structure, illustrating the danger of relying on model species in management initiatives to predict population structure and dispersal in the context of marine protected area delineation.

## 14.511

**Interspecific And Intraspecific Genetic Variation in Deep-Sea Octocorals**

**Amy BACO-TAYLOR*[1]**, Juan ARMANDO SÁNCHEZ[2], Stephen CAIRNS[3]

[1]Associated Scientists at Woods Hole, Woods Hole, MA, [2]Universidad de los Andes, Bogota, Colombia, [3]Smithsonian Institution, Washington, DC

Corals are a key component of the fauna of deep-sea hard substrate habitats and are of interest as habitat-forming organisms for invertebrates and fishes. They are the dominant taxon and the most diverse invertebrate group on seamounts. Deep-sea corals are generally long-lived and slow growing with potentially limited recruitment, making them particularly unlikely to recover from anthropogenic impacts. The threats to seamounts make their study time-critical, with corals making an ideal model organism for research into the biology, ecology and vulnerability of seamount fauna. However, a global deficiency of scientific expertise in morphological taxonomy has been cited as a significant impediment to our understanding of deep-sea coral diversity, coral biogeography, and seamount ecology. Molecular genetic methods can be used to overcome this impediment and more rapidly assess species diversity in archived specimen collections. However, these methods have not yet been widely applied to deep-sea corals. Here we compare levels of interspecific and intraspecific genetic variation for six genes in two octocoral taxa, the Family Paragorgiidae and the primnoid genus *Narella*. All specimens were concurrently examined morphologically for species identifications. Phylogeographic patterns of both taxa on North Pacific seamounts will also be presented.

## 14.512

Sewal Wright's F-statistics are the most common measures of genetic differentiation, are commonly used to delineate population boundaries, and figure prominently in the design of Marine Protected Area networks. AMOVA estimates of $\Phi_{ST}$ and its analogues are known to be biased by factors such as sample size and levels of heterozygosity. Consequently, $\Phi_{ST}$ values do not typically range from zero (complete connectivity) to one (complete isolation), making comparisons of genetic differentiation among populations tenuous. This is especially critical for highly variable markers such as microsatellites where the magnitude of heterozygosity is typically great. To correct this bias, it has been recommended that F-statistics be standardized relative to their maximum possible value. We demonstrate that both the minimum and maximum possible values of $\Phi_{ST}$ are affected by sample properties other than genetic differentiation. Consequently, $\Phi_{ST}$ must be standardized relative to its minimum and maximum possible values for each population comparison. This also applies to the permutation test, which is used to assign statistical significance to $\Phi_{ST}$ values. The maximum and minimum possible $\Phi_{ST}$ values change in each iteration of the permutation test, and the P-value obtained from an unstandardized permutation test is occasionally incorrect. This study highlights the limitations of comparing and drawing conclusions based on unstandardized F-statistics and validates the use of F-statistics that are standardized by the minimum and maximum possible values in comparative population genetic and phylogeographic studies.

## 14.513

**Range Expansion Of An Introduced Coral: Investigating The Source And Ecological Impact Of The Invasion**

**Tonya SHEARER*[1]**

[1]School of Biology, Georgia Institute of Technology, Atlanta, GA

The introduction of non-native species can have devastating impacts on natural ecosystems and can result in severe economic costs. A population genetics approach to studying marine invasions is emerging as a valuable tool to address risk management, identify source populations, determine the means of introduction and predict persistence and ecological impacts. Such an approach is being used to evaluate the dynamics and impact of the human-mediated introduction of the orange cup coral, *Tubastraea coccinea*, introduced into the Caribbean and subsequently into Florida, including the Florida Keys National Marine Sanctuary. As observed with many introduced species, *T. coccinea* can proliferate rapidly, due to production of asexual larvae, and appears to exclude native organisms on particular substrates likely causing a loss of biodiversity. Genetic analyses are being utilized to identify the potential source populations and evaluate levels of genetic diversity and clonal structure. Ultimately, the genetic analysis of the introduction and range expansion of this coral will be used to model biological connectivity throughout the Caribbean and Gulf of Mexico.

## 15.515

**Influence Of Florida Current Frontal Eddies On Circulation And Fish Recruitment Around The Florida Keys Reef Tract**

**HEESOOK KANG*[1]**, Vassiliki KOURAFALOU[1], Claire PARIS[2]

[1]MPO, RSMAS/Univ. of Miami, Miami, FL, [2]MBF, RSMAS/Univ. of Miami, Miami, FL

The coastal seas around the Florida Keys Reef Tract exhibit complex dynamics resulting from the interaction with offshore flows, namely the Loop Current/Florida Current system and the frontal eddies that interact with the complex reef topography. A nested modeling approach has been employed to ensure the proper representation of such interactions. A high resolution (~900m) application of the HYbrid Coordinate Ocean Model has been developed focusing on the Florida Keys (FKEYS-HYCOM model). Nesting to a succession of coarser, regional models (South Florida SoFLA-HYCOM and Gulf of Mexico GoM-HYCOM) and finally to basin-wide and global models allows the downscaling of large scale flows to scales appropriate for the study of reef related processes.

Eddies that travel along the Loop Current/Florida Current front are known to be an important mechanism for the interaction of nearshore and offshore flows. They enable upwelling in the vicinity of the Reef Tract and they influence transport and recruitment pathways, as they carry waters of different properties (such as river-borne low-salinity/nutrient-rich waters from as far as the Mississippi River) and waters containing larvae from upstream source, or entrained from nearby spawning grounds. As such, they play an important role in the circulation around the Reef Tract and connectivity pathways with the Gulf of Mexico and the Caribbean at large. FKEYS-HYCOM is able to simulate both mescoscale and sub-mesoscale eddy passages during a targeted 2-year simulation period (2004-2005), forced with high resolution/high frequency atmospheric forcing. Coupling with the ecological population connectivity BOLTS model (BiOphysical Larval Tracking System) allows simulations of larval transport, taking into account not only the dispersion of active physical larvae, but also the interaction of factors influencing larval survival, habitat selection and condition at settlement.

## 15.516

**Wave Transformation And Wave-Induced Currents On A Submerged Barrier Reef: Field Observations And Boussinesq-Type Modelling**

**Philippe BONNETON*[1]**, Rodrigo CIENFUEGOS[2], Sylvain OUILLON[3], Patrice BRETEL[1], Jean-Pierre LEFEBVRE[3], Natalie BONNETON[1]

[1]UMR EPOC, CNRS - Bordeaux 1 University, Talence, France, [2]Pontifica Universidad Catolica de Chile, Santiago de Chile, Chile, [3]IRD Nouméa, Nouméa, France

As waves break on a reef, they create a radiation stress gradient that drives wave-setup and wave-induced currents (e.g. Symonds et al. (1995), Hearn (1999) or Gourlay and Colleter (2005)). These phenomena exert a major influence on the hydrodynamics and biological variability of shallow submerged coral reefs and have a significant impact on the circulation and flushing of lagoons. Wave-induced circulation is mainly controlled by wave dissipation due to wave breaking and bottom friction. When waves propagate over a submerged barrier reef they may decompose into shorter components referred to as secondary waves. This process can strongly affect wave dissipation and then the wave-induced circulation. To improve our understanding of these phenomena, a 3-week field experiment was conducted on the Aboré coral reef (southwest lagoon of New Caledonia) in October 2005 (Bonneton et al. (2007)). In this area the tides are semidiurnal (Douillet (1998)), with a tidal range on the reef between 0.6 and 1.4 m at neap and spring tides. At low water spring, the reef-top is located just below the sea surface. During the experiment, the significant offshore wave height ranged between 0.3 and 1.8m. Pressure and current were synchronously measured along a cross-reef transect at a 8 Hz sampling rate. In this communication, we analyse the tidal modulation of wave-setup and wave-induced currents on the reef and interpret our results using analytical models by Symonds et al. (1995) and Hearn (1999). Then, we present "high frequency" observations, showing that turbulent bores propagating over the Aboré reef flat frequently evolve into non-breaking oscillating bores. Classical time-averaged models do not account for the generation of secondary waves. To analyse the impact of this phenomenon on wave-induced circulation, time-dependent numerical simulations based on a Boussinesq-type model (Cienfuegos et al. (2006, 2007)) are compared to the Aboré reef data set.

## 15.517

**Numerical Modelling Of A Coastal Reef–lagoon System**

**Ryan LOWE*[1]**, James FALTER[2], Stephen MONISMITH[3], Marlin ATKINSON[2]

[1]School of Environmental Systems Engineering, University of Western Australia, Perth, Australia, [2]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [3]Civil and Environmental Engineering, Stanford University, Stanford, HI

The response of the circulation of a coral reef system in Kaneohe Bay, Oahu, Hawaii to varying environmental forcing conditions is investigated using the numerical circulation model DELFT3D, coupled with the wave model SWAN. To validate the model, field data was obtained during a two-month experiment in winter 2006, in which current and wave conditions were measured continuously at several locations on the fore reef, reef flat and lagoon. The model was forced for the observation period with the known tidal constituents for the NE coast of Oahu, the offshore wave conditions measured by a directional wave buoy, and hourly wind data measured in the southern end of the Bay. Modeled and observed wave heights are in good agreement throughout the system, and indicate that the dominant source of wave energy dissipation in Kaneohe Bay is bottom friction (and not wave breaking), due to the large physical roughness of the reef. The modeled wave setup peaks just shoreward of the surf zone (on the reef flat), however setup within the lagoon is found to be a surprisingly large fraction (40-70%) of the peak reef value, and clearly not zero as assumed in many one-dimensional reef hydrodynamic models. A comparison between the observed and modelled current time-series at the various sites reveals that the model accurately predicts the dominant circulation in Kaneohe Bay. We can use model output of bottom friction and near-bottom flow speeds to drive mass-transfer models of phosphate uptake across the entire Kaneohe Bay Barrier revealing spatial zonation of uptake and release which are ultimately responsible for driving ecosystem net primary production.

## 15.518

**A Multi-Scale, Large-Area Analysis Of Coral Reef Roughness**

**David G. ZAWADA*[1]**, John C. BROCK[1]

[1]Center for Coastal and Watershed Studies, U.S. Geological Survey, St. Petersburg, FL

Coral reefs represent one of the roughest structures in the marine environment. This roughness or topographic complexity is a significant component of the high degree of habitat complexity associated with reefs and may vary over a range of spatial scales. In this study, we present a synoptic view of reef roughness for a 5-km x 5-km portion of Biscayne National Park, FL, extending from patch-reef to forereef zones. A 1-m spatial-resolution digital-elevation model of the study area was constructed from lidar data (NASA's Experimental Advanced Airborne Research Lidar or "EAARL"). A number of different biological, chemical, and physical processes, acting on different spatial scales, affect the surface of the reef. In this context, the fractal dimension (D) is an appropriate metric for quantifying reef roughness and potentially represents an effective means for designating different zones within a reefscape. Values of D are bounded between 2 for a flat plane and 3 for a cube. A difference in D of 0.1 corresponds to a significant and visually apparent change in roughness. Fractal dimensions were computed over spatial scales ranging from 3 m to 1 km. The results reveal how roughness varies as a function of reef zone. In general, roughness increased with distance from shore as relatively smooth patch reefs (D = ~2.3) gave way to more complex fore reefs (D = ~2.6).

## 15.519

**Defining the Reefal Bay System Hydrodynamically**

**Ava MAXAM*[1,2]**, Dale WEBBER[2]

[1]Mona Geoinformatics Institute, University of the West Indies, Kingston, Jamaica, [2]Life Sciences Department, University of the West Indies, Kingston, Jamaica

Investigations into the hydrodynamics of a partially enclosed reefal bay, Wreck Bay, showed that inner bay waters re-circled the reef constantly. This circulation formed permanent gyres, the extents of which were utilized to delineate a boundary for the reefal bay system. Results from in-situ, long-term current meter and drogue measurements depicted the spatial and temporal variability in circulation, revealing that inner bay water diverged on to the fore-reef, then either re-entered the back-reef to close the circum-reef circulation, or continued along the fore-reef as open circum-reef circulation. Multiple regression values confirmed that back-reef currents played a major role in driving channel flow, accounting for 47% of the variability in the channel currents. Open circum-reef circulation was found to be the larger gyre of the system and facilitated greater extension of the inner bay, while closed circulation gave smaller but more retentive gyres. Gyres expanded or abated around the same reef location, demonstrating that the presence of subtending reef with channels offered stability in the location of circum-reef systems. Reef parabola, fringing and partially enclosing bays, are generally accepted as the boundary of the reef-bay system. However, the dynamics displayed at Wreck Bay showed the reef as the heart - not the limit - of main circulation and therefore the centre of the hydrodynamic bay.

## 15.520

**Patterns in Benthic Communities At A Remote Subtropical Atoll Along A Wave Exposure Gradient**

**Kimberly PAGE-ALBINS*[1]**, Peter VROOM[2], Mark ALBINS[1], Ronald HOEKE[2], Celia SMITH[3]

[1]Department of Zoology, Oregon State University, Corvallis, OR, [2]Joint Institute for Marine and Atmospheric Research, Honolulu, HI, [3]Department of Botany, University of Hawaii at Manoa, Honolulu, HI

In coral reef ecosystems, wave exposure and its associated bed shear stresses can be both essential and detrimental to organisms; therefore, a morphological tradeoff may exist favoring some species over others depending upon the wave exposure regime. In this study, we examined whether wave exposure is responsible for variations in benthic community composition at Pearl and Hermes Atoll in the Northwestern Hawaiian Islands. Our expectation was that sites with similar levels of wave exposure would exhibit similar benthic community composition. Additionally, species richness of coral and macroalgae were compared to predictions from Connell's intermediate disturbance hypothesis (IDH) with the expectation that sites with intermediate levels of wave exposure would have the highest species richness. To test each of the above hypotheses, percent cover of benthic organisms was observed at 34 sites from 4 wave exposure categories: high, intermediate-high, intermediate-low, and low. Multivariate statistical analyses revealed variation among sites both within and between all wave exposure categories with the exception of low. Despite such variation, a nonmetric multidimensional scaling ordination (nMDS) and cluster diagram grouped sites from low, high, and intermediate-high wave disturbance areas into three relatively discrete clusters. Sites with low wave exposure exhibited highly homogenous community assemblages. Sites experiencing intermediate-low wave exposure did not group together in the nMDS ordination or cluster diagram, suggesting greater variability in benthic compositions among these sites. In accordance with expectations based on the IDH, coral and macroalgal species richness was significantly higher at sites with intermediate-high and intermediate-low levels of wave exposure than at sites with low wave exposure, although not significantly higher than sites with high wave exposure. Our results support IDH and suggest that the absence of a disturbing force is a strong homogenizing mechanism in communities.

## 15.521

**The Particle Tracking Model: Method To Quantify External Sediment Loading To Coral Reef Regions**

**Zeki DEMIRBILEK*[1]**, Tahirih LACKEY[1], Joseph GAILANI[1], Jarrell SMITH[1]

[1]US Army Corps of Engineers, Engineer R&D Center (ERDC-CHL), Vicksburg, MS

Coral reefs can be adversely impacted by anthropogenic, intermittent sediment sources introduced, for example, by dredging operations, placement of dredged material, ship passage, construction, etc. PTM is a Lagrangian particle tracking model specifically designed to monitor the pathway and fate of sediment sources generated by human activity. The USACE has developed methods for quantifying sediment sources released to the water body by dredging and placement operations as well as ship passage. These source terms are used as input to PTM, which then tracks the sediment pathway and fate. The model is often used to predict quantity of sediment (loading) introduced to sensitive habitat. Diagnostic tools such as PTM are applied prior to dredging operations to quantify sediment pathways and assess environmental impact. PTM is also used to compare various scenarios that may minimize impacts. PTM simulates sediment transport by applying hydrodynamics and wave data as forcings to user defined sediment sources. The model contains algorithms designed to represent relevant transport processes such as advection, diffusion, settling, and particle bed interactions. Regions of coral reefs are represented by variations in roughness. The PTM interface is the Surface-water Modeling System (SMS) which provides data analysis tools for concentration, exposure, deposition, and accumulation mapping. PTM is applied to a hypothetical dredging operation near a sensitive habitat (coral reef) to demonstrate model utility and applicability to assess sediment loadings to these habitats. Multiple scenarios are analyzed to determine variability in loadings due to variations in dredging operations.

## 15.522

**Water Quality And Movement Over The Forereef At Carrie Bow Cay, Belize: A Wind-Driven System?**

**Karen KOLTES*[1]**, Tom OPISHINSKY[2]

[1]Office of Insular Affairs, U.S. Department of the Interior, Washington, DC, [2]Interactive Oceanographics, East Greenwich, RI

Meteorological and oceanographic conditions have been monitored at the Smithsonian Institution's Field Station at Carrie Bow Cay (CBC), Belize, since 1993 through the CARICOMP monitoring program and since 1997 through an automated monitoring system. Qualitative and quantitative observations indicate that turbidity has increased since monitoring began and that the frequency and degree of "turbidity events" are related to several factors including rainfall and tidal stage. To better characterize water quality, light meters were installed on the forereef at the CARICOMP site (13.5 m). Light intensity (L/sf) has been recorded there intermittently since 2002. Temperature has been recorded continuously at this site since 1993 as well as in the seagrass beds at Twin Cays (1.4 m) and in the lagoon behind CBC (2.0 m).

Comparisons of meteorological and oceanographic data from the weather station and CARICOMP revealed significant correlations between certain weather conditions, both episodic and seasonal, and water properties. Wind direction has emerged as a strong driving force of water movement. Observations demonstrate that shoreward (coastal) water and ocean water flow into and mix in the survey area. Strong signatures of different water masses are most evident following major weather events, however strong correlations are also apparent during less prominent changes in weather and particularly wind direction.

We suggest that the prevailing northeasterly winds normally hold turbid coastal water shoreward of the barrier reef. Under decreased or westerly winds, turbid coastal water drifts or is pushed out onto the reef from the lagoon. We also note that only about 36% of incident light reaches the reef in December compared to about 65% of incident light in June, suggesting that increased turbidity, lower sun angle and/or higher sea states are causing the attenuation of incident solar radiation to nearly double during the winter months.

## 15.523

**Island-Scale Circulation Patterns Around Moorea, French Polynesia**

**James LEICHTER*[1]**

[1]Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA

A 2.5 year record of water column temperature and currents was collected at multiple fore reef sites to study spatial and temporal patterns in physical forcing around the island of Moorea. Dominant modes of variability were analyzed across a range of frequencies from seasonal to daily time scales. At low frequencies variability was dominated by seasonal temperature trends and seasonal patterns in mean and peak velocities among shores. Daily mean temperatures varied from approximately 26 to 29 °C and peak velocities ranged from approximately 30 to 50 cm s-1. Mesoscale oceanographic processes associated with oceanic currents and possibly influenced by an island wake generated by the neighboring island of Tahiti appear to dominate the observed variability. Strong variability was also observed at scales of multiple days to weeks. At higher frequencies, variability included diel patterns associated with daily warming and cooling as well as fluctuations at scales of hours to minutes associated with thermocline oscillations indicative of the impact of internal waves especially at deep (depth > 20 m) sites on the fore reef slope. These processes across the range of studied frequencies have significant implications for the delivery of nutrients and for larval transport and recruitment in this system. The high frequency variability associated with internal waves was itself variable at lower frequencies among seasons, pointing to modulation of forcing by low frequency, large scale phenomena. The high frequency temperature patterns and spatial variability among sites and across depths apparent in the in situ records was not predictable from remotely sensed surface data. Thus, long term physical data collected in situ, continuously, and at high frequencies are necessary to characterize oceanographic forcing in this oceanic reef system and to measure effects at annual to climate scales.

## 15.524

**Laboratory And Field Experiments Of Waves And Water Levels Over Fringing Reefs in Guam And Hawaii**

**Zeki DEMIRBILEK*[1]**, Mark MERRIFIELD[2], Okey NWOGU[3]

[1]US Army Corps of Engineers, Engineer R&D Center (ERDC-CHL), Vicksburg, MS, [2]SOEST, University of Hawaii, Honolulu, HI, [3]Naval Arch. and Marine Engineering, University of Michigan, Ann Arbor, MI

The US Army Corps of Engineers has partnered with the National Data Buoy Center, The University of Hawaii (UH), and CDIP of the Scripps Institution of Oceanography, to measure wave and water level, and meteorological conditions on the fringing reefs of islands of Oahu and Guam. The goal is to determine protective role of fringing coral reefs on inundation of exposed coastlines for the design of Pacific island coastal infrastructure, and protection of coastal residents and their property. A CDIP directional wave buoy was deployed on the SE coast of Guam on the steep shelf break offshore of the fringing reef. A directional wave buoy was deployed by UH/CDIP seaward of reef on the NE side of Oahu. The UH deployed a bottom mounted instrumentation packages on the fore and mid reef of a site on the NE shore of Oahu near Kahuku, and a cross-shore instrument transect on the SE side of Guam near Ipan. Real time data at these sites are analyzed to calculate spatial variation in water level and waves over fringing reefs. Data shed light into poorly understood reef processes such as wave setup, wave-induced ponding, wind-forced wave uprush, and wave runup. Study plans, logistics, experience with instrumentation, and different field measurements obtained over reefs are discussed with samples of measured raw and analyzed data.

Part two of this presentation describes a laboratory study conducted at the University of Michigan (UM) wind-flume to provide data for waves, winds, wave setup and wave runup over a scaled (1:64) fringing reef of Guam at Ipan modeled in these experiments. A large number of tests were performed at four water levels with only waves or winds, and both. A unique data set for fringing reefs is established for research and engineering analysis of reefs.

## 15.525

**Reef Rip Current Generated By Tide And Wave During Summer Season: Field Observation Conducted in Yoshiwara Coast, Ishigakijima, Okinawa, Japan**

**Mario DE LEON*[1]**, Ryuichiro NISHI[2], Fumio KUMASAKA[3], Tsuyoshi TAKAESU[4], Ryosuke KITAMURA[5]

[1]Graduate School of Science and Engineering, Kagoshima University, Kagoshima, Japan, [2]Faculty of Fisheries, Kagoshima University, Kagoshima, Japan, [3]Japan Hydrographic Association, Tokyo, Japan, [4]Japan Coast Guard, Tokyo, Japan, [5]Department of Ocean Civil Engineering, Kagoshima University, Kagoshima, Japan

In 2004 and 2005, five drowning accidents in Ishigakijima, Okinawa were documented by Japan Coast Guard and local people and were found out to be caused by a strong offshore current in coral reef. The strong seaward current is commonly known by the local people in Okinawa as “reef current”. However, in this paper, the researchers define offshore current in coral reef as “reef rip current”. Thus, a reef rip current study was conducted to determine the location and time of strong offshore current. A nearshore hydrodynamic project which consists of field observation was then carried out in Yoshiwara Coast in two phases; Phase 1 was conducted during normal (tide dominated) condition and Phase 2 during storm (wave dominated) condition. The project was implemented during summer season from June 25 to July 25, 2006, the period during which the drowning accidents occurred. Wave gages, electronic current meters, ADCP, tide gages, and thermometer were installed in reef lagoon, on reef flat, edge and gap. In addition, GPS floats and fluorescent dye experiment were performed. An anemometer was also set up on the dry beach. Water level, wave height, wave period, current and wind speed and direction were measured for both tide and wave dominated conditions. In this study, a strong reef rip current was revealed at the reef gap during ebb tide with maximum average velocity at 1.2 m/s (2.4 knots) during normal condition. This velocity definitely has an impact on the safety of swimmers, snorkelers, and scuba divers. Therefore, understanding the mechanism, location and time of occurrence of strong reef rip current will definitely lead to reduction of drowning accidents which is the ultimate goal of this project.

## 15.526

**Spatial differences of the linear extension of Pocillopora damicornis in Polhena reef of Southern Sri Lanka**

**Wickrama Arachchige UPASANTA KUMARA*[1]**, Terney PRADEEP KUMARA P.B. [1], Cumaranatunge P.R.T. [1]

[1]University of Ruhuna, Matara, Sri Lanka

Near shore patchy reefs located at the leeward side of the fringing reef in Polhena at Southern coastal belt of Sri Lanka were surveyed in 2005. This study was carried out on a patchy reef considering three slopes of the reef front, side and back and identified as sites. Three locations were selected in each site as surface, bottom and middle considering the depth. Pocillopora damicornis colonies were selected for diameter extension studies.

Mean, standard deviation and one–way ANOVA was used during the statistical analysis. Multiple comparisons were done using least significant different (LSD) for light intensity and sediment volume. The physico-chemical parameters of water observed were 28.06±1.140C for temperature, 8.78±0.40mgL-1for DO, 1.40±0.32 mgL-1for BOD, 31.91±3.49ppt for salinity, 8.12±0.40for pH, and 1.01±0.61mgL-1for reactive phosphate, 5.78±2.37NTU for turbidity, 49.17±1.89Lux for light intensity and 90.08±39.65mL for sediment volume respectively. It was observed that the mean difference of light intensity and sediment volume between each location were significantly different. The highest sediment volume and the lowest diameter extensions (0.055±0.01mm day-1) of coral colonies were observed at back bottom location. The highest value for diameter extension (0.22±0.01mm day-1) was observed at front surface location. ANOVA showed a significant difference of the diameter extension of P. damicornis between locations and sites. Diameter extension was significantly low at the back bottom location showing a significant negative correlation with increased sedimentation rate (7897.26gm-2 day-1).

## 15.527

**Environmental Vs. Intrinsic Determination Of Colony Symmetry in The Coral Pocillopora Verrucosa**

**Tali MASS*[1]**, Amazia GENIN[1]

[1]ESE department, Life Sciences Institute, Heberw University,Jerusalem, Eilat, Israel

The morphology of corals is strongly dependent on environmental conditions.

Different morphologies can be induced by flow and light due to their remarkable effects on the rates of respiration, production, calcification and prey capture of corals.

Yet, colonies of many branching corals exhibit a remarkable radial symmetry, possibly indicating an intrinsic determination of colony morphology.

The scleractinian coral Pocil1opora verrucosa (Ellis and Solander, 1786) is a common species in a variety of reef environments of the Red Sea and displays a striking morphological variation in colony shape depending on the flow regime in their habitat. Branches are thick and compact in habitats exposed to high flow conditions, becoming open and thinner in protected habitat

The objective of this study was to experimentally examine whether flow conditions can affect the radial symmetry in colonies of the branching coral Pocillopora verrucosa. Eight colonies of P. verrucosa were transplanted to transparent, flow-manipulation chambers which were effectively shielding the coral from the ambient flow. Thereby, the coral was exposed to a unidirectional flow, creating asymmetric flow conditions with stronger current at the up- than down-flow side. Within 4 months, the up-current side of the corals had higher concentration of chlorophyll and proteins, greater density of zooxanthellae, and more compact morphology. While asymmetry in photosynthesis and photosynthetates may disappear due to within-colony translocation, our findings on asymmetry in proteins and, in particular, skeletal morphology indicates that asymmetry in environmental conditions generates permanent asymmetry in corals. The ubiquitous symmetry observed in branching corals in many reefs is apparently determined by corresponding symmetry in the flow, rather than intrinsic mechanisms in the colony.

## 15.528

**Pumping Rates Of The Giant Barrel Sponge *xestospongia Muta* On Caribbean Reefs: Size Scaling, Environmental Controls, And Bleaching Effects.**

**Christopher FINELLI*[1]**

[1]Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC

Sponges are among the most diverse and abundant taxa on Caribbean coral reefs, with numbers of species and biomass equaling or exceeding that of corals and algae. Their success on reefs can be partially attributed to the ability remove very small particles (bacteria and viruses) from the water column and their ability to permeate the entire three dimensional structure of the reef. Because bacterioplankton are likely to be a significant fraction of the planktonic community (including as primary producers) in oligotrophic waters, sponges represent a major pathway of carbon flux from the water column to the benthos and a mechanistic understanding of sponge filtration rates is needed. The giant barrel sponge, *Xestospongia muta*, comprises up to 60% of sponge biomass on Caribbean reefs with a size range (diameter) that spans three orders of magnitude. Moreover, this species exhibits two types of bleaching ('cyclic' and 'fatal') that may affect both individual (via decreased vigor) and population (via size specific mortality) filtration rates. To address the effects of sponge size and bleaching on filtration rates, I measured pumping rates of bleached and healthy *X. muta* across wide range of sizes on Bahamian reefs in June 2007. Velocity distributions across the oscula were uneven, with maximal centerline velocities 3 to 4 times greater than the average. Resulting volumetric pumping rates scaled linearly with tissue volume and averaged 40 ml-H2O h-1 ml-tissue-1. Pumping rates were constant over periods up to 24 hrs, although some specimens decreased pumping during rapid fluctuations in water temperature. Cyclic (non-fatal) bleaching did not affect filtration rates.

## 15.529

**Physical Processes Influencing The Locations Of Nassau Grouper (Epinephelus Striatus) Spawning Areas And Implications For Reef Fishery Management**

**Mandy KARNAUSKAS*[1]**, Laurent CHERUBIN[2,3], Vera AGOSTINI[4], Claire PARIS[2]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [2]Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [3]Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, Miami, [4]The Nature Conservancy, Seattle, WA

Spawning aggregations (SPAGs) of Nassau groupers (*Epinephelus striatus*) have been observed along the Mesoamerican Reef and offshore atolls of Belize. SPAGs are consistently located on the seaward side of reefs adjacent to submerged capes with steep walls. In order to elucidate the factors underlying preference of these spawning areas by groupers, characteristics of known SPAG locations were compared to similar locations where spawning does not occur. Modeling experiments of current flows around capes have shown that the main controlling parameter affecting flow patterns is the equivalent Reynolds number (Ref), which gives the ratio between advection and bottom friction terms. When Ref is small (Ref values <4) and bottom friction dominates, laminar flow occurs and currents tend to follow the cape without separating. For higher Ref values (4-25), flow tends to detach from the cape and form a stationary eddy in the lee of the current, and for Ref values above 25, the eddy detaches and leads to an eddy-shedding regime. The average Ref value for capes where spawning occurs was 28.40, whereas capes where spawning does not occur had an average Ref value of 4.35. This suggests that spawning occurs preferentially in areas where physical mechanisms to promote larval retention exist. These findings, along with further modeling of the flow patterns around these capes, have significant implications for management of coral reef fisheries and design of marine reserves. If spawning areas have evolved to be located in areas favorable for limiting dispersal, then maximizing local stock recovery may be accomplished by designing reserves around nearby SPAGs. Furthermore, if aggregations become overexploited, they may relocate to areas that do not favor high recruitment or high survival rates, and overall productivity may decline.

## 16.530

**Satellite Detection Of Low Wind Events Conducive To Mass Coral Bleaching: The Noaa Coral Reef Watch Experimental Doldrums Product**

**Dwight GLEDHILL*[1]**, T.R.L. CHRISTENSEN[1], L.J. GRAMER[2], R.K. HOEKE[3], R. IGLESIAS[4], Derek MANZELLO[2], C.M. EAKIN[5], W.J. SKIRVING[5], G. LIU[1], S.F. HERON[5], J.A. MORGAN[1], A.E. STRONG[5]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]NOAA OAR AOML, Miami, FL, [3]NOAA Fisheries and Ecosystems PIFS, Honolulu, HI, [4]Prieto of UNAM in Puerto Morelos, Puerto Morelos, Mexico, [5]NOAA Coral Reef Watch, Silver Spring, MD

It is generally thought that wind influences the conditions that cause coral bleaching. Wind-driven water movement mixes cooler water up to the surface, and facilitates the removal of waste products from corals. Wind-generated waves can reduce harmful levels of incoming solar radiation by surface reflection and refraction, and light can be further attenuated by sediments resuspended by wind-driven turbulence. Periods of sustained low wind may therefore serve as a contributing factor to coral bleaching, by promoting environmental conditions conducive to high thermal and/or light stress. NOAA Coral Reef Watch now offers an experimental near-real-time doldrums product that identifies regions of sustained low wind speed, derived from satellite measurements of surface wind speeds obtained from NASA's Quick Scatterometer (QuikSCAT). The algorithm was derived from *in situ* data including wind speed, light penetration, and temperature. These persistent low wind regions are updated daily on the web, to help coral reef managers and scientists better assess conditions that may lead to coral bleaching.

## 16.531

**Semi-Automatic Patch Outlines And Cover Classification From Marine Benthic Communities**

**Nuria TEIXIDO*[1]**, Emilie COLLEU[2], Didier BOLBO[3], Joaquim GARRABOU[4]

[1]Centre for Advanced Studies in Blanes (CEAB-CSIC), Blanes, Spain, [2]Institut Géographique National, Ramonville Saint Agne, France, [3]Institut Géographique National, Saint-Mandé, France, [4]Centre d'Océanologie de Marseille, Marseille, France

Knowledge on the abundance, spatial distribution, and diversity of species within a community is fundamental to understand ecosystems. The use of modern imaging techniques provides a view of non-destroyed benthic community structure over large spatial and temporal scales. However, there still is a paucity of analytical methods to obtain ecologically relevant data from images. The aim of this research is twofold: first, we introduce a software program to get semi-automatically segmented images (patch outlines) from underwater photographs of rocky benthic communities, where each individual patch is routinely associated to its cover and perimeter; second, we provide a semi-automatically classification of species or cover categories. The process starts with a hierarchical segmentation, using a colour space, texture parameters, and shape criteria adapted to the problem of segmenting complex benthic images (e.g. characterized by high coverage of sponges, cnidarians, bryozoans, and ascidians). As an end product, we obtain an image segmented into classified homogenous regions, which present measures for each part of the segmentation. The development of this semi-automatically outline tool and classification constitute an important step forward in the analysis of the sea-bottom images and represent a powerful technological platform to analyze underwater images not only for coral reefs in the tropics but also to other marine rocky habitats (e.g. from Mediterranean benthic communities to Antarctic habitats in temperate and polar seas, respectively) at any scale.

## 16.532

**Development And Implementation Of A Marine Monitoring Program In The National Park Service Pacific Island Network (PACN) Using A Split Panel Design**

**Eric BROWN*[1]**, Larry BASCH[2], Jim BEETS[3], Peter CRAIG[4], Raychelle DANIEL[5], Kimber DEVERSE[5], Gordon DICUS[5], Alan FRIEDLANDER[6], Fritz KLASNER[5], Tahzay JONES[5], Dwayne MINTON[7], Allison SNYDER[5]

[1]Kalaupapa NHP, U.S. National Park Service, Kalaupapa, HI, [2]Pacific Islands Coral Reef Program, U.S. National Park Service, Honolulu, HI, [3]Department of Marine Science, University of Hawaii-Hilo, Hilo, HI, [4]National Park of American Samoa, U.S. National Park Service, Pago Pago, American Samoa, [5]Inventory and Monitoring Program-Pacific Island Network, U.S. National Park Service, Volcano, HI, [6]Biogeography Branch and The Oceanic Institute, NOAA, Waimanalo, HI, [7]Pacific Islands Fish and Wildlife Office, US Fish and Wildlife Service, Honolulu, HI

The National Park Service in cooperation with the University of Hawaii-Hilo, NOAA's Biogeography Branch, and the Oceanic Institute initiated a marine monitoring program in four national parks around the Pacific. Monitoring protocols for 1) benthic community, 2) fish, and 3) water quality were co-located and co-visited. The benthic community protocol addresses changes in the composition and physical structure of the coral reef benthos, patterns in coral recruitment, and the frequency of disease/bleaching in corals. The fish protocol examines trends in the abundance and biomass of coral reef fishes of ecological, cultural or harvest significance. The water quality protocol investigates spatial and temporal patterns in temperature, oxygen, pH, and turbidity in various water bodies within the parks.

A split panel sampling design was implemented with thirty randomly selected sites sampled annually between 10 and 20 meters depth. Fifteen of the sites were permanent with the remaining sites randomly selected each year. The split panel design allows for increased spatial sampling while simultaneously examining multiple temporal scales and permitting broader ecological and statistical inference beyond that provided by fixed or permanent sampling locations alone. The water quality protocol doubled the number of sites to increase statistical power. This sampling regime represents the maximum sustainable effort given logistical and fiscal constraints. Based on previous data, the sampling design should have statistical power ranging from 0.34 (fish) to 0.80 (benthic) to 0.99 (water quality) to detect relative change in various parameters after 10 years. A principal investigator for each protocol oversees data analysis and reporting, park staff facilitates data collection, and a park lead ensures that vital signs address park management needs.

## 16.533

**Three Dimensional Laser Scanning Of Coral Skeleton**

**Michal RAZ BAHAT*[1]**, Hanny FAIBISH[2], Buki RINKEVICH[1]

[1]Invertebrate Zoology, National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel, [2]Zoology, Faculty of Natural Sciences Ben- Gurion University of the Ne, Be'er- Sheva, Israel

In many taxa, the organism's surface area is a fundamental characteristic, determining biological and physical levels of impacts. In scleractinian corals, as in many sessile colonial organisms, measurements of surface area are used to allow indirect estimates of biomass, assessments of photobiology, nutrient dynamics, population dynamics of symbiotic organisms, metabolism, growth rate, reproduction, and other ecologically important processes. However, despite this routine use of surface area measurements, the outcomes are no sufficiently accurate and repeatable.

Notwithstanding the intense efforts invested, in the last three decades, in developing an accurate and rapid method for direct surface measuring, especially in branching corals with variable 3D architectures, all attempts failed to develop an accurate and consistent methodology characterized by short analysis and processing time. Here we present a novel application, using a 3D desktop laser scanner for imaging and measuring accurately skeletal surface area of coral fragments and whole small colonies. The scanner is easy to operate and economically viable as a scientific tool in every laboratory. We present the scanner surface measuring performance, and compare results to the performance of several commonly used methods: the foil paper technique, methylen blue dipping and caliber measuring, showing the advantages of our new approach.

## 16.534

**The Installation of a Coral Reef Early Warning System (CREWS) Monitoring Station**

**Jules CRAYNOCK*[1]**, Michael SHOEMAKER[1], Nancy ASH[1], Mike JANKULAK[2], James HENDEE[1]

[1]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, [2]Cooperative Institute for Marine and Atmospheric Sciences, University of Miami, Miami, FL

CREWS monitoring stations offer several advantages over traditional buoy monitoring stations, including ease of deployment and maintenance, high bandwidth to accommodate large number of instruments, modular components for maintenance, and dynamic strength against wind and waves. The process of CREWS station installation is described in five stages: 1) site survey and permit processing, 2) bottom pin and plate installation, 3) pylon pre-deployment construction finalizing, 4) pylon installation to the ocean floor and bottom plate, and, 5) electronics installation and testing. Subsequent to the installation, a special training session is conducted with local station maintainers to ensure continuance of data transmission of the highest integrity. The use of specialized instrumentation, as well as total cost and logistical considerations are discussed.

## 16.535

**Coral Point Count With Excel Extensions (Cpce) V3.5: Improvements To Software For The Analysis Of Coral And Substrate Coverage Using The Random Point Count Method And Planar Area Calculation**

**Kevin KOHLER*[1]**

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL

Coral Point Count with Excel Extensions (CPCe) is a standalone Windows-based program which automates the random point count method using underwater imagery to determine coral and substrate coverage. Additionally, CPCe uses image calibration to calculate planar areas and lengths of benthic features. CPCe has been made available to the coral reef community since 2004. Since the time of its release, CPCe has been met with great enthusiasm from researchers worldwide, and has been continually updated and improved with additional features suggested by users. These improvements have enhanced the usability and functionality of the software. The current version of CPCe (V3.5) contains several significant improvements over prior versions. CPCe allows users to specify a customized coral code file containing species and habitat listings appropriate for their region of interest. The program now contains an enhanced code file checker which allows users to quickly recognize and fix errors in the code file. The area analysis portion of the program has also been updated with several new features. First, CPCe now contains an optional mini-zoom function which magnifies the pixels surrounding the tracing cursor, allowing users to make more accurate traces. Second, V3.5 introduces the concept of master and subordinate areas which allows the specification of an encompassing area with the ability to subtract areas of internal regions. Third, the area data can now be exported into Excel spreadsheets automatically. These improvements make CPCe V3.5 a very robust tool for calculating coral and substrate coverage in an efficient manner.

## 16.536

**The Construction Process Of A Coral Reef Early Warning System (Crews) Pylon**

**Michael SHOEMAKER*[1]**, Jules CRAYNOCK[1], Manuel COLLAZO[2], James HENDEE[1]

[1]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, [2]Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL

Hollow extruded Fiberglas tubes, 12.5 m long and 25 cm in diameter, have been custom engineered and strengthened to serve as meteorological and oceanographic monitoring stations that move dynamically with wind and waves, and serve as platforms for robust instrumentation that monitor and transmit data hourly through a GOES satellite to NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida. These monitoring platforms, nicknamed Coral Reef Early Warning System (CREWS) stations, undergo a construction process of approximately 350 man hours, which includes the special fabrication of a "step" for insertion of the station on a pre-installed stainless steel plate-and-ball, the interior placement of conduit housing for cable runs between instrument and data acquisition hardware, specialized component fabrication and re-attachment to the pylon, custom bulkhead and instrument bracket fabrication, installation of an internal radar reflector, partial fill of buoyancy material, and many other specialized tasks. The stations are eventually carefully situated within coral reef ecosystems that meet specific criteria. These stations have been installed at four sites (Lee Stocking Island, Bahamas; Salt River, St. Croix; La Parguera, Puerto Rico; and Discovery Bay, Jamaica) and have operated with high reliability with the assistance of local site maintainers and biological observers. One of the stations has withstood tropical storm force winds (Bahamas), and one a hurricane (Jamaica). The stations offer special advantage over buoys, but are meant for shallow deployment (~ 6 m).

## 16.537

**Getting To The Point: Accuracy Assessment Of Point Counting To Monitor Degrading Reefs**

**Eric PANTE*[1]**, Phillip DUSTAN[2]

[1]Biology, University of Louisiana at Lafayette, Lafayette, LA, [2]Biology, College of Charleston, Charleston, SC

The statistical behavior of cover estimation on coral reefs by pointcounting was assessed using a simple computer simulation, modeled after actual benthic data from a small Bahamian patch reef surveyed using 20 m video line transects. The simulations revealed that estimating true variation in cover within a benthic population appears to require more effort than estimating true mean cover. The probability of under or overestimating cover and/or cover variance along a 20 m transect decreases with increasing number of points per frame. The minimum number of random points necessary to accurately estimate cover and its variation increases with decreasing cover. Therefore, coral reefs with lower cover and less heterogeneous populations require an increased number of points. These results, corroborated using video data from the USEPA-CRMP in the Florida Keys, strongly suggest that careful consideration must be given to sampling design and data analysis prior to attempting to estimate benthic cover, especially in the context of monitoring temporally degrading coral reef ecosystems.

## 16.538

**Coral Literature Education and Outreach, CLEO**

**Linda PIKULA*[1]**, Erica RULE[2], Derek MANZELLO[3]

[1]LISD, NOAA, Miami, FL, [2]NOAA, AOML, Miami, FL, [3]AOML, NOAA, Miami, FL

The CLEO Program leverages techniques developed at NOAA/AOML under the **Explorer of the Seas**, **Coral Health and Monitoring Program**, and Integrated Coral Observing Network (**ICON/CREWS**) programs, under which knowledge transfer of oceanographic instrumentation and coral reef processes have been developed.

The **Gray Literature Section** Coral Literature Education and Outreach (CLEO) project is designed to provide access to "gray" (unpublished or largely uncirculated) literature, data, and documentation on coral reefs constituting the Integrated Coral Observing Network/Coral Reef Early Warning System (ICON/CREWS) monitoring stations. The literature collected in CLEO bibliographies provides foundational and unique research to scientists, educators, and other interested parties who are researching coral reefs, reef dynamics, reef ecology, and reef processes. The items found in these databases are readily accessible in an online, full-text format.

CLEO databases provide background literature for sites at La Parguera (Puerto Rico), St. Croix (U.S. Virgin Islands), St. Thomas (U.S. Virgin Islands), Exuma (Bahamas), and Molasses Reef (United States), with several more sites, including Discovery Bay (Jamaica) planned for future release. The ICON/CREWS project is pursuing a U.S. Coral Reef Task Force goal of establishing monitoring stations at all **major U.S. coral reef areas** by 2010. The gray literature database intends to complement these sites.

The **Educational Modules** are being developed for middle school classes. Each module consists of three segments: background information (science behind the instrument), classroom experiment (experiment to test parameter instrument measures), and teacher's section (describes the Educational Objectives / National Science Standards, Preliminary Activities/Demonstrations, Suggestions for teaching the concept, and Follow-up or Extension Activities for the class.) Students will be engaged to plot and manipulate the data, and to witness events live on the Web via the **ICON/CREWS Coral Cam**. The current modules are **Coral Spawning, Coral Bleaching and Effects of CO2 on Coral Reefs.**

Both Modules at : http://www.coral.noaa.gov/cleo/literature.shtml

## 16.539

**Vdms Archiving And Providing Online Access To The Noaa Ocean Exploration Digital Video And Image Data On Deep Corals**

Anna FIOLEK[1], Janice BEATTIE[1], Eileen MCVEY[1], **Linda PIKULA*[2]**

[1]NOAA Central Library, Silver Spring, MD, [2]NOAA Miami Regional Library, Miami, FL

Hundred of digital video clips, movies, still images and products from the NOAA signature expeditions to coral reef areas are available via NOAALINC, the NOAA Central Library online catalog.

In 2003, the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean Exploration (OE) embarked on a collaboration with the NOAA Central Library (NCL), the National Oceanographic Data Center (NODC), and the National Coastal Data Development Center (NCDDC) to address the requirements for archiving, preserving, providing online access and managing digital video, and still images from OE oceanographic expeditions.

As a result of this collaboration with OE, NOAA's Coral Reef Information System (CoRIS), and other NOAA offices, the library team has developed the Video Data Management System (VDMS) to provide online information and access to NOAA oceanographic cruises that comply with applicable metadata standards. Knowledge of metadata and metadata-making tools was essential. In January 2003, they developed the pilot plan and gave a presentation to OE stakeholders.

Using existing library tools and infrastructure, the library team led the process of archiving, preserving and providing online access to NOAA oceanographic information. Currently, via the NOAA Library and Information Network Catalog (NOAALINC), the library online catalog (http://www.lib.noaa.gov/uhtbin/webcat), information on thousands of hours of digital videos from NOAA signature expeditions from 2001 are accessible to a global community. NOAA scientists can retrieve the expeditions' original tapes from the NOAA Library Archives. Online information includes digital video highlights, still images, cruise reports, educational lesson plans, original video and image annotations, Web sites, and more.

## 16.540

**The Instrumental Architecture Of A Coral Reef Early Warning System (Crews) Station**

**Mike JANKULAK*[1]**, Michael SHOEMAKER[2], James HENDEE[2]

[1]Cooperative Institute for Marine and Atmospheric Sciences, University of Miami, Miami, FL, [2]Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL

CREWS stations originated at, and are constructed by, NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida, and have been deployed at Lee Stocking Island (the Bahamas), St. Croix (USVI), La Parguera (Puerto Rico), and Discovery Bay (Jamaica), with new installations planned for Little Cayman, Saipan, Antigua, and elsewhere. The dynamic pylon supports an architecture that includes all the basic meteorological instruments (e.g., for winds, barometric pressure, precipitation, light), oceanographic instruments (e.g., sea temperature, salinity, light, $pCO_2$, PAM-fluorometry), data logger, solar panels, batteries, satellite transmitter, GPS tracker, lightening arrestor, and, as required, a microwave transmitter for transmitting real-time underwater and above-water video. This report explains how the instrumental architecture is arranged, the considerations necessary for proper maintenance, how the metadata are logged, how the data logger is programmed, and how instruments of importance to specific coral reef research projects can and soon will be accommodated. An outline for a technology transfer program at upcoming installations is also presented.

## 16.541

**The Minimum Sampling Effort For Monitoring Coral Reefs Applying The Video-Transect**

**Igor CRUZ*[1]**, Ruy KIKUCHI[1], Zelinda LEAO[1]

[1]Federal University of Bahia - Brazil, Salvador, Brazil

The main goal of this work was to define the fastest and the least expensive sampling program capable of giving information regarding species composition of important taxa, in a selected coral reef complex, namely Itacolomis Reefs, in the Corumbau Marine Extractive Reserve, located at the southern part of the state of Bahia, in Eastern Brazil. Ten, 20 m long, belt-transects were performed at the top of the Pedra do Silva Reef, covering its northern half in water depths of around 3 m. The average living coral coverage, coral diversity index and coral species richness were evaluated based on the analysis of 20 points per frame in each of the ten belt-transects (average 98.2±7.4 frames per belt-transect). For both quantitative and qualitative data sets, the coral species richness estimators (ICE, ACE, Chao 1, Chao 2 and Cole), and the unique and duplicate occurrences of species, plotted against the cumulative transect data, indicate that almost all curves stabilized with six to seven transects and with up to ten coral species (maximum of eleven coral species was found). These results indicate that six 20 m long transects with an analysis of 20 points per image (frame) was sufficient for sampling the broad taxonomic categories of hard corals, and that the whole field operation could be performed during a single dive per station, up to 10 m deep, saving considerable time and compressed air consumption. The technique may also be applied in other reefs with similar characteristics, as well as along the whole Brazilian Coast considering that the coral richness of Pedra do Silva Reef is comparable, or even higher, than any other reef area in Brazil.

## 16.542

**Improved Intermittent Flow Respirometry -Comparison Of The Metabolic Rates Of Coral Reef And Temperate Scorpaenid Fishes**

**Marian-Alexander MERCKENS*[1]**, Andreas KUNZMANN[1]

[1]Center for Tropical Marine Biology, Bremen, Germany

The metabolism of fishes has been studied for many years. The determination of the metabolic rate of fishes has been optimized stepwise and for a few species valuable comparative data are available. This also includes the introduction of combined respiration and activity measurements .

Although activity level and particularly spontaneous activity of fishes have a strong impact on their metabolic rates, it has been neglected in numerous publications. Our present experimental set-up enables both the detailed documentation of spontaneous activity and also the subsequent calculation of its contribution to the metabolic rate. We were able to study both tropical fishes from coral reefs of Indonesia and temperate fishes of the same family with exactly the same method. This allows for the first time a comparison of metabolic rates from different climate zones.

In this study the metabolic rates of three species of the genera *Scorpaenopsis* and *Parascopaena* from the tropics (Indonesian Seas) and *Myoxocphalus scopius* from the temperate zone (North Sea) were examined.

The metabolic rates for a 50 gram fish are 40.9 $mgO_2 \cdot h^{-1}kg^{-1}$WM (tropical 24-25°C) and 74.3 $mgO_2 \cdot h^{-1}kg^{-1}$WM (temperate 14°C) and therefore clearly lower as compared to literature data.

In addition the metabolic rates of the temperate fishes were investigated at three different temperatures (8°C, 14°C und 18°C). An increased temperature of 10°C induced a doubling of the metabolic rate. At 18°C the metabolic rate of *M. scopius* is 106 $mgO_2 \cdot h^{-1}kg^{-1}$WM, which is twice as high as the metabolic rate of the tropical species at 24-25°C. The substantial lower metabolic rate of tropical species could be an expression of a much more sluggish mode of life and a high potential scope for spontaneous acitivity.

## 16.543

**Coralwatch: A Flexible Coral Bleaching Monitoring Tool For You And Your Group**

Justin MARSHALL[1], **Dave LOGAN*[1]**, Ulrike SIEBECK[1], Ove HOEGH-GULDBERG[2], Joanne MARSTON[3], Jenny Miller GARMENDIA[4], Ania BUDZIAK[4]

[1]School of Biomedical Sciences, University of Queensland, Brisbane, Australia, [2]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [3]Project AWARE Foundation, Frenchs Forest, Australia, [4]Project AWARE Foundation, Rancho Santa Margarita, CA

Coral bleaching events seem set to become more frequent over the next decades. We have developed an intermediate-scale, participative method of monitoring coral bleaching: CoralWatch. The methodology centres on using a colour chart based on a mixture of calibrated coral physiology and colour science. Since the chart's introduction in 2001 we have seen the publication of research papers and reports using the method and users have contributed 15,356 samples from 160 reef sites www.coralwatch.org. Today, CoralWatch is a monitoring system used globally (80 countries) by hundreds of groups from schools to environmental groups, universities and government agencies.

Over a year ago, CoralWatch and Project AWARE Foundation, a non-profit environmental organisation within the scuba diving community, formed a partnership to involve the recreational and professional scuba divers in the effort to raise awareness and gather data on a global scale. Since then, Project AWARE has registered over 600 AWARE CoralWatch operators worldwide and the number of data entries has quadrupled. A Project AWARE workshop already conducted and a survey in design seek to understand the opportunities and obstacles to program growth and enhancement.

Our goal is to expand and refine the program as a hands-on tool used to raise awareness on perils of global warming. We also aim to engage and support individuals and groups interested in using CoralWatch to monitor coral bleaching and contribute to a global data set available to all and of use in research, school projects and policy guidance. In 2008 we will continue to integrate with other systems including remote sensing surveys, ReefBase, Coral Reef Watch, BleachWatch and Reef Check. In this presentation we introduce the system and answer some FAQs as well as provide methodological suggestions to enhance monitoring and raise awareness simultaneously.

## 16.544

**Mapping The Spatial Characteristics Of Acropora Populations:**

**Barry DEVINE*[1]**, Pedro NIEVES[1]

[1]Eastern Caribbean Center, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Acropora palmata, Elkhorn Coral, has been recently added to the Endangered Species List as a result of the catastrophic decline of these dominant nearshore corals over the past 20 years. Understanding the spatial geography of existing populations is a key to understanding their status for management and recovery. The authors have been advancing the technology needed for the digital collection of population data using highly accurate GPS/PDA's in shallow surface water locations. The data collection method captures location and population characteristics in a rapid, accurate process that reduces error and post sampling effort and provides downloadable excel files for GIS manipulation, graphic display and data anaylsis.

## 16.545

**A Direct Physiological Approach To Coral Bleaching Detection: Meaning For Managers?**

**Derek MANZELLO*[1]**, James HENDEE[2], Erik STABENAU[3], Michael LESSER[4], Mark WARNER[5]

[1]Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School, University of Miami, Miami, FL, [2]NOAA AOML, Miami, FL, [3]Everglades National Park, National Park Service, Homestead, FL, [4]Dept. of Microbiology, Univ. of New Hampshire, Durham, NH, [5]College of Marine and Earth Studies, Univ. of Delaware, Lewes, DE

NOAA's Integrated Coral Observing Network (ICON) obtains meteorological and *in situ* oceanographic data hourly in near real-time (through satellite relay) with high temporal resolution from select coral reef areas to complement the high spatial resolution of NOAA's Coral Reef Watch program. Satellite-derived sea surface temperature (SST) products are effective at highlighting regions of the globe where SSTs are warmer than normal (e.g., 'hotspots') and where bleaching might be expected. However, additional causative or modifying factors of coral bleaching (e.g., light, hydrodynamics) are usually ignored and the physiological status of coral-algal symbioses cannot be evaluated with satellite monitoring alone. Utilizing a specially constructed Pulse Amplitude Modulating (PAM) fluorometer, *in situ* active chlorophyll fluorescence of the endosymbiotic zooxanthellae was measured remotely and in near real-time for two common Caribbean species of reef-building coral at Lee Stocking Island, Bahamas during the Caribbean-wide 2005 bleaching event. Both species displayed evidence of chronic photoinhibition coincident with thermal stress and seasonally high doses of solar radiation (both ultraviolet and visible). Hurricane-associated cooling and shading appears to have been responsible for minimizing the impact of bleaching at this site in 2005 as was shown for Florida that same year. PAM fluorometry, coupled with simultaneous long-term measurement of *in situ* light and temperature, can provide much more detail for understanding coral photobiology and coral bleaching than sporadic point measurements from research divers alone. Of particular benefit, is that these methods can be used to monitor the physiological status of specific coral species at a few key sites if an earlier detection of bleaching 'stress' is desired for potential management activities.

## 16.546

**Investigations Of The Deep Reef Environment Of Palau, 60-600 M**

**Patrick COLIN*[1]**, Lori BELL-COLIN[1]

[1]Coral Reef Research Foundation, Koror, Palau

The outer reef slope of Palau was investigated by mixed gas diving and small submersible from 1997 to the present. Below the shallow reefs the area is characterized by steep limestone slopes with depauperate biological communities in the range of 75-100 m depth. The area is impacted by some of the largest internal waves known in the world causing highly variable thermal regimes. Above 60-90 m communities are characterized by elements of the shallow water fauna. Below 100-110 m the benthic faunal structure shifts to lithistid sponge species which are not found in shallower water. Hermatypic reef corals do not occur below about 75 m, but a distinctive ahermatype fauna is found to over 300 m. Investigation has resulted in descriptions of many new deepwater reef-related species as well as new discoveries of outer slope pinnacles and geologically complex features.

## 16.547

**Coral Reef Information System (Coris): A One Stop Shop For Coral Information**

Kelly LOGAN[1], **Michele NEWLIN*[2]**

[1]National Oceanic and Atmospheric Administration, Silver Spring, MD, [2]National Oceanic and Atmospheric Adminstration, Silver Spring, MD

Destructive fishing practices, increases in sea surface temperatures, habitat destruction, diseases, and invasive species: such are the trials and tribulations in the life of a coral reef. The nation's coral reefs are threatened and in decline. It is estimated that 10 percent are now beyond recovery, 30 percent are in their critical stages and may die in the next 10-20 years, and 60 percent may die by the year 2050. (Coral Reef Task Force (CRTF). 2000. *The National Action Plan to Conserve Coral Reefs.* Washington, DC: CRTF. p. 3.)

As a coral reef ecosystem manager, one may be overwhelmed with the range of threats encountered on a daily basis. "How do I diagnose coral diseases?" "What are others doing about habitat destruction so that I can learn from their work?" "Which invasive species may inhabit my reef area?" Scientists and students may also find themselves perplexed over the answers to these same questions. "What is being done to combat these issues?" "Where can I find discussions on coral related topics?"

The answers to these questions, and many more, may be found in the National Oceanic and Atmospheric Administration's (NOAA's) web-enabled Coral Reef Information System (CoRIS). CoRIS data discovery tools provide access to metadata, data, and information from the NOAA Coral Reef Conservation Program (CRCP) and other coral reef projects. CoRIS offers original essays that describe coral biology and physiology, reef structure, and types of reefs, among other topics. The CoRIS Library enables searching and browsing through a growing collection of NOAA's coral ecosystems-related publications, reports, web sites, educational materials, and digital images. One of the most popular features of CoRIS, the Glossary, defines thousands of terms used in coral reef science and management. Whatever your coral reef data and information needs may be, you can begin your search at **www.coris.noaa.gov**.

## 16.548

**Use Of Marine Habitat Mapping And Dive Observation Of Marine Turtles To Identify Feeding Areas in Martinique, Fwi**

**Laurent LOUIS-JEAN*[1]**, Philippe LENFANT[2], René GALZIN[2], Claire CAYOL[3], Jean-Philippe MARÉCHAL[4]

[1]OMMM, Fort-de-France, Martinique, [2]EPHE - University of Perpignan, Perpignan, France, [3]ONCFS - Réseau tortues marines de Martinique, Fort-de-France, France, [4]OMMM, Fort-de-France, France

In the early nineteen's, marine turtles populations decreased to a critical level. This situation was followed by a fully protection policy of the species living in the French West Indies (FWI) in 1991 (Guadeloupe archipelago) and 1993 (Martinique). Recent studies throughout the Caribbean showed an increase in turtle populations. However, they did not reach a sustainable status yet. The green turtle, Chelonia mydas, and the hawksbill turtle, Eretmochelys imbricata, are the main species living in the FWI waters. They are respectively classified as critically endangered and endangered. The aim of the study is to correlate benthic community structure with marine turtle abundance or presence.

Two life history stages can be observed: the feeding turtles and the nesting ones. The turtles present in the FWI most part of the time are juveniles or feeding turtles which migrate once every two to three years to nest. The present study, focusing mainly on the resident species, has two objectives: 1) define experimental sites to follow the evolution of the local populations versus time and 2) define experimental fishing sites to analyze small scale fisheries by-catch.

Benthic communities (sea grass beds and coral reef) and their boundaries were visually analyzed using aerial photographs and validated with ground truthing campaigns. The data were transferred to GIS. The abundance of marine turtles was assessed by the Martinique Marine Turtle Network using the Ina-Scuba protocol. The protocol relies on visual observation of turtles by local dive centers throughout the year. Three parameters are recorded: species, time and location. Maps of benthic communities and turtle distribution were drawn from the results and compared to determine the major turtle feeding areas.

## 16.549

**Mesophotic Coral Ecosystems: A New On-Line Resource Database For Research in The Mesophotic Zone**

**Pim BONGAERTS*[1]**, Felix MARTINEZ[2]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]Center for Sponsored Coastal Ocean Research, National Oceanic and Atmospheric Administration, Silver Spring, FL

Studies on mesophotic coral communities (> 30m) are extremely scarce, due to their location outside of the usual depth range of scientific SCUBA diving. However, recent advances in mixed-gas diving techniques and Remotely Operated Vehicle (ROV) and Autonomous Underwater Vehicle (AUV) design are gradually making the mesophotic zone more accessible to scientists. This is an important development as these largely unexplored ecosystems may harbor unique benthic communities and have the potential to play an important role by acting as refugia during periods of environmental disturbance. Despite these advances, research in the mesophotic zone remains logistically complicated and expensive, so collaborations and sharing of resources are extremely beneficial to maximize the amount of knowledge gained from operations. In order to facilitate the establishment of new partnerships, we have set up a new website **www.mesophotic.com**, which will function as an on-line resource database focused on mesophotic coral communities.

## 16.550

**Methodological Proposal Of Cartography Of Mexican Pacific Coral Reefs**

**Carlos CANDELARIA*[1]**, Norma CORADO-NAVA[1], Manuel OSEGUERA[1], Emmanuel TEYSSIER[1], Magali HONEY[1], Andres OCAMPO[1]

[1]Facultad de Ciencias, Universidad Nacional Autonoma de Mexico, Mexico city, Mexico

One of valuable tool to know diverse biological phenomena and processes that happen in coral reefs related with its spacial dimension have been maps. These have been used to represent topographical conformation of the reefs, distributional patterns of corals and other species, as referential for successional studies and for applied purposes related with conservation programs and sustainable development.

In this study a methodological proposal of underwater cartography is presented, applied to reefs communities of Huatulco, Oaxaca, and Zihuatanejo, Guerrero, in the Mexican Tropical Pacific.

The mapping protocol consists of four general phases: 1) planning and organization; 2) topographical survey; 3) data processing; and, 4) cartography.

Two types of bathymetric maps were obtained, one two-dimensional representation (2D) and other three-dimensional (3D), showing complementary relief˙features.

## 16.551

**Coral Bleaching Response Plan For South Florida's Reefs: A Florida Reef Resilience Project**

**Rowena GARCIA*[1]**, Meaghan JOHNSON[1], Philip KRAMER[1]

[1]The Nature Conservancy, Summerland, FL

Coral bleaching due to climate change is projected to increase; therefore it is important that a coral bleaching response plan be developed. The Florida Reef Resilience Project (FRRP) developed and implemented a coral bleaching response plan in the summers of 2005, 2006 and 2007 on the South Florida reef tract. Twelve teams composed of federal, state, and local agencies, non-profit groups and universities were trained on bleaching response assessment by The Nature Conservancy during each year. Bleachwatch, a volunteer early warning program and the NOAA Coral Reef watch products HotSpot Maps and Degree Heating Weeks were used to establish the start of the survey period. Approximately 160 independent surveys were undertaken across the South Florida reef tract within a six week period each year. The sampling design was developed to capture spatial variability in bleaching response throughout the South Florida reef tract. A random stratified sampling design was used to establish sampling stations, and coral colonies were evaluated using belt transects randomly placed within each sampling location. Four main parameters are recorded for all stony corals greater than 4 cm in diameter within each transect: live coral cover, hard coral density, hard coral size, and hard coral condition (bleaching, disease, partial mortality). In addition to developing the methodology for bleaching response assessment, we realized that the time required to complete annual surveys will generally take longer than anticipated due to delays caused by weather events and the difficulty in coordinating the schedules of a diverse group of organizations. The fact that there is a high level of commitment from all organizations involved has led to the successful implementation of the coral bleaching response plan.

## 16.552

**Fishbone Transect: A New Hybrid Methodology For Spatio-Temporal Characterization Of Macrobenthos On Hard Surfaces**

**Diego COSTA*[1]**, David BÉLANGER[2], André SANTOS[3], Sheila RAFI[4], Natalia VIEIRA[5], Carlos PERÉZ[6]

[1]Zoology department, Federal University of Pernambuco, Recife, Brazil, [2]Biology Department, Université de Sherbrooke, Sherbrooke, QC, Canada, [3]Biology Departament, Federal University of Pernambuco, Recife, Brazil, [4]Zoology Department, Federal University of Pernambuco, Recife, Brazil, [5]Zoology department, University Federal of Pernambuco, Recife, Brazil, [6]Biology department, University Federal of Pernambuco, Recife, Brazil

Brazilian coral reefs extend over almost 3.000 km along the northearstern coast of Brazil and represent the only reef ecosystems of South Atlantic. A seasonal study has been conducted on three beaches on the south littoral of Pernambuco state, Brazil, enter 2005 to 2007. The aim of this study was to compare the traditional methodology, using standard sampling units for assessing colonial and punctual macrobenthics organisms with a new bidimensional hybrid methodology using a new sampling unit named fishbone transect. It is constitute by isobathymetrical lines or bands with a 5m long transect perpendicular to the coastline (the column) intercepted by two 2m long transects parallel to the coastline (the ribs) each of them crossing the column at 1,5m and 3,5m respectively. Each transect (perpendicular and parallel) are made out of a measuring tape in order to measure the covering of each organisms that are encountered above the tape and are split in 1m section for estimating the frequencies of organisms. In addition, 1m X 0,5m quadrats were disposed on the right side of each transect for every 1m section in order to counted punctual organisms. Colonial organisms and algae were quantified using the line intercept transect method. The density of punctual organism was estimated by counting them in band transects. The data were integrated in a GIS ArcView 3.2 software. The results have demonstrated that the fishbone, when it is compare to traditional methodologies, represents in a more parsimonious way the community structure of the reef relating to the zonation gradient of the organisms. Moreover, better richness and abundance results were obtained as well as it increased the graphical illustrations (map) quality of the distribution of organisms in a space and time scales.

## 16.552A

**A Simple, Low-Cost System For Determining High Resolution Particle Distributions On Coral Reefs**

**Alex WYATT*[1]**, Roger NOKES[2], Stuart HUMPHRIES[3], Anya WAITE[1]

[1]School of Environmental Systems Engineering, The University of Western Australia, Crawley, Australia, [2]Civil and Natural Resources Engineering, University of Canterbury, Christchurch, New Zealand, [3]Department of Animal & Plant Sciences, University of Sheffield, Sheffield, United Kingdom

There is increasing interested in the role that suspended particles play in the trophodynamics of coral reefs and the importance of heterotrophic feeding by reef organism in energy budgets, calcification and resilience to stressors. Exploring the mechanistic role of heterotrophy in various aspects of coral reef ecology requires detailed understanding of the composition and dynamics of suspended particulate material (SPM). Variation in the size-structure of SPM in response to biological and physical forcing is of particular interest. Techniques for examining the size-structure of SPM typically involve the use of expensive equipment that measure acoustic or optical backscatter or laser diffraction, all of which have significant limitations. We have developed a simple, low-cost particle imaging system that uses a light sheet and standard digital still camera to obtain information on particle distributions to as low as 20 μm. This system has been optimised and tested in the laboratory using known artificial particle distributions and deployed in the field to measure natural variation.

## 17.553

**GIS Derived Spatial Analysis as a Tool to Predict Nearshore Coral Reef Fish Species in American Samoa**

**D. Paul BROWN*[1]**, Gerald ALLEN[2]

[1]National Park Service, Pago Pago, American Samoa, [2]Department of Aquatic Zoology, Western Australian Museum, Perth, Australia

The U.S. National Park Service has undertaken a monumental task of inventorying species found within park boundaries both below water and on land. This is part of the Inventory & Monitoring program aimed to increase our management efforts in all the U.S. National Parks. In the National Park of American Samoa, the inventory of coral reef fish has helped to discover 44 new species records for the territory of American Samoa. This was done using both GIS polygons derived from known geographic distributions of marine fish as well as in-water surveys using SCUBA and technical diving procedures. A distribution map was created for all known coral reef fish species from the central South Pacific. Using ArcInfo GIS software, a point was generated on an equal area map of the South Pacific for each recorded occurrence of a given species. These point records, whether collection or observational records, were then used to create a GIS polygon. Although these polygons include broad expanses of deepsea/ pelagic habitat, it is assumed that fish species only occur in suitable habitat. When American Samoa fell inside this polygon, it was assumed that this species could be found. GIS benthic habitat maps were then used to locate suitable and likely locations for a given species. In-water surveys were then conducted to look for the assumed present species. Using this technique 118 additional species were presumed to be located in Am. Samoa. To date the in-water surveys have found 44 new records, of these, 27 were assumed present from the GIS modeling but had never previously been found. Many of the remaining species are small and cryptic and are unlikely to be encountered without the use of icthyocides.

## 17.554

**Monitoring The Health Of Coral Reef Using Multi-Temporal Remote Sensing -A Case Study Of Pirotan Island, Marine National Park, Gulf Of Kachchh, Gujarat , India**

**Sahadev SHARMA*[1]**, Anjali BAHUGUNA[2], Nandini Ray CHAUDHARY[2], Shailesh NAYAK[3], Sachin CHAVAN[4], Chavi Nath PANDEY[4]

[1]University of the Ryukyus, Okinawa, Japan, Nishihara, Japan, [2]Space Applications Centre (ISRO) Ahmedabad, India, Ahmedabad, India, [3]Indian National Centre for Ocean Information Service, Hyderabad, India, hyderabad, India, [4]Gujarat Ecological Education and Research Foundation, Gandhinagar, India, Gandhinagar, India

Multi-temporal coral reef study is required for monitoring the climate and human impact changes. We have evolved an indicator-based (mainly satellite-derivable indicators) approach for monitoring health of reefs. The indicators tell about the damage already done, current ecological condition and early warning to the reefs. Early warning indicators are Sea Surface Temperature Anomaly, Turbidity, and Delay in Onset of Algae. The ecological indicators are diversity (both floral, faunal and habitat), percentage cover of live and dead corals, etc., and the Damage indicators are the deposition of mud and sand on the reef, erosion, phase shift, etc. The health status for Pirotan reef ($22.6^0$N, $70^0$E) located in the Gulf of Kachchh, India, has been assessed using health indicators. Indicators of Pirotan Reef health are temperature rise, high salinity, increase in macro-algae, over-fishing, high sedimentation rate, human influences, and deposition of mud over reef, etc. Indian Remote Sensing Satellite LISS III sensor data of periods 1998, 2000 and 2005 were analysed to zone the eco-morphological zones of the reef like algal ridge, mud over reef, sandy muddy reef flat, live coral zone, seagrass, macro-algae, algae on muddy reef flat, etc. with an accuracy of 87% at 90% confidence level. NOAA-AVHRR average monthly SST data was analyzed from 1998 to 2005 (March, April, May and June) to identify the effect of temperature rise on coral reef like bleaching and increased macro-algae cover. Depositions of sand and mud have increased owing to the high sedimentation rate, sand mining and cutting of mangroves. Coral bleaching and stress has resulted in increased macro-algal growth. Onset of coral reef friendly macro-alga (Sargassum) has shifted from September-October to early December. The Pirotan reef is under severe degradation as is apparent from the indicators of health. Efforts are currently underway to model the indicators for establishing health.

## 17.555

**Coral Color - Reflection And Absorption**

**Noga STAMBLER*[1]**

[1]Life Sciences, Bar Ilan University, Ramat Gan, Israel

Light absorption per unit of coral surface area decreased with increase in colony size, with a clear effect of different coral morphologies. In branched colonies, shading among branches reduced the absorbed light per unit area and per zooxanthellae.

Corals often have different colors; color is variable, even among colonies of the same species growing together. While the colors blue, pink, and green are due to the protein pigments in the host tissue, the brown color is due to the absorption of the zooxanthellae pigments.

Coral colors change as a result of acclimation and adaptation to environmental conditions. Dark brown colors, representing higher absorption, are due to low-light intensities or exposure to high-nutrient concentration, while lightness colors are due to low pigment concentrations, in some cases due to natural conditions while others indicate stress conditions.

The absorption range of the corals and their symbiotic zooxanthellae, and their ability to change their color by photo-acclimation and photoadaptation enable the coral to grow and survive.

These variations can monitor on a reef level, however corals can exhibit different colors in the same colony. The spectral variation between color morphs of the hermatypic corals Stylophora pistillata and Pocillopora damicornis in the northern Red Sea was found to be higher than between species. Therefore species recognition based on reflectance spectra is only possible in certain cases.

## 17.556

**Geomorphological Symbolization Of Coral Reef Environments Along The Southeast Coast Of Florida: Interpretation Of Airborne Laser Bathymetry And Development Of An Extension For Arcinfo GIS**

Jacob ESTEBANELL BECERRA[1], Victoria ACHATZ[2], **Charles FINKL*[3]**

[1]Facultat de Geologia, Universitat de Barcelona, Barcelona, Spain, [2]School of Geoinformation, University of Applied Sciences Villach, Villach, Austria, [3]Coastal Geology & Geomatics, Coastal Planning & Engineering, Boca Raton, FL

Interpretation of laser airborne depth sounding (LADS) imagery along the SE Florida coast initially identified numerous coral reef environments that were displayed as discrete polygons on maps. Although this recognition of morphoforms provided a comprehensive overview of spatial differentiation and interrelationships between reef subsystems, the topology lacked clear integration of form with function and morphodynamic processes. In an effort to glean more information from the LADS imagery that would better reflect the detailed distribution of morphoforms, we amalgamated symbolization as recommended in manuals for meso- and microscale geomorphological mapping as seen in the Geomorphological Map of Europe. The procedure involved detailed subdivision of mapping units already derived for the 600 km2 study area by interpretation of morphoforms and onscreen digitizing using symbols specifically created for this purpose. The characterization of coral reef environments involved classification of different geomorphic forms and processes followed by the creation of index forms for maps. After adapting existing landscape symbols to seafloor forms and adding new symbols, hand drawn maps including all patterns (point, line, polygon) were prepared as overlays to the LADS imagery. Polygon and point patterns were digitized in a graphics drawing program while line patterns were created in the ArcGIS Style Manager. After importing geomorphic symbols into the ArcGIS Library, shape and color patterns were adjusted for final digitalization of the geomorphic map with a self programmed extension for ArcGIS. The result produced maps showing coral reef environments displayed in terms of true geomorphic symbolization.

## 17.557

**Reef Mapping Technologies For Marine Management in Brazil And Belize**

John MUSINSKY[1], **Debra FISCHMAN*[1]**, Daniel KLEIN[2], Guilherme Fraga DUTRA[3], Rodrigo MOURA[4], Phillip LOBEL[5], Peter STETSON[5], Alex BASTOS[6], Ruy KIKUCHI[7]

[1]Center for Applied Biodiversity Science, Conservation International, Arlington, VA, [2]Conservation International Brazil, Caravelas, Brazil, [3]Conservation International Brazil, Ondina, Salvador, Brazil, [4]Conservation International Brazil, Caravelas, BA, Brazil, [5]Department of Biology, Boston University, Boston, MA, [6]Department of Geology, Universidade Federal do Espírito Santo, Goiabeiras, Vitória, Espírito Santo, Brazil, [7]Instituto de Geociências, Universidade Federal da Bahia, Salvador, BA, Brazil

This poster describes and compares different types of reef and inter-reefal mapping and monitoring technologies being used to support the Marine Management Area Science Program, a scientific effort coordinated by Conservation International seeking to understand and improve management effectiveness and design of marine management areas. In two study areas, the Abrolhos Bank (Brazil) and the Mesoamerican reef (Belize), a combination of high-resolution optical satellite imagery, side-scan sonar, multi-beam echo sounder, remotely operated vehicle (ROV), and SCUBA dives (for video and photographic records) are being used to map and validate classification of shallow (up to 20 meters) and mid-depth (up to 100 meters) coralline and inter-reefal habitats. These technologies were chosen for: 1) their ability to map extensive geographic areas; 2) their capacity to provide high-quality information; 3) their suitability to the varying environmental conditions of the reef and inter-reefal areas; and 4) cost and availability. For shallow coral reef systems, QuickBird and IKONOS satellite images are being used to classify fine-scale biophysical characteristics (e.g. macroalgae, corals, sand, mud) and create a baseline map for long-term monitoring of these reefs. We are systematically sampling deeper benthic habitats with side-scan sonar profilers and acoustic doppler topographic survey devices to detect potential reef structures and map bottom types. Anomalies and prominent features (e.g. pinnacles, channels) identified in the acoustic mapping surveys are subsequently ground-truthed using SCUBA dives to 60 m and ROV coupled to video cameras to 100 m. Comparisons between the technologies used and their appropriateness for the different habitat mapping objectives are discussed.

## 17.558

**Habitat Isolation Negatively Influences Reef Fish Populations Of A Hawaiian Atoll**

**Erik FRANKLIN*[1]**

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI

Experimental studies have demonstrated that reef fish richness and abundance tend to be greater on more isolated reefs. The relatively small spatial scale of these experimental studies may have led to results not applicable to the scales and distribution of natural reef areas. A thematic benthic habitat map derived from an IKONOS satellite image was used to define a sampling domain to test a hypothesis regarding the influence of isolation on reef fish among natural reef habitats. Fish populations associated with fourteen reef patches of similar size and biogeomorphological characteristics were surveyed within the lagoon at Midway Atoll in July 2007. Reef fish populations were assessed using a visual belt transect method that recorded the size and species of each individual. In contrast to other studies, a gradient of decreasing abundances and fish sizes coincided with greater habitat isolation. The trend in species richness with isolation was not as strong. These results suggest that habitat isolation can have a negative effect on fish communities if examined at spatial scales that may better reflect the inaccessibility of adjacent habitat patches from the reef fish perspective.

## 17.559

**Assessing Florida and Hawai'i coral reef ecosystem health using a GPS-based underwater video mapping system**

**Paul AYERS*[1]**, Rebecca MESSER[1]

[1]University of Tennessee, Knoxville, TN

Assessing and monitoring coral reef ecosystem health is essential for understanding immediate and long-term environmental impacts. An Underwater Video Mapping System (UVMS) is a technique to acquire Global Positioning System (GPS)-based georeferenced underwater images that allow mapping of underwater features. The system automatically interfaces the GPS and underwater video image providing a location for each picture. Using the UVMS, underwater features essential for assessing and monitoring coral reef ecosystem health can be acquired and mapped using Geographic Information System (GIS).

The UVMS was used to acquire georeferenced underwater images in sections of the coral reef ecosystem in Moloka'i, Hawaii and Biscayne National Park (BISC), Florida. In BISC, increasing swath width from 20 meters to 40 meters decreased substrate map accuracy from 93.4% to 73.6%. In Moloka'i, dense coral was observed for 40% of the transect, and sand with algae represented 13% of the survey site.

In addition to mapping of substrate conditions, factors contributing to the assessment of coral reef health were identified and mapped. These features include marine debris (discarded items including ropes, traps, etc.), coral damage (from boat, anchor, etc.), coral disease and other health issues (i.e. black band disease). In the 0.2 square km survey within BISC, 8 locations of black band disease were recorded. In a 1.7 km transect over Pacific Reef, 9 observation of marine debris were mapped.

The UVMS is a useful tool for providing large-scale assessments of the coral ecosystem health, and identifying areas that need further detailed investigation. It also provides a georeferenced video history of coral health and an opportunity to resurvey the same coral reef ecosystem and monitor health changes.

## 17.560

**Comparison Of A Benthic Terrain Model To Benthic Habitat Classification Maps Of Moloka‘i, Hawai‘i, Usa**

**Susan A COCHRAN*[1]**

[1]USGS Pacific Science Center, Santa Cruz, CA

A study was undertaken to compare modeled morphological complexity of a coral reef to benthic habitat maps to investigate patterns of habitat preference. Using the Benthic Terrain Modeler (BTM), an extension created for ArcGIS by the joint efforts of the seafloor-mapping lab at Oregon State University and NOAA's Coastal Services Center (Wright and others, 2005), a benthic terrain model of the fringing coral reef on the south shore of Moloka‘i was created from high-resolution SHOALS lidar bathymetric data (~2.5 m spacing between data points). The BTM classifies data based on a combination of slope (a first-order derivative of bathymetry), broad- and fine-scaled bathymetric position indices (BPIs, second-order derivatives of bathymetry) describing the depth of a specific point relative to the surrounding bathymetry, along with rugosity, and produces grid layers of terrain-based zones and structures. Modifications were made to the default classification scheme provided with the BTM tool to better reflect the changes in depth and slope found on the Moloka‘i fringing reef.

The results from the BTM were compared to high-resolution (100 $m^2$ Minimum Mapping Unit) benthic habitat classification maps of Moloka‘i (Cochran-Marquez, 2005), to determine relationships between mapped benthic habitats and modeled BPI structures. Areas that were mapped with high coral cover were found to be the areas of highest morphological complexity in the terrain-based model. Establishing associations between benthic coverage (and in some instances percent cover) and modeled structures and zones will allow users to extend mapping capabilities to areas where field validation of remotely-sensed underwater resources is limited.

## 17.561

**Gis Technology As A Tool To Improve Coastal Resource Management**

**Kim BALDWIN*[1]**, Ramon ROACH[2]

[1]CERMES, University of the West Indies, St. Michael, Barbados, [2]Coastal Zone Management Unit, St. Michael, Barbados

Spatial technologies, namely geographical information systems (GIS) can improve the efficacy of coastal resource management initiatives by providing a visual framework to link, relate and analyse both spatial and attribute data. GIS can allow for the integration of information from a variety of sources, time periods and at multiple spatial scales; and collate a range of natural resource data as automated spatial features which can be rapidly merged, accessed and updated. Furthermore, GIS can be used to statistically identify unique relationships and interactions among mapped variables and allow for a range of innovative spatial queries, interpretation and modelling, which can improve decision-making and planning within a coastal resource management framework. In Barbados, a wide range of environmental data have been collected over the past twenty years and analysed using conventional scientific methods to inform coastal resource management policy. This paper will explore the advantages of using GIS as a tool to integrate and analyse an array of coral reef information, and compare this to conventional methods currently employed in Barbados. Ultimately, the power of utilising GIS as a functional tool for more efficient coastal resource management in Barbados will be demonstrated.

## 17.562

**Modelling Susceptibility Of Coral Reefs To Environmental Stress Using Remote Sensing Data And Gis Models**

**Joseph MAINA*[1,2]**, Valentijn VENUS[2], Tim MCCLANAHAN[3], Ateweberhan MEBRAHTU[1]

[1]Coral Reefs Conservation Project, Mombasa, Kenya, [2]International Institute for Geoinformation Science and Earth Observation, Enschede, Netherlands, [3]Wildlife Conservation Society, Mombasa, Kenya

There is a need to develop methods and a decision support system to establish marine protected areas that harbor coral reefs that are resilient to climate change. This requires understanding patterns of coral's susceptibility to thermal stress and how coral communities will change with the environmental variables associated with climate change. This study combined surface currents, wind velocity, sea surface temperature (SST), UV radiation, photosynthetically active radiation (PAR), and chlorophyll-a concentration for the western Indian Ocean and known relationships with coral bleaching and mortality to derive predictor variables that correlate with thermal stress. SST variability, UV, maximum temperature and wind speed had the highest influence on susceptibility estimates. Two susceptibility models were developed using Spatial Principal Component Analysis (SPCA) and cosine amplitude-AHP methods and a fuzzy logic technique for integrating environmental variables into a measure of susceptibility. Susceptibility models identified regional gradients in environmental stress, with the north western Indian Ocean and some central Indian Ocean Islands as high and the southern African coastline and islands east of Madagascar as low vulnerability regions. Half of the strictly no take zones in the region are situated in locations with medium to high susceptibility. Future studies using high-resolution data can better estimate the vulnerability of specific locations and the establishment of marine protected areas where coral reef diversity is more likely to persist through climate change.

## 17.563

**Development Of A Hybrid Mapping Tool (Hmt) For The Characterisation Of Coral Reef Landscapes**

**Samuel PURKIS*[1]**, Kevin KOHLER[1], Steven ROHMANN[2]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [2]Special Projects Office, NOS/NOAA, Silver Spring, MD

Remote sensing is routinely used as the basis for the production of reef-scale benthic habitat maps and is unsurpassed in terms of accuracy and cost. In cases where atmospheric status, bathymetry and water column optical properties can be adequately described, automated classification of benthic character is possible with high accuracy. For region-wide mapping initiatives such an automated approach is unfeasible since optical closure of the system is unattainable over large areas. Consequently, regional mapping has heretofore been done using a strategy of expert-driven manual digitisation of reef habitat. Although accurate, this strategy is expensive and time-consuming in regions of high complexity and area. The Hybrid Mapping Tool (HMT) is being designed to aid the expert-driven process and accelerate map production through automated delineation of habitat boundaries. It uses a suite of edge-detection methods combined with a statistical assignment of map polygons to habitat classes on the basis of their spectral, textural and boundary properties. By combining automated and visual techniques, HMT will be able to produce thematically accurate maps of shallow-water benthic habitats from a variety of image sources including multibeam sonar, LiDAR, and satellite sensors such as Quickbird and IKONOS.

## 17.564

**Classification Of Coral Reefs Multispectral Remote Sensing Images Using Classifiers Combination Based in Support Vector Machines (Svm)**

Antônio HENRIQUES[1], Adrião NETO[1], **Ricardo AMARAL*[2]**

[1]DCA, Federal University of R. G. do Norte, Natal, Brazil, [2]Federal University of R. G. do Norte, Natal, Brazil

We report the use of derived maps from remote sensing orbital images submitted to digital processing, at Maracajau path reef Northeastern Brazil, to optimize conservation, monitoring and valuation actions. The accuracy reached in the mapping of submerged areas it is limited by variation of the water column that degrades the sign received by the orbital sensor, creating inter-classes, which introduce mistakes in the final result of the classification. The limited capacity of the traditional methods based on conventional statistical techniques to solve the problems related to the inter-classes, it conducted to the investigation of an alternative strategy based on classifiers combination. The basic idea of the classifiers combination is to used a set of classifier and combine the individual predictions with the goal of achieving improved generalization performance if compared to the performance achievable with a single estimator. In this work a classifiers combination is based on the serial combination of two support vector machines set and in minimum-distance classifier algorithm were used as an alternative tool for Classification of Remotely Sensed Image of the Coral Reefs Ecosystem. SVM is a special type of learning machine, based on the statistical theory of the learning. The method applied has as objective the progressive refinement of the classification process. The image was classified into five bottom-types (accuracy %): deep water (100); under-water corals (93); inter-tidal corals (80); algal (73); sand (100). The highest overall accuracy (89%) was obtained from SVM trained whit 80 cases of each class. A problem observed during the development of this study it was the similarity spectral among the class Inter-tidal corals and the class algal. The classification accuracy, verified through field observation and photo interpretation, revealed itself more accurate than classifications derived from the use classifier single with basic multilayer perceptron, and kmeans algorithms.

## 17.565

**Different Pigments Composition Can Influence The Remote Sensing Reflectance Of Caribbean Shallow-Water Coral Species**

**Juan TORRES*[1]**, Roy ARMSTRONG[2]

[1]Biology Department, University of Puerto Rico at Rio Piedras, San Juan, Puerto Rico, [2]Department of Marine Sciences, University of Puerto Rico at Mayaguez, Lajas, Puerto Rico

The pigment composition of the Caribbean shallow-water coral species *Acropora cervicornis* and *Porites porites* was determined using HPLC analysis. Nineteen different pigments were identified including chlorophylls and carotenes. Of these, ten were common in both species; six appeared only in *A. cervicornis*, and four appeared only in *P. porites*. It is hypothesized this is the result of different zooxanthellae clades that inhabit these coral species. The results showed how the differences in pigments composition influence the remote sensing reflectance (Rrs) signal of both species. While the Rrs appeared to be very similar in both species, derivative analysis showed marked differences resulting from the absorption of the pigments, especially in the blue region of the spectrum (400-500 nm). The combination of both techniques can be used to further create a spectral library to identify shallow-water coral species in hyperspectral images.

## 17.566

**A New Method for Monitoring Along-Track Topographic Complexity**

**Monica PALASEANU-LOVEJOY*[1]**, John BROCK[2], Kristi FOSTER[3], Amar NAYEGANDHI[4], David NAGLE[1]

[1]FISC, USGS / Jacobs, St. Petersburg, FL, [2]FISC, USGS, St. Petersburg, FL, [3]NOVA University, Dania Beach, FL, [4]FISC, USGS / ETI, St. Petersburg, FL

Topographic variability is an important characteristic of habitat complexity that influences the abundance and distribution of many reef organisms. One measure of topographic variability is rugosity, defined as the ratio of the real distance between two points and their projected distance on a horizontal plane. Traditionally, rugosity is measured in the field using the chain transect method. In this study, we used Marimatech sounder data collected at a nominal horizontal spacing of 2 to 10 cm to calculate along-track rugosity. Concomitant, geo-located images were acquired via the Along-Track Reef-Imaging System (ATRIS) placed opposite the Marimatech sounder transducer on the survey vessel. The ATRIS Data Analysis and Processing Tool (ADAPT) allows interactive geographic browsing, scalling, and classification of each image. We identified six different habitats: seagrass, sand, hard ground / algae / turf, dense coral reef, sparse coral reef, and dead coral. Each point for which rugosity was calculated was associated with the closest classified image. The Welch t-test confirmed that the true divergence in population means is different than zero. The f-test endorsed that the true population variances are statistically dissimilar for each habitat class, although hardground, dense coral and sparse coral variances were not essentially different than dead coral variances in the Fligner - Killen test of homogeneity of variances. The mean habitat rugosity values indicated that seagrass had the least complex topography, with complexity increasing from dead corals to sand, hard-ground / algae/ turf, and sparse mixed reef. Probably sand had a higher rugosity mean value due to dense ripples. The dense mixed reef had the highest habitat complexity among the six identified classes.

## 17.567

**Assessing Patterns Of Patch Reef Distribution in The Lower Florida Keys, Usa, Using Ikonos Satellite Imagery**

**Melanie PETERS*[1]**, David PALANDRO[1], Pamela HALLOCK-MULLER[2], Eugene SHINN[2]

[1]Florida Fish and Wildlife Research Institute, St. Petersburg, FL, [2]College of Marine Science, University of South Florida, St. Petersburg, FL

Declines in overall coral cover throughout the Florida Keys are well-documented. However, coral cover on patch reefs is variable, with high coral cover remaining on some patch reefs. As live coral cover on the offshore bank reefs continues to decline, remaining shallow-water coral assemblages may ultimately be concentrated in the large number of thriving patch reefs. Previous efforts to determine the number of patch reefs in the Lower Keys utilized aerial survey methods. A major study published in 1977 identified 420 reef structures from Big Pine to the Marquesas Keys. Our study used IKONOS satellite imagery to find and map the size and distribution of patch reefs; we identified approximately 2500 patch reefs in the same region. Initial observations indicate that patch-reef distribution is non-random and appears to correlate with geologic features. Patch reefs occur in three distinct cross-shelf zones, each with increasing distance from shore. There is also clear segregation between patch-reef morphologies, with different types rarely sharing a given zone. It is crucial to understand not only the spatial distribution of patch reefs, but also why they originated and persist in specific geographic locations. Previous studies cited Florida Bay water and mobile calcareous sands as primary determinants of patch-reef growth, with patch-reef development focused on trough edges bordering Hawk Channel. In addition to the patch reefs along Hawk Channel, we found a third zone of thriving patch reefs near shore (0.3% - 52% coral cover, mean 17%). Key to our long-term analysis will be to determine what affects, if any, environmental and geological influences have on patch morphology and how this is manifested in the spatial arrangement of patch reefs.

## 17.568

**Sea Surface Temperature Trend in The Coral Triangle in Two Decades**

**Eileen PEÑAFLOR*[1]**, William SKIRVING[2], Scott HERON[2], Laura DAVID[1]

[1]Marine Science Institute, University of the Philippines, Quezon, Philippines, [2]Coral Reef Watch, National Oceanographic and Atmospheric Administration, Townsville, Australia

Increasing ocean temperature has become one of the major concerns in the recent decades. Pronounced increase in sea surface temperature (SST), for example, had caused massive coral bleaching in many regions particularly during the 1997-98 ENSO event. This study focuses on the Coral Triangle and utilizes the National Oceanographic and Atmospheric Administration-Coral Reef Watch (NOAA-CRW) SST from 1985 to 2006 to investigate the SST condition in the area during this period. Another NOAA-CRW product, Hotspot, is also used as a supporting data to locate areas with anomalously warm surface waters. Results show that this region's SST has been increasing at the rate of 0.2 oC/decade on average from 1985-2006. Warming within this region, however, is not uniform in space or time. Overall, sites located on the north and east of the triangle show a faster warming trend. Also, although an overall increase has been seen through the years, the eruption of Mount Pinatubo in the Philippines in 1991 had contributed to a significant lowering down of SST in the region for at least 2 years after the eruption.

## 17.569

**Regional-Scale Seagrass Habitat Mapping in The Wider Caribbean Region**

**Colette WABNITZ*[1]**, Serge ANDREFOUET[2], Damaris TORRES-PULLIZA[3], Frank MUELLER KARGER[4], Philip KRAMER[5]

[1]Geography, SAUP, Fisheries Centre, Vancouver, BC, Canada, [2]IRD, Noumea, New Caledonia, [3]USF, St Petersburg, FL, [4]UMASS, North Dartmouth, MA, [5]Nature Conservancy, Sugarloaf Key, FL

Seagrass meadows occupy a large proportion of the world's coastal oceans, but human activities have caused significant declines in the extent of these marine communities. Effective conservation and the provision of effective conservation targets for seagrass is presently limited by the absence of reliable information on the extent of these systems. Here we tested the feasibility of large-scale seagrass mapping using Landsat-based images in the context of limited ground-truth data. Using geomorphological segmentation, contextual editing, and supervised classifications, we mapped seagrass throughout the Western Carribean Region (WCR). Products' accuracies were assessed against (i) selected in situ data; (ii) patterns detectable with high-resolution IKONOS images; and (iii) published habitat maps with documented accuracies. Overall classification accuracies (46-88%) represent a drastic improvement relative to current regional databases. This new mapping will provide an adequate baseline for further research and large-scale conservation action. It will also allow re-estimation of regional carrying capacity for green turtles.

## 17.570

**NASA Airborne AVIRIS and DCS Remote Sensing of Coral Reefs**

**Liane GUILD*[1]**, Brad LOBITZ[2], Roy ARMSTRONG[3], Fernando GILBES[4], Art GLEASON[5], James GOODMAN[6], Eric HOCHBERG[7], Mark MONACO[8], Randall BERTHOLD[1], Jeremy KERR[9]

[1]Earth Science Division, NASA Ames Research Center, Moffett Field, CA, [2]NASA Ames Research Center, CSUMB Foundation, Moffett Field, CA, [3]Dept. of Marine Sciences, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico, [4]Center for Hemispherical Cooperation in Research and Education in Engineering and Applied Science, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico, [5]RSMAS, University of Miami, Miami, FL, [6]Center for Subsurface Sensing and Imaging Systems, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico, [7]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI, [8]Biogeography Program, NOAA, Silver Springs, MD, [9]Earth System Science and Policy, CSU Monterey Bay, Seaside, CA

Abstract – To adequately image through a water column and to delineate variation in coral reef ecosystem benthic types, sensors having high spatial, e.g., a Cirrus digital camera system (DCS), and spectral, e.g., the Airborne Visible Infrared Imaging Spectrometer (AVIRIS), resolution and high signal to noise are needed. Further, there is a need to better understand the optical properties of coral reefs, seagrass, other benthic types, and water column constituents from field-collected data so current and future remote sensing can be optimized for coastal zone ecosystem research and management. In August 2004, we flew the AVIRIS and DCS on a NASA ER-2 over the Florida Keys and Puerto Rico. In March 2005, we flew AVIRIS/DCS on the Twin Otter over Kaneohe Bay, Oahu. Also, in December 2005, we flew AVIRIS/DCS on the Twin Otter over Puerto Rico and the US Virgin Islands for assessment of the 2005 Caribbean coral reef bleaching event. For each of these deployments, we collected coincident spectral data from dominant bottom types and coral under various health conditions using a hand-held spectroradiometer. These spectral data will be used to classify the benthic types within the AVIRIS imagery. An overview of the airborne missions and coincident field data collection for calibration and validation of the airborne remote sensing data will be presented along with preliminary image and field-collected spectral data products.

## 17.571

**NOAA Coral Reef Watch: Global Satellite Monitoring For Coral Bleaching Conditions**

**C. Mark EAKIN*[1]**, Tyler R.L. CHRISTENSEN[2], Dwight K. GLEDHILL[2], Scott F. HERON[1], Gang LIU[2], Jessica A. MORGAN[2], William J. SKIRVING[1], Alan E. STRONG[1]

[1]NOAA Coral Reef Watch, Silver Spring, MD, [2]IMSG at NOAA Coral Reef Watch, Silver Spring, MD

A variety of stressors, including biogeochemical, anthropological, weather, and climate, may exert a critical influence on reef ecosystems and contribute to bleaching events and disease outbreaks. Satellite-based observations can monitor, at a global scale, the environmental conditions that influence both short-term and long-term coral reef ecosystem health. From research to operations, NOAA Coral Reef Watch (CRW) incorporates paleoclimatic, *in situ*, and satellite-based biogeophysical data to provide information, tools, and expertise on coral reef bleaching for managers, researchers, and stakeholders. CRW has developed an operational, near-real-time product suite that includes sea surface temperature (SST), SST time series data, SST anomaly charts, coral bleaching HotSpots, and Degree Heating Weeks (DHW). Bi-weekly global SST analyses are based on operational nighttime-only SST at 50-km resolution with a complementary satellite-derived maximum monthly mean (MMM) climatology. HotSpots indicate areas experiencing thermal stress conducive to coral bleaching. Degree Heating Weeks indicate the accumulation of HotSpots over time, where one DHW is equivalent to one week of SSTs 1 degree C warmer than the expected summer-time maximum. DHWs can be considered as a proxy for the amount and residence time of accumulated thermal stress; coral bleaching becomes likely to occur at 4 DHWs, with widespread bleaching and some bleaching-related mortality likely at 8 DHWs. Automated Satellite Bleaching Alerts (SBAs) notify managers of changing conditions and are available at Virtual Stations around the world. All CRW products can be accessed on the web at http://coralreefwatch.noaa.gov/satellite/.

## 17.572

**Remote Sensing For Coral Mapping in Nha Trang Bay**

Tong PHUOC HOANG SON[1], **Tong PHUOC HOANG SON*[2]**

[1]GIS and Remote Sensing, Institute of Oceanography, Nha trang, Vietnam, [2]Institute of Oceanography, Nhatrang, Vietnam

Nha trang Bay lie in co-ordinates from 109° 20' – 109° 30' E and 12°20' – 12°30' N. It is one of most beautiful bay of the world where exist many coral reefs with high biodiversity and recognize as a Marine Protected Area with title of Hon Mun MPA. Coral reefs in Nha Trang usually exist in non-typical fringing reefs with 50 - 100m wide.

Base on satellite images such as Landsat ETM+, ASTER, SPOT5, AVNIR2 together with the aerial photographs, the distribution of coral and underwater habitats in islands lie surrounding Nha Trang have been detected. The method of calculation of "Depth Invariance Index – D.I.I" is main method for detecting coral and other underwater habitats in Nha Trang Bay. Some others by combination between satellite image with the aerial photographs such as fusion method, spectral analysic have been used also.

Some results from difference methods, imageries sensors have been presented. The comparions and the choice of best appropriate method also have been introduced. An assessment of history evolution on the change of reef areas in some areas of Nha Trang Bay also have been presented.

The results show that, the distributed area of coral reefs in Nha Trang Bay is about 200 ha wide with seperated to some underwater habitats as hard coral, dead coral, algea, seagrass, rock, sand, ... In present time, some areas of coral reef have been heavenly degradated and even have been disapeared under effects of human activities such as tourism, construction and unreasonable exploitations (bomb, poison, anchorage on the reefs,….). A functional zoning and appropriate utility the coral reefs in Nha Trang Bay have been proposed.

## 17.573

**Determination Of Water Depth From Ikonos And Quickbird Satellite Imagery**

**Donald FIELD*[1]**, Amit MALHOTRA[2]

[1]NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, NC, [2]NOAA Center for Coastal Fisheries and Habitiat Research, Beaufort, NC

IKONOS and QuickBird multispectral images were used to create bathymetric maps for an area of approximately 100 sq. km. in the Dry Tortugas. A previously described algorithm utilizing a ratio of the blue and green bands for deeper areas and the blue and red bands for shallow areas was applied to both image sources. A georeferenced database of nearly 25,000 soundings was used to develop the algorithm and assess the accuracy of the final bathymetric maps. Initial application of the algorithm to the QuickBird imagery yielded much lower accuracies than with IKONOS. Closer examination of the QuickBird imagery revealed two issues: 1) radiometric miscalibration in the green band; and 2) an irregularity referred to as the "circuit board pattern", that was most obvious over areas of deep water. While the initial algorithm was based on a linear function, an additional ratio algorithm was developed for the QuickBird imagery based on a second order polynomial regression curve. The final bathymetric maps for both image sources were able to compensate for variable bottom types and albedo (sand, seagrass, colonized hardbottom). Both image sources were also able to predict depths up to 15 m, but past that depth, error between the bathymetry estimates and known depths increased rapidly. While the overall accuracies for both image sources were similar, the more variable, noisy nature of the QuickBird data may be inadequate for some uses.

## 17.574

**Mapping Coral Reef Benthic Communities With High Spatial Resolution Image Data**

**Ian LEIPER*[1]**, Stuart PHINN[1], Chris ROELFSEMA[1]

[1]University of Queensland, Brisbane, Australia

An new approach using image pixel scale *in-situ* spectral reflectance libraries to supervise classification of high spatial resolution satellite image data was tested on Heron Reef, Great Barrier Reef, Australia. Spectral reflectance signatures of homogeneous benthic features (~2.0 cm sample area diameter) on coral reefs have previously been shown to be distinguishable from one another. However, the occurrence of such pure endmembers is rare at the spatial scale of high spatial resolution airborne and satellite sensors (1.0 - 5.0 m pixel size). We investigated the separability of *in-situ* spectral signatures collected at a lower spatial resolution (~1m sample area diameter) that is more appropriate to the types of reef communities being mapped with currently available high spatial resolution remote sensors. 3500 geo-located photos were collected during a field survey of Heron reef, and used to create a classification scheme based on Bray-Curtis Similarity Analysis. For each class, *in-situ* spectra were then collected on Heron Reef using an Ocean Optics VIS-NIR spectrometer across a range of 400-900nm, with a 1.0 m sample area diameter. Multivariate techniques were used to explore these spectral reflectance signatures and identify features that could be used to discriminate between the classes. A Quickbird multi-spectral satellite image was classified using the *in-situ* spectral library to supervise classification, and a standard error assessment conducted using the field survey data. This research presents an approach to mapping coral reef benthic communities based on benthic community spectral properties.

## 17.575

**Pre-Processing Of 2005 Aviris Data For Coral Reef Analysis**

**brad LOBITZ*[1]**, liane GUILD[2], marcos MONTES[3], roy ARMSTRONG[4], James GOODMAN[5]

[1]California State University, Monterey Bay, moffett field, CA, [2]NASA Ames Research Center, moffett field, CA, [3]Naval Research Laboratory, Washington, DC, [4]Dept. of Marine Sciences, Univ. of Puerto Rico, Mayaguez, Mayaguez, Puerto Rico, [5]Center for Subsurface Sensing and Imaging Systems, Univ. of Puerto Rico, Mayaguez, Mayaguez, Puerto Rico

Abstract – In December 2005, the Airborne Visible Infrared Imaging Spectrometer (AVIRIS) was flown on the Twin Otter over Puerto Rico and the US Virgin Islands for assessment of the 2005 Caribbean coral reef bleaching event. A hand-held spectroradiometer was also operated in the field to collect concurrent field data for dominant bottom types and coral. Benthic-type classifications of the AVIRIS imagery will be generated with these spectral data, after a number of image processing steps. An overview of the pre-processing phases, including stray light and sun glint suppression and atmospheric correction with Tafkaa will be presented.

Keywords: coral reefs, airborne remote sensing, AVIRIS, imaging spectrometry, hyperspectral, Tafkaa.

## 17.576

**Use Of Aerial Photographs And Acoustic Techniques For Mapping Benthic Marine Communities Of Martinique**

**Helene LEGRAND*[1]**, Ian SOTHERAN[2], Robert FOSTER-SMITH[2], Cécile PERES[3], Yann ROUSSEAU[3], Philippe LENFANT[4], René GALZIN[4], Jean-Philippe MARECHAL[3]

[1]Observatoire du Milieu Marin Martiniquais, FORT DE FRANCE, Martinique, [2]Envision, Newcastle, United Kingdom, [3]Observatoire du Milieu Marin Martiniquais, Fort de France, Martinique, [4]EPHE - Université Perpignan, Perpignan, France

A remote sensing survey of the marine benthic communities was conducted along the whole coastal zone of Martinique (French West Indies). A Geographic Information System (GIS) was developed to locate and assess the health status of the marine habitats.

Several techniques (visual and acoustic) were combined to produce the final maps. Benthic communities in shallow waters (0-7 m) were identified visually from aerial photographs (IGN 2004 campaign) and ground-trusted. Habitat health status was assessed based on hypersedimentation, macroalgae and coral necrosis levels.

The sublittoral zone (7-30m) was surveyed using Acoustic Ground Discrimination System (RoxAnn) and interferometric swath bathymetric system. The relatively high resolution of the swath system provided information on bedform features and major seabed sediment categories as well as a detailed bathymetry. A drop-down video camera was used to check the biology and physical characteristics of the seafloor.

Six community types were identified: coral community, seagrass, mixed community (assemblage of coral, sponges and gorgonians with seagrass beds), soft bottom community, sponge and gorgonian community, and algal community.

The final maps show significant differences in the distribution of habitats and communities between the Caribbean and the Atlantic sides. The Atlantic coast has an outer spur and groove reef and inner lagoon system which extend about 4kms away from the land. The Caribbean coast has sporadic fringing reefs amongst sandy sediment habitats. The largest reef is located in the south.

Community health appears largely degraded all around the island, especially in large bays and downstream of river mouths, where anthropogenic impacts are more important.

The amount of numeric data collected and the marine GIS developed are valuable resources for managers and policy makers for the coastal zone preservation of Martinique.

## 17.577

**Deep Atris: A New Towed System For Unobtrusive Mapping Of Benthic Habitats And Organisms**

**David G. ZAWADA*[1]**, Philip THOMPSON[1], Jerry BUTCHER[1]

[1]Center for Coastal and Watershed Studies, U.S. Geological Survey, St. Petersburg, FL

Geo-positioned observations of coral reefs and associated habitats are critical to many resource-conservation, monitoring, and research projects. Applications for these types of data include characterizing essential habitat, assessing changes, monitoring the progress of restoration efforts, and ground-truthing acoustic, lidar, and satellite imagery. Acquiring such imagery for large areas can be expensive and time-consuming. To enhance its mapping capabilities and provide a more efficient alternative, the U.S. Geological Survey has developed the Deep Along-Track Reef-Imaging System (Deep ATRIS), a towed sensor package deployable from boats of moderate size (~8 m). Deep ATRIS is based on a light-weight, computer-controlled, towed vehicle that is capable of following a programmed diving profile. The vehicle is 1.3 m long with a 63-cm wing span, a maximum tow speed of 2.6 m/s, and an operating tow-depth limit of 27 m, extendable to 90 m. Transect lengths of 56 km can be surveyed in 6 hr. Deep ATRIS can carry a wide variety of instruments, including conductivity-temperature-depth sensors, fluorometers, transmissometers, and cameras. The current payload consists of a high-speed (20 frames/s), color digital camera, custom-built light-emitting diode lights, a compass, a 3-axis orientation sensor, a pressure sensor, and a nadir-looking altimeter. Images are displayed and archived in real time on the surface computer, along with the corresponding GPS coordinates. The first sea trial was conducted in a coral reef setting within Biscayne National Park, Florida, USA, in July 2007. Several example geo-located mosaics will be presented to illustrate the high quality of Deep ATRIS imagery. Types of information that can be obtained from the rich dataset include percent cover, species abundance and richness, and morphological characteristics. The images also reveal the potential for unobtrusive animal observations; fish and sea turtles imaged seem unperturbed by the presence of Deep ATRIS.

## 17.578

**Using Remotely Sensed Lidar Data To Examine The Relationship Between Habitat Complexity And Fish Assemblage Structure in Hawaii**

**Lisa WEDDING*[1]**, Alan FRIEDLANDER[2]

[1]Department of Geography, University of Hawaii at Manoa, Honolulu, HI, [2]NOAA Biogeography Branch, Honolulu, HI

Remotely sensed LIDAR (Light Detection and Ranging) data has recently been utilized in coral reef ecosystems to derive rugosity, a measure of habitat complexity. We used LIDAR-derived rugosity to examine the relationship between habitat complexity and various fish assemblage metrics (numerical abundance, diversity, richness, and biomass) in Hawaii. We established significant positive associations between LIDAR-derived rugosity and these measures of fish assemblage structure in hard bottom habitat. We also demonstrated that LIDAR-derived rugosity was a good predictor of fish biomass and found that different components of the fish assemblage responded to different spatial scales of LIDAR-derived rugosity depending on their size and mobility. Habitat complexity derived from remotely sensed data can be used to predict the fish assemblage of an area and can therefore aid in the optimal location and design of marine protected areas by identifying specific areas that offer great natural protection. The results of our study suggest that LIDAR data has the potential to assist in prioritizing areas for conservation and management in the Main Hawaiian Islands and similar insular tropical ecosystems.

## 17.579

**Image Time Series Analysis For The Inference Of Coral Reef Ecosystem Health**

**Alicia SIMONTI*[1]**, Ronald EASTMAN[1], John ROGAN[1]

[1]Graduate School of Geography, Clark University, Worcester, MA

Recent evidence of changes in global climate leads to the question of the geographic extent and impacts on ocean productivity and the status of tropical coral reefs. New methods in remote sensing of coral reefs have proved to be imperative. In light of current obstacles in the remote sensing of coral reef health due to fine spatial heterogeneity, water column interference, and differentiation of varying benthic substrata, this research endeavors to apply newly developed methods of image time series analysis to various image series related to coral health. Time series analysis of remotely sensed imagery has traditionally been limited to Principal Components Analysis which decomposes the series into its major spatial and temporal dimensions of variability. New developments in image time series analysis include spatial and temporal Fourier and Wavelet Spectral Analysis which investigate the oscillatory behavior and several parametric and non-parametric image trend procedures based on the Mann-Kendall test and the robust Theil-Sen slope which determine linear and monotonic trends. Additionally, phenological trends in ocean productivity can be investigated with a procedure based on trend analysis of annual harmonic regression coefficients. Furthermore, this software development is capable of removing seasonality in order to better investigate change over time and space. These newly developed methodologies can prove quite beneficial in the study of coral reef health via remote sensing indirectly by investigating numerous factors which impact corals. These factors can be investigated and correlated simultaneously, including, but not limited to, chlorophyll a concentration, sea surface temperature, ocean currents, aerosols, sea surface height, and non-remotely sensed data such as climatic teleconnections. Initial findings show significant trends in chlorophyll a concentration, sea surface temperature, and sea level height that could have implications for coral reef health.

## 17.580

**Remote Sensing Of Seagrass Biomass in Case Of Spectrally Variable Bottom Types**

**Ele VAHTMÄE*[1]**, **Tiit KUTSER*[1]**

[1]Estonian Marine Institute, University of Tartu, Tallinn, Estonia

We developed an in situ method for fast estimation of seagrass biomass (dry weight) based on comparing of photos of study area with photo-library of quadrates with known seagrass biomass. The method was used to get seagrass biomass estimates over a spatially heterogeneous coral reef area (Ngederrak Reef, Palau) where the bottom below the seagrass varied from bare sand to almost 100% coral or macroalgal cover. The biomass estimates along four one hundred meters long transects were compared to QuickBird and Ikonos data. The results show that it is possible to estimate seagrass biomass in seagrass beds where the substrate is bare sand. High macroalgal or coral cover makes it difficult to estimate seagrass biomass when multispectral data is used.

## 17.581

**Sun Glint Correction For Hyperspectral Shallow Water Imagery**

**Tiit KUTSER*[1]**, Ele VAHTMÄE[1]

[1]Estonian Marine Institute, University of Tartu, Tallinn, Estonia

Current sung glint removal procedures assume zero water leaving signal in near infrared part of spectrum. This assumption is not true in waters less than about 2 m deep where part of the water leaving signal is originated from the bottom. As a result the shallow water pixels are overcorrected during glint removal procedure and the shapes of reflectance spectra are distorted. This has serious implications on shallow water bottom classification results, especially if spectral libraries of in situ measured or modeled reflectance spectra are used in classification of remote sensing imagery. Reef tops, shallow water lagoons and many coastal areas are in waters less that 2 m deep. Therefore, it is important to preserve spectral signatures of these areas if sun glint removal is necessary. We propose an alternative sun glint removal procedure where the amount of glint in each pixel is estimated from the depth of oxygen absorption feature at 760 nm relative to a baseline. The new method removes sung glint successfully and at the same time preserves the shape and magnitude of shallow water reflectance spectra.

## 17.582

**Mapping A Path Reef Area in Detail Using Small-Format Aerial Photographs (Sfaf) And Handy Gps in North-Eastern Brazil**

**Ricardo AMARAL*[1,2]**, Filipe LIMA[1], Luiz GONÇALVES[3]

[1]Department of Geology, Universidade Federal do Rio Grande do Norte - UFRN, Natal, Brazil, [2]Programa de Pós-Graduação em Geodinâmica e Geofísica - PPGG, UFRN, Natal, Brazil, [3]Departamento de Engenharia da Computação, UFRN, Natal, Brazil

An area approximately 750 x 550m with small underwater bioconstructions, at Maracajau path reef, was mapped in detail using SFAP. It was georreferenced with help of handy GPS and vetorized in a GIS software to produce and organize spatial information. Maracajau path reef occurs about 60km to the north of Natal city. It is approximately 3km wide, 9km long, 7km away from the coast line and is partially visible at spring low tides. SFAP were taken during low spring tide, to capture the underwater features better by using a 35mm camera at 300m to 1000m over the ground, from a small aircraft. The photographs were processed and analyzed using image processing softwares. Field works using GPS pointed out the contour of the bigger bioconstructed bodies that were recognized in the photos afterwards. The images were georeferenced using as ground control points the bioconstructed bodies identified as well as little vessels. The features were vetorized using visual interpretation and it was stored in a GIS. As a result we can quantify the features in the area which is composed by approximately 60% of bioconstructed bodies and by carbonate sand botton. We identified 555 bodies that were separated by size. About 9% of them have less than 100m2 in area; 34% is between 100 and 1000m2; about 20% is between 1000 and 10000m$^2$ and a much closer assemblage of bodies at the oceanic side of the area were classified altogether as a unique feature with approximately 48000m2. This accurate and low cost protocol to map underwater features has been done and the results showed efficiency and effectiveness, meanwhile it must be considered as a complementary method and must be done associated with others techniques.

## 17.583

**Life After Death: Pleistocene Reefs Of Sisal; Yucatan Shelf**

**Salvador ZARCO-PERELLÓ*[1]**, Joaquín Rodrigo GARZA-PEREZ[2], Nuno SIMOES[2], Maite MASCARO-MIQUELAJAUREGUI[2], Xavier CHIAPPA-CARRARA[2]

[1]Ecology, National Autonomous University of Mexico, Mexico City, Mexico, [2]Ecology, National Autonomous University of Mexico, Mérida, Mexico

The shelf reefs in the Campeche Bank might be playing an important role in the connectivity between the Caribbean and the Gulf of Mexico ecosystems. However, information from these reef systems is scarce. This study focuses on the Sisal, Madagascar and Serpiente reefs, in the northwest portion of the Yucatan Peninsula. A bathymetric survey was carried with a GPS-sounder and geostatistical methods were used to generate a geomorphology 3-D model. These models were used to select Madagascar reef to implement a case of study to define and quantify major reefscapes and zonation patterns. Fifteen 200 m phototransects were collected along the bathymetric gradient direction; photographs (0.8 sq.m) were taken every 5 meters. Percentage of cover of Morph-Functional Gruops was determined with a systematic 13 point count method and a classification analysis (using multivariate statistics) defined five reefscapes. Distribution maps of biotic components were generated using kriging. Few hexacorals were recorded, but the structural complexity of the reef evidences coral accretion in the past. The hard coral community was more likely killed during the last ice-age, with the decrease in the sea-level, after when the sea-level increased they started flourishing under different environmental conditions, favoring algal and octocoral development but no reef building hexacorals settlement and growth. This work is the first in this specific region, the basis for many future studies and a necessary ingredient of a GIS for the Yucatan Shelf.

## 17.584

**Satellite Imagery As A Predictor For Diversity And Abundance Of Reef Fish in Diego Garcia (Chagos Archipelago)**

**Samuel PURKIS*[1]**, Nick GRAHAM[2], Bernhard RIEGL[1]

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [2]School of Marine Science & Technology, University of Newcastle, Newcastle-upon-Tyne, United Kingdom

The diversity, abundance and distribution of reef fish are related to heterogeneity and physical complexity of benthic habitat. However, the field effort required to evaluate these aspects of the benthos *in situ*, at the scale of entire reefscapes, is greatly constrained by logistical and resource limitations. With moderate ground-truthing, both substratum type and seabed topography are amenable to monitoring using satellite data. Here, remote sensing imagery was used to resolve the bathymetry and benthic character of a reef system in Diego Garcia (British Indian Ocean Territory). Replicate fish counts were made at seven measurement stations across the study area using visual census. Monte Carlo simulation revealed that species richness and abundance of several guilds and size groupings of reef fish appraised in situ were correlated with the satellite-derived seabed parameters over areas of seafloor as large as 5,030 m2. The study suggests that satellite remote sensing is capable of predicting habitat complexity at a scale relevant to fish. Furthermore, as larger size classes of fish were better predicted with the satellite habitat complexity data, this technique could be used to predict fish stocks and identify potential sites for marine protected areas where intensive field surveys are not practical.

## 17.585

**A Hyperspectral Remote Sensing Campaign in Southwestern Puerto Rico With Multiple Environmental Applications**

James GOODMAN[1], **Carmen ZAYAS*[2]**, Samuel ROSARIO[2], Orian TZADIK[2], Fernando GILBES[2]

[1]University of Puerto Rico at Mayaguez, Miami, FL, [2]University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico

Airborne hyperspectral imagery was collected in southwestern Puerto Rico in 2007 covering extensive areas of aquatic and terrestrial habitats. The primary purpose of the mission was to support ongoing research into improving the capacity for the assessment and monitoring of benthic habitats using remote sensing technology. This includes research on image calibration, resolution enhancement, water column correction, spectral unmixing and the classification of benthic composition. The overall project has a particular focus on coral reefs, but also includes applications related to seagrass, water properties, metal contamination in mangroves and the distribution of terrestrial vegetation. The acquisition area covers more than 2000 km$^2$ at a spatial resolution of 4 m, as well as three aquatic science areas totaling 100 km$^2$ at 1, 2, 4 and 8 m resolution and a terrestrial science area of 35 km$^2$ at 1 and 4 m resolution. The science areas represent regions where extensive coincident fieldwork was conducted as groundtruth, and the multi-resolution collection is being used to investigate spatial scaling issues associated with spectral unmixing and to identify appropriate resolutions for local and landscape level reef analysis. In addition to the lead project team from the University of Puerto Rico at Mayagüez, a collection of researchers from other universities and federal agencies also participated in both the field data collection and image analysis efforts. This collaborative approach expanded the availability of instrumentation and expertise, and also allowed us to address a greater number of scientific questions and application driven objectives. We present an overview of the mission and provide specific examples of the data that was collected and the image products being produced. These examples are used to illustrate the enhanced reef analysis tools that can be derived using hyperspectral imagery.

## 17.586

**Use Of Geospatial Technologies in The Assessment Of Coral Reefs And Abalone Distribution in Sagay Marine Reserve, Central Philippines**

Armi May TORRECHILLA[1], **Armi May TORRECHILLA*[1]**

[1]Asian Institute of Technology, Bangkok, Thailand

The main objective of this research is to assess the status of coral reefs and the abundance of abalone in Sagay marine reserve that would serve as baseline information for the local government of Sagay, Negros Occidental, Philippines. To achieve this, benthic maps (coming from the July 2005 atmospherically and geometrically corrected Aster image) were produced from which geospatial technologies as remote sensing, GIS and GPS were used as primary tools to produce the benthic habitat maps. These maps were classified with the aid of image processing techniques such as band ratio, principal component analysis and water column correction algorithm. Groundtruth and results from the multivariate classification of the field data were used as training area for the classification of the satellite image and that 8 different habitat types were successfully identified. Post classification and contextual editing produced a final output of an image accuracy of 58.71%.

Reef habitat map showing 4 different zones ranging from very good to damaged zone were produced using the ratio of live and dead corals based on the criteria developed by Thailand's Phuket Marine Biological Center.

Most of the abalones prefer habitats of dead corals with algae and rubble-algae zones. Furthermore, finding for the potential suitable sites for the abalone was done by considering the factors on habitat type, depth and sea surface temperature data. Also, one premise can be inferred in that a preferred habitat can only be an area to have been known by the abalone to reside on.

## 17.587

**A Hyperspectral, Remote-Sensing Approach To Spectral Discrimination Of Marine Habitats At Ningaloo Reef, Western Australia**

**Nicole PINNEL*[1]**, Halina KOBRYN[1], Thomas HEEGE[2], Matt HARVEY[1], Lynnath BECKLEY[1]

[1]Environmental Science, Murdoch University, Murdoch, WA 6150, Australia, [2]EOMAP GmbH&Co KG, D-82205 Gilching, Germany

Optical remote-sensing techniques, especially hyperspectral sensors, provide an non-invasive and cost-effective approach to mapping and monitoring the condition of reefs over large areas because of their capability to identify reef components on the basis of their spectral response. The aim of this study is to develop a reliable and repeatable procedure for mapping submerged coral reefs using airborne hyperspectral data. Spectral reflectance of corals, macro-algae and sediment were measured underwater with an OceanOptics2000 spectro-radiometer. These spectra were used for development of algorithms for automated applications to image classification. A genetic algorithm technique was used to determine optimal waveband combinations (including derivatives) for identification of substrate types. Initial results show that *in situ* reflectance spectra of reef substrates were significantly different for various spectral wavelengths. Using a linear discriminant analysis, the *in situ* spectra of six benthic groups (branching, digitate and tabulate *Acropora*, massive corals (e.g. *Porites)*, submassive corals (e.g. *Pocillopora*) and macro-algae) could be classified to 90 % accuracy with as few as six bands. A classification of major habitat groups was applied to airborne hyperspectral data from HyMap acquired in November 2005 and April 2006 over the Yardie Creek area at Ningaloo Reef. The images were corrected for atmospheric, air-water interface and water column effects using the Modular Inversion & Processing System. This removes subjectivity from the classification and approaches an automated classification allowing for improved transferability to other reefs and monitoring applications. The retrieved bottom albedo image was used to classify the benthos, generating a detailed map of benthic habitats, followed by accuracy assessment. The outputs of multi-temporal image analysis contain percent cover of corals, macro-algae and sediment. Results indicate that the spectral response of corals can be determined to 10 m depth and shows that hyperspectral remote sensing techniques offer great potential in mapping coral reefs.

## 17.588

**Changes in Spectral Reflectance in Response To Salinity Variation in *siderastrea Radians* From Florida Bay, Florida Usa.**

**Michael DURAKO*[1]**, Kathryn CHARTRAND[1]

[1]Biology & Marine Biology, Univ. N. Carolina Wilmington, Wilmington, NC

Spectral reflectance (*R*) of coral reefs is an apparent optical property that is widely used to distinguish these communities in remote sensing assessments. In this study *R*'s of *Sidereastrea radians* collected from five basins in Florida Bay were measured at the termination of a 2-week salinity (30, 20, 15, 10) versus population mesocosm experiment. The five basin populations represented a spatial and freshwater-land influence gradient from northeast (estuarine-to-hypersaline) to southwest (marine) Florida Bay. Spectral reflectances generally increased with decreased salinities with the greatest increases occurring in the more marine populations. The marine populations also exhibited the "brown" reflectance spectra mode while the more estuarine populations exhibited predominantly "blue" reflectance spectra. Two of the interior basin populations exhibited spectral shifts from "blue" to "brown" in response to low salinity treatments. Non-metric multidimensional scaling analyses indicated stronger salinity-based versus population-based clustering of the reflectance spectra. Thus, while coral R may be independent of taxonomic or geographic differences, reduced salinity does affect this parameter in *S. radians* from this marginal coral habitat.

## 17.589

**A Pan-Sharpening Method For Coral Reef Monitoring With Higher Accuracy**

**Hiroshi HANAIZUMI*[1]**, Mizue AKIBA[1], Hiroya YAMANO[2], Tsuneo MATSUNAGA[2]

[1]Faculty of Computer and Information Sciences, Hosei University, Tokyo, Japan, [2]Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Japan

Satellite based remote sensing is a powerful tool to detect and monitor coral reef decline due to events such as bleaching. Here, we propose a pan-sharpening method for increasing the availability of satellite remote sensing. Some satellites have physically separated two sensors; one is for multi-spectral bands with low spatial resolution and the other is for panchromatic band with high spatial resolution. The separation yields parallax depending on depth of the coral reef (and height of land objects). Thus, it is indispensable to register the panchromatic band image onto zoomed multi-spectral band images. After the registration, each multi-spectral density is separated to color and brightness components. The former corresponds to direction of the multi-spectral density vector and the latter its norm. The blur in the zoomed multi-spectral images are removed by replacing the brightness component with the panchromatic density. In order to preserve the hue (i.e. density histogram) of the pan-sharpened multi-spectral image, we have to determine the optimal estimator of the brightness component. Applying a multiple regression algorithm, we obtained the optimal estimator. In our method, both coral reef area and land area are pan-sharpened at a time. In the point of view of coral reef change detection using pan-sharpened images, this feature enables us to select control point pairs near the foreshore for the image registration.

In order to evaluate the performance of the proposed method, FORMOSAT images were processed. The target area was the Ishigaki Island, Ryukyu Islands, Japan. The FORMOSAT has 3 visible bands and 1 near infrared band with spatial resolution of 8m, and also has panchromatic band, whose spectral band covers all visible and near infrared bands, with spatial resolution of 2m. The proposed method was successfully applied to the images. Multi-spectral density histograms of the pan-sharpened image were well agreed with those of the original ones.

## 17.590

**An Integrative Spatial Decision Support System**

Hrishi PATEL[1], **Suchi GOPAL*[1]**, Les KAUFMANN[1]

[1]Boston University, Boston, MA

We describe a spatial decision support system called **MIDAS (Marine Integrated Decision Analysis System),** designed to support the process of decision-making for Marine Management Areas (MMAs) users, public, and policy makers. The MIDAS interface consists of three panels: the user can input data for 12 variables ("independent" socio-economic, governance and ecological) in panel 1 as well as two spatial variables (for 16 cells). Panel 2 of MIDAS displays a series of Java applets representing outcomes of the interactions between the variable states that the user input in Panel 1. These applets show the ecological resilience and health of the reef, state of governance and its impact of MMA, fishing pressure and availability of fish in the market, relationship between quality of life and ecological health of the reef. As the user's input in Panel 1 varies, Java applets representing key interactions amongst the three groups of factors dynamically changes in Panel 2, giving the user an instant feedback on what would happen to key outcomes ("dependent" variables). In addition, the user can input 2 variables spatially over 16 cells and the outcome is a map of threat or risk displayed in Panel 3, along with relevant factors that threaten the reef, including run-off from the rivers. We demonstrate MIDAS for Hol Chan, Belize, that can assist the *MMA users* there to understand the critical factors for success of MMA so that they can plan accordingly, and to estimate the likely effects of their MMA based on the ecological, socioeconomic and governance conditions.

## 17.591

**Classification and spatial analysis of the benthic facies of the southeastern Arabian Gulf using passive optical remote sensing**

**Linda KNOECK*[1]**, Sam PURKIS[2], Bernhard RIEGL[2]

[1]Regulatory, United States Army Corp of Engineers, Jupiter, FL, [2]Oceanographic Center, Nova Southeastern University, Dania Beach, FL

It was the focus of this manuscript to use passive optical remote sensing to classify the benthic facies of a large study area such as the southeastern Arabian Gulf. Landsat TM and Quickbird sensors were also evaluated for the determination of benthic facies. Spatial distributions were further examined from the classified image to study facies patterns. It was found that Landsat TM sensors could be used to accurately classify benthos of a large study area such as the southeastern Arabian Gulf if sufficient ground control data was available. This was determined by using both the unsupervised and supervised classification techniques in the ENVI 4.1 program. When discussing the issue of scale in relevance to classification for small areas considered in isolation (i.e. Butina Bank), the Landsat TM sensor returned classification results comparable to those obtained with a higher spatial resolution (Quickbird sensors). By using the classification results from the southeastern Arabian Gulf, the patch frequency of the facies concluded that patch frequency and area were inversely related, with smaller areas being more common and larger areas rare. The data showed a linear relationship on log-log plots and therefore could be termed a power function. Due to the linear relationship, perhaps patch frequency and area follow a power function.

## 17.592

**A Spectral Linear Mixing Model And Analyses Of Mixed Pixels, Broward County (Florida)**

**Adrienne CARTER*[1]**

[1]Marine Science & Biological Research, Coastal Planning & Engineering, Inc., Boca Raton, FL

Ideally spectral discrimination of reef habitat components allows for the generation of benthic classification maps via spectral and spatial digital remote sensing. The processing of *in situ* spectral signatures into calibrated reflectance forms an essential component of aquatic remote sensing projects that utilize spectroradiometric data in support of airborne image analyses. In the offshore waters of Broward County, Florida from 25°58'40"N to 26°3'13"N, *in situ* spectral signatures were measured using a diver-operated spectroradiometer. Reflectance spectra data was gathered from dominant benthic substrate types at depths ranging from 15m - 30m. Target photographs via SCUBA were used to quantitatively identify habitat composition. Generic spectral signatures for the dominant reef habitat types were calculated. Linear spectral mixing was conducted by mixing the generic spectral reflectance data according to the prevalence of the benthic types as quantified using photography at meter-scale. Differences between mixed spectra were investigated through fourth derivative analysis. Results of the spectral mixing analysis determined areas of wavelength dominance by resident endmembers found within a mixed spectrum. Ideal wavelengths are also identified for spectral discrimination between spectrally similar benthic types.

## 17.593

**Delineating The Acoustic Signature Of Coralline Tissue**

**Gal MOR*[1]**, Baruch RINKEVICH[2], Haim AZHARI[3], Yizhaq MAKOVSKY[1]

[1]Department of Marine Geology and Geophysics, University of Haifa, Haifa, Israel, [2]Israel Oceanographic and Limnological Research Institute, Haifa, Israel, [3]Technion, Haifa, Israel

Various acoustic techniques are suggested for efficient monitoring of the state of corals. We aim to characterize the acoustic scattering signature of living coralline tissues to provide basic understanding of the utility of the various techniques suggested. We will present preliminary results of high resolution (1 MHz) acoustic scattering measurements on the hermatipic coral Stylophora Pistillata. The acoustic measurements are performed in vitro on a few mm fragment of S. Pistillata grown for approximately three months on a glass surface. Acoustic measurements are first performed when the horizontal distal tissue edges develop thin "clean" transparent tissue extensions with no skeleton. The measurements are repeated as skeletogenesis progresses. To delineate the changes of acoustic response of the skeletal structure from that of the tissue, the measured acoustic responses will be compared in terms of frequency, amplitude and phase at different angles of emergence.

## 17.594

**Investigating The Potential Of Monitoring Coral Reef Using Unmixing Of Spaceborne Hyperspectral Imagery**

**Tamir CARAS*[1]**, Arnon KARNIELI[2], Eyal BEN-DOR[3], Geoff MEADEN[4]

[1]Fisheries GIS Unit, Geography Dpt., Canterbury Christ Church University, Canterbury, United Kingdom, [2]Jacob Blaustein Institutes for Desert Research, Sede-Boker Campus, Israel, [3]Tel Aviv University, Tel Aviv, Israel, [4]Canterbury Christ Church University, Canterbury, United Kingdom

Remotely sensed data has become standard practice for reef investigation, assessment and monitoring. While often providing accessible data for large areas and is cost effective, results integrity is often questioned. Remote sensing of coral reefs is constrained by spatial and spectral attributes of the sensor. Additional noise and distortion are imposed by water and air mediums above the substrate of interest. Furthermore, spectral similarity of reef components makes their separation particularly difficult. One rectifying solution suggested by previous work is using unmixing to investigate images in sub-pixel scale. Unmixing is a mathematical method that calculates the fractional contribution of each component to a final mix.

The aim of this study is to investigate the potential of unmixing of spaceborne hyperspectral data to extract benthic composition. The success of unmixing is evaluated by comparison to available monitoring data.

To correct the water column effect, bathymetry and GIS mapping of reef features were combined. Based on Beers law Lr=L0 exp(-2rk) water column was corrected using bathimetry and the calculated k coefficient. Attenuation coefficient k was calculated from in situ measurements. In situ spectral signatures of reef components were collected and used as input for the unmixing process. Linear unmixing was modelled on the resulting image.

Preliminary results seem to indicate successful unmixing potential for habitat level detection (eg: reef, sand etc). However, in the highly heterogenic site – the Coral Beach Marine Reserve - it was very difficult to accurately overlap the image with the GIS mapping and therefore - groundtruth. Moreover, Hyperion notoriously bed signal quality and the large pixel size impairs the separation between otherwise similar end-member spectra. However a certain degree of confidence is suggested by reasonable error values and acceptable end-members contributions. More research is needed using more homogenous study site, a better image quality and smaller pixel size.

## 18.595

**Reefs at Risk in Central Sulawesi, Indonesia - Status and Outlook**

**Abigail MOORE*[1]**, Samliok NDOBE[2]

[1]Marine, Yayasan Palu Hijau, Palu, Indonesia, [2]Marine and Fisheries, Sekolah Tinggi Perikanan dan Kelautan (STPL-Palu), Palu, Indonesia

Central Sulawesi Province, Indonesia in the heart of the Coral Triangle has over 4,500km of coastline and over 700 islands including the Banggai and Togean Archipelagos, with almost continuous fringing reefs, extensive barrier reefs, patch reefs and several atolls. The Togean National Park was declared in 2004 and there are several smaller national and regional MPAs. Since the Reefs at Risk study in 2000/2001 predicted high threat levels for most reefs in the Province, several survey and monitoring programmes have been undertaken with support from international, national and local sources.

This paper summarises coral reef condition and socio-economic data collected over the period 2001-2007 in 7 out of the 10 District/City areas, key conclusions drawn and some local initiatives.

Based on the Global Coral Reef Monitoring Network (GCRMN) scale, the overall average condition is Poor, with reefs in Very Poor, Poor, Average and Good condition in all 7 areas but extremely limited areas of reef in Very Good condition. The main causes of coral reef degradation vary between sites but include coral mining, sedimentation and eutrophication, destructive fishing (including the collection of invertebrates especially Tridacnidae and *Haliotis* sp.), and predation by *Acanthaster plancii*. Overfishing is increasingly severe and take of protected species is rife. Awareness is relatively high regarding bomb and cyanide fishing, but is low regarding many other illegal and/or destructive practices.

Initiatives include the introduction of coastal ecosystem/coral reef ecology, survey and conservation in three fisheries and marine Higher Education institutes, village-level MPAs, COTs clean-up, habitat restoration, and developing integrated aquaculture and conservation concepts. However the extent and scope of activities need to be greatly increased to reverse the destructive trends and ensure "Reefs for the Future" in Central Sulawesi.

## 18.596

**Survival / Destruction of coral reefs under anthropogenic stress in Arabian Gulf and Red Sea regions**

**Joseph Sebastian PAIMPILLIL*[1]**, Joseph Sebastian PAIMPILLIL[1]

[1]Envirosolutions, Center for Earth Research & Environment Management, Cochin 17, India

The excessive excavation, land reclamation, landfill, illegal dumping and pollution - among other things are contributing for the destruction of coral reefs in the Middle East waters. The Fasht Al Adhm reef located between Bahrain and Qatar, thrived and showed strength during 1985 - turned out as "bed of rubble" due to the enormously sloppy engineering. Today, less than one per cent of what was Fasht Al Adhm survives. Up to 40pc of the reef has been turned into rubble and 60pc into bare rock. Bahrain risks losing the coral reefs due to coastal development and the resulting sedimentation are stressing the coral reefs. Fasht Abul Thama may be the only remaining intact reef of Bahrain, but the question is for how long? There are many young corals there and very much alive. The fish traps had already encouraged the formation of big patches of algae and seaweed. All Bahrain needs is a little bit of management. Looking at the developments in the Yanbu coral region (Red Sea), where the Royal commission of Yanbu and Jubail had successfully built up the port facilities in 1985, but the health of the Port barrier reefs were restored by the strict monitoring of the industrial discharges into the vicinity of the coral reef environment. The highest number of coral recruits was 127 at 10m depth. The percentage of live coral cover at vicinity of waste discharge point had not differed much (20.1 - 20.4) since 1985, but a distant location on the barrier reef had (28.9-32.7) and (23-34.5) for a Control station. Reasonable levels of coral recruitment were observed, but the competition for space with filamentous algae had restricted the coral development. The dominant coral forms had changed from the branching to the massive forms. Several years after the construction of the port facilities, there are good signs that the coral reef is recovering under strict monitoring of the waste discharges, although it is still in an unstable stage.

## 18.597

**Long-Term Changes In Stony Coral Assemblages In Jakarta Bay And The Thousand Islands Archipelago (1920 – 2005)**

Sancia E.T. VAN DER MEIJ[1], **Bert W. HOEKSEMA*[1]**

[1]Zoology, National Museum of Natural History Naturalis, Leiden, Netherlands

Coral reefs are essential in terms of productivity and diversity of tropical coastal ecosystems. Current social and economic developments in tropical regions include accelerated urbanization in coastal areas, increasing pressure on these species-rich ecosystems. Coral reefs are becoming increasingly degraded, if not destroyed, as a result of high sedimentation rates, nutrient loading and chemical contamination, as well as physical destruction associated with human exploitation, such as destructive fisheries and sand mining.

For the recognition of global change signals and human impact on marine ecosystems, a solid historical baseline is needed. Data on the biodiversity of Jakarta Bay and the Thousand Islands archipelago (Kepulauan Seribu) has been collected in an 85-year time span. The reefs off Jakarta have been extensively studied by some Dutch scientists in the 1900s, facilitated by the long-term presence of research infrastructure in the area. Their historical collections (mostly stony corals and molluscs) are accessible in two museums in The Netherlands.

This research gives insight in the changes in coral reef diversity since the first half of the 20th century in Jakarta Bay and adjacent Thousand Islands archipelago. The coastal resources of Java have since long been subjected to considerable human pressure, and heavy bleaching occurred in the area in 1983. The availability of data, from 1920 (collection material, historical documents, nautical maps; LIPI-UNESCO workshops) to recent fieldwork in 2005, offers the opportunity to detect long-term changes in the composition of Jakarta's marine biodiversity. Depauperation of Jakarta Bay's reefs ranges from 80% loss in species for the islands closest to shore, to shifts in species composition for offshore coral assemblages.

## 18.598

**Coral community structure at Pearl and Hermes Atoll in the Northwestern Hawaiian Islands: unique conservation challenges in the Hawaiian Archipelago**

**Jean KENYON*[1]**, Matthew DUNLAP[1], Casey WILKINSON[1], Kimberly PAGE[1], Peter VROOM[1], Greta AEBY[2], Oliver DAMERON[1]

[1]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI

Pearl and Hermes is the third northernmost atoll in the Hawaiian Archipelago and is included within the Papahānaumokuākea Marine National Monument. The distribution and abundance of scleractinian corals at Pearl and Hermes Atoll were determined from georeferenced towed-diver surveys covering more than 85,000 m2of benthic habitat and site-specific surveys at 34 sites during 2000 – 2002. Three complementary methods (towed-diver surveys, videotransects, and photoquadrats) were used to quantify percent cover of corals by genus or species in the forereef, backreef, and lagoon habitats. Three genera – *Porites*, *Montipora*, and *Pocillopora* – account for 97% of the coral cover throughout the atoll, although their relative abundances vary considerably according to habitat and geographic sector. Forereef communities are dominated by massive and encrusting *Porites*, while the backreef is dominated by *Montipora,* and the lagoon by *Porites compressa*. All taxa also show habitat-specific differences in colony density and size-class distributions, as assessed through colony counts within belt transects at fixed sites. These demographic data, which provide the most thorough quantitative description of the coral communities at Pearl and Hermes Atoll produced to date, are used to focus a discussion on risks of reef degradation from salient contemporary hazards including bleaching, disease, marine debris, and *Acanthaster* predation. Coral communities at Pearl and Hermes Atoll may be the most vulnerable in the Hawaiian Archipelago to bleaching and accumulation of marine debris and thus may warrant special management attention.

## 18.599

**A Palaeoecological Perspective On Coral Community Structure And Resilience To Long-Term Terrigenous Sediment Influence**

**Chris PERRY*[1]**, Suzanne PALMER[1], Scott SMITHERS[2], Ken JOHNSON[3]

[1]Manchester Metropolitan University, Manchester, United Kingdom, [2]James Cook University, Townsville, Australia, [3]Natural History Museum, London, United Kingdom

Increased terrestrial sediment and nutrient yields are regarded as serious threats to coral reef 'health'. These issues are relevant to many regions, but have particular significance to the Great Barrier Reef (GBR) lagoon where coastal catchments were extensively cleared after Europeans settlement (~1850 AD), reportedly increasing catchment erosion, sediment and nutrient export. Such increases have been perceived as a threat to inner-shelf reefs, although the evidence for actual ecological change remains controversial – largely because long-term, baseline (> decadal timescale) coral community records have hitherto been lacking. Here we present high resolution records of coral species assemblages from two inner-shelf nearshore reefs (Paluma Shoals and Lugger Shoal) from the central GBR. Core data demonstrates that these reefs have been under terrigenoclastic sediment influence since reef initiation (~1200 years BP at Paluma Shoals, ~800 years BP at Lugger Shoal), and that both sites contain a relatively depauperate, but temporally persistent, suite of corals – dominated by Acropora pulchra, Montipora mollis and (at Paluma Shoals) Turbinaria frondens, and (at Lugger Shoal) Galaxea fascicularis and Astreopora sp. Although the relative abundance of coral species varies between cores, there are no significant differences between overall species composition or the identities of dominant framework contributors before and after the period of European settlement. The largest changes in community structure occurred as reefs reached sea-level and reef-flat communities developed, changes driven by intrinsic rather than extrinsic factors. The data suggest that reefs that developed under pre-existing conditions of at least episodic terrigenous sediment and run-off influence appear resilient to reported recent deteriorations in water quality. We argue that these reefs - which are often considered inferior – should rank highly for conservation due to their high coral cover and apparent reduced exposure to catastrophic bleaching.

## 18.600

**Change In Coral Reef Condition In The Southwestern Cuba (2001-2007): AGRRA Assessed Sites Revisited**

**Pedro M. ALCOLADO*[1]**, Darlenys HERNÁNDEZ-MUÑOZ[1], Hansel CABALLERO[2], Linnet BUSUTIL[1], Susana PERERA[3], Gema HIDALGO[1]

[1]Departamento de Bentos, Instituto de Oceanología, La Habana, Cuba, [2]Acuario Nacional de Cuba, La Habana, Cuba, [3]Departamento de Planinficación de Áreas Marinas, Centro Nacional de Áreas Protegidas, La Habana, Cuba

An ecological assessment using the AGRRA protocol was carried out on March 2001 providing a baseline for further comparisons. A recent AGRRA assessment (June 2007) enabled us to assess the impact of unprecedented frequent and intense cyclones since 2001 (1 cyclone/year versus 0.4 cyclones/year in 1969-2000) on both well preserved and degraded coral reefs (four reef crest sites and four fore-reef sites). In the reef crest sites live coral cover reduction varied from no-change (Cayo Rosario) to 21% (Cayo Palomo = "Nirvana"), while average coral diameter reduction varied from 16 cm (Cayo Palomo) to 40 cm (Cayo Rico). In fore-reefs the reduction of coral cover varied from no-change (Rico and Campos keys) to 14% (Cayo Palomo), while diameter reduction varied from no-change (Cantiles and Rico keys) to 26% (Cayo Campos). However, in crest sites where little or no-change were observed in both indicators, great shifts occurred from the numerical dominance of Acropora palmata and other corals towards great increases of Millepora complanata or, in lesser extend, of Porites astreoides or Acropora prolifera (in combination or not). In the fore-reefs the shift occurred from the dominance of Montastraea annularis, M. faveolata, M. franksi, Diploria strigosa or Agaricia agaricites towards combined increases of P. astreoides, Siderastrea siderea or M. faveolata. The population density of the sea-urchin Diadema antillarum remained unchanged and negligible in the south of the gulf, while it increased significantly at Cayo Palomo reef crest. Percentages of recent mortality and disease in corals remained low suggesting their lesser influence on coral reef decline than cyclones.

## 18.601

**Organisms Associated With Live Scleractinian Corals As Indicators Of Coral Reef Status in The Wakatobi Marine National Park (Se Sulawesi, Indonesia)**

**Patrick SCAPS*[1]**, Vianney DENIS[2], Jessica HAAPKYLA[3]

[1]University of Lille 1, Villeneuve d'Ascq, France, [2]University of La Réunion, Saint-Denis, France, Metropolitan, [3]James Cook University, Townswvlle, Australia

Organisms associated with live scleractinian corals were studied on four sites located around Hoga and Kaledupa islands in the Wakatobi Marine National Park. The number of coral colonies infested by coral associates was estimated along 20 m long line intercept transects and the number of coral associates found on each coral colony was recorded. A 0.5 m point intercept transect method was used to describe the benthic cover.

A total of 2815 associates were recorded infesting 376 coral colonies. The most conspicuous coral associates were lithophagid bivalves making up for 73% of total coral infestations; followed by dwelling hermit crabs of the genus *Paguritta* with 10.9% and the vermetid snail *Dendropoma maxima* with 8.6 %. The highest number of infested colonies was found for the genera *Montipora*, *Pavona* and *Porites*. The number of infested coral colonies and the density of *Lithophaga* spp.were high in the most impacted site (Sampela) and one of the intermediately impacted site (Pak Kasim's) whereas they were low in the most pristine site (Kaledupa). The other intermediately impacted site (Buoy 3) had an intermediate number of infestations. Despite the lack of any significant difference in biotic cover between the most pristine site and the intermediately impacted sites, a common gradient seems to emerge based on coral associates. Despite the high biotic cover of Pak Kasim's, this site suffers from a similar level of infestation as Sampela suggesting process of reef degradation previously experienced by the most impacted site. Our results suggest that coral associates can be used as indicators of coral reef status.

## 18.602

**The Planetary Coral Reef Foundation: An Overview**

**Lindsey FELDMAN*[1]**, Abigail ALLING[2], Phil DUSTAN[3], Orla DOHERTY[2], Heather LOGAN[2], Carol MILNER[2], Kitty CURRIER[2]

[1]Planetary Coral Reef Foundation, Durham, NC, [2]Planetary Coral Reef Foundation, Pacific Palisades, CA, [3]Biology, College of Charleston, Charleston, SC

In 1995, Planetary Coral Reef Foundation (PCRF) launched a coral reef science program onboard its ship at sea to monitor coral reefs in the Red Sea, Indian Ocean, Southeast Asia, Melanesia, Polynesia and the Great Barrier Reef. The methodologies used were developed in collaboration with Dr. Phil Dustan and include:

**A Reef Report.** A detailed, narrative report about the state of coral reefs at the study site, including reef images.

**Vitareef Summary.** A statistical summary using 19 codes to identify the health and vitality of minimally 2,000 coral colonies per study site.

**Coral and Fish ID Data.** A summary of the type and number of coral and fish species found at the study site within four 20 meter 2-banded transect lines (80 $m^2$ zone).

**Pointcount Summary.** An assessment of ground cover recorded to the level of coral genus.

**GPS Data.** Global Positioning System data at each study site provides the precise location of the study and is also used on occasion with satellite imagery to test the ability of mapping coral reefs from space.

PCRF's scientists post 100% of the data for each coral reef study site online free of charge to encourage collaboration, and to provide a trusted source of data about remote coral reefs for users in science, education and conservation. This collaborative approach optimizes environmental reach because other scientific organizations that conduct even limited surveys of coral reefs, often make their data unavailable which greatly limits the impact of conservation programs. A poster will be presented to highlight this program and data gathered from Lizard Island off the Great Barrier Reef (2005) will be used to feature the work.

## 18.603

**Sea Urchin Abundance, Distribution And Erosion Along Kuwait's Coral Island Reef**

Shaker ALHAZEEM[1], Adel ALSAFFAR[2], **Shaker ALHAZEEM*[2]**

[1]Mariculture and Fisheries Dept. (MFD), Kuwait Institute for Scientific Research (KISR), Kuwait City, Kuwait, [2]MFD, KISR, Kuwait City, Kuwait

Changes in sea urchin abundance and distribution around three of Kuwait's coral islands, Kubbar, Qaru and Umm AlMaradim, in the northern Arabian Gulf, were studied between 2003 and 2004 with particular emphasis on the role and impact of sea urchins in structuring the coral reef communities. Diver surveys of sea urchin Echinometra mathaei and Diadema setosum, densities along transects taken at different depths around the reefs demonstrated no significant differences in density (19.35-33.44 m-2) between 2003 and 2004 or between transect depth, coral reef island, or reef exposure. The highest densities of E. mathaei (35 mÎ²) were observed at Umm AlMaradim Island. The distribution and abundance of E. mathaei and D. setosum around the coral islands suggests they are a bioindicator of reef health and of environmental stress. The contribution of sea urchins to bioerosion of the reefs was investigated using cage exclusion and gut evacuation experiments. Using a gut evacuation experiment grazing rates of E. mathaei were calculated at 3.84g of coral.sea urchin-1.day-1. The cage exclusion experiment highlighted the extent of the damage caused by boat anchor and fishing practices around the 3 reefs.

## 18.604

**Disturbance And Rehabilitation Of Tsunami Impact On Mangrove Forests And Macrobenthic Communities in Andaman Sea, Thailand**

**Yoshimi FUJIOKA*[1]**, Ryuichi TABUCHI[2], Yasumasa HIRATA[2], Reiji YONEDA[2], Pipat PATANAPONPAIBOON[3], **Takuro SHIBUNO*[4]**, Hideo OHBA[5]

[1]National Research Institute of Aquaculture, Minami-ise, Japan, [2]Forestry and Forest Products Research Institute, Tsukuba, Japan, [3]Chulalongkorn University, Bangkok, Thailand, [4]Seikai National Fisheries Research Institute, Okinawa, Japan, [5]Tokyo University of Marine Science and Technology, Tokyo, Japan

On December 26th, 2004, the impact of tsunami waves caused by an undersea earthquake off Sumatra Island generated severe damage to artificial constructions and natural ecosystems especially coral reefs and mangroves on the coastal area of Andaman Sea. One year before the tsunami disaster, we established permanent survey plots for some characteristic mangrove forests on the coast of Ranong, Thailand. Since that time, we have continued to survey mangrove stands and macrobenthic assemblages. Therefore, this survey became not only to monitor the usual dynamics of mangrove ecosystems but also to demonstrate the tsunami impact and rehabilitation process after the tsunami. Damage of mangrove stands were occurred by (1) direct physical destruction by wave impact and (2) sand settlement on the substratum of mangrove swamp. Three dominant macrobenthic communities, polychaetes, mollusks and arthropods, on the mangrove swamps were changed by tsunami; endobenthic organisms such as polychaetes and bivalves decreased due to be buried in sand, while epibenthic organisms such as gastropods and crustaceans decreased at once but recovered immediately, and terrestrial organisms such as insecta increased on dried sandy substratum. On damaged areas, biomass and diversity of macrobenthos decreased significantly after tsunami.

## 18.605

**Coral Reef Conservation Status In The East Coast Of Peninsular Malaysia**

**Asami NAKAYAMA*[1]**, Ryota NAKAJIMA[1], LaiPeng FOONG[2], Rajuddin KUSHARI[3], Victor KUWAHARA[1], Hideo MIYAGUCHI[1], Ross OTHMAN[2], Tatuki TODA[1]

[1]Soka university, Tokyo, Japan, [2]Universiti Kebangssan Malaysia, Selangor, Malaysia, [3]Universiti Industri Selangor, Selangor, Malaysia

The conservation status of coral reefs was investigated along the east coast of Peninsular Malaysia in years 2001 and 2007. In 2001, a total of 7 sites from 3 islands were selected for this investigation; Dalam Bay and Ruang Bay at Perhentian Island; Tulai Reef, Manggo Reef and Renggis Reef at Tioman Island; Pasir Bay and Rimba Reef at Sibu Island. In 2007, the same sampling sites were revisited and investigated with additional sites in Batu Tengara and Coral Garden of Kapas Island, totaling to 9 sites. Estimated coverage of coral communities was examined by applying quantitative digital image analysis to the line transect method. In 2001, three coral community types were characterized by dominant genera and lifeforms: *Montipora-Acropora* community, *Acropora* branching community and *Heliopora* community. Among them, the most dominant coral community in the east coast was *Montipora-Acropora* community. Dalam Bay in Perhentian Island showed the highest community diversity at 19 coral genera, while Renggis Reef in Tioman Island had the lowest at 9 genera. Live coral coverage in study sites ranged from 21% to 69%. Most reefs were in ″good″ or ″fair″ condition while some reefs were shown to be in ″poor″ condition following the criterion of Gomez et al. (1994). The coral conservation status of year 2001 and 2007 in the east coast of Peninsular Malaysia is compared, and changes in the reef community and effect of human activity on the coral community between 2001 and 2007 are discussed.

## 18.606

**The Distribution Of Coral, Reefs And Coastal Habitats in North Central Cuba**

**Aisling BRADY*[1]**, Sharon COWLING[1]

[1]Geography, University of Toronto, Toronto, ON, Canada

A coastal causeway connecting Cayo Coco to Cayo Guillermo in Ciego d'Avila, Cuba, has not only transformed the tourism industry in this region, but has also produced new reef habitats. Scleractinian coral communities have begun to form under small inlet-style bridges along the causeway, surrounded by seagrass beds, mangroves and natural reefs. To identify the role of these bridge reefs in the ecological functioning of the Cayo Coco-Guillermo reef tract, we need to understand how these bridge reefs formed and characterize their attributes relative to surrounding communities. A combination of ecological observations and δ13 carbon isotopes were collected from the bridges and surrounding reef communities, mangrove channels and *Thalassia* patches. Detrended Correspondence Analysis and Canonical Correspondence Analysis were carried out to group which physical attributes contributed to the coral communities in the bridge reefs and also which habitats the bridge reefs were most similar to, with respect to coral and benthos composition. $\delta^{13}$ C was used as a tracer in the bridges, marking where organic sediment originated from, and how their origins changed in surrounding habitats. Coral assemblages at bridge reefs resembled communities in surrounding patch reefs and mangrove channels, while benthic coverage at bridge sites was most similar to mangrove channels, suggesting the inflow of water through mangroves during high tides played a role in shaping the substrate of the bridge reefs. Of the physical attributes measured, depth, current speed and turbidity gradients were considered the most important environmental factors influencing coral communities. By understanding how these bridge reefs formed, recommendations can be made for recreating ecologically similar conditions during future development of surrounding cays, while results also contribute to growing inventories of benthic communities in North Central Cuba.

## 18.607

**Susceptibility Of Corals To Skeletal Growth Anomaly And Trematodiasis According To Species And Seasons At Wai`Opae Tide Pools, Hawaii**

**Misaki TAKABAYASHI*[1]**, T. Makani GREGG[1], Kaikaika TEVES[1], Shauna Kehau TOM[1]

[1]Marine Science Department, University of Hawaii at Hilo, Hilo, HI

Scattered along the east side of Hawai`i Island are tide pools with porous basaltic lava rock substrate. These tide pools, ranging in depth of 1-4m, have a high freshwater input from ground water and runoff, resulting in the large salinity variability of 24.6-35.1ppt. Given the proximity to residential areas, porosity of substrate, and high rainfall in the area, the Wai`opae tide pools are suspected to be heavily exposed to terrigenous influences. Approximately one third of these tide pools fall within the Wai`opae Marine Life Conservation District (MLCD), where collection of any kind is prohibited. The MLCD pools are however available for recreational use and popular with snorkelers. We monitored random and permanent colonies of eight scleractinian coral species inside and outside of the MLCD monthly over the last two years. Our results to date show that higher proportions ($p < 0.05$) of corals are affected by trematodiasis, skeletal growth anomaly, and tissue loss of unknown causes; 1) during summer months than winter; and 2) inside the MLCD than outside. Skeletal growth anomaly affects Montipora capitata, and trematodiasis is observed in Porites spp. at a higher rate ($p < 0.05$ in both cases) than other species. Repeated monitoring of permanently marked colonies indicate that there is no clear correlation between the fate of skeletal growth anomaly (change in size and frequency) and species, location, or season. The same lack of correlation was observed in colonies affected by trematodiasis and tissue loss. Some coral colonies have recovered from these conditions partially or completely during our monitoring period, however, showing some level of resilience within the Wai`opae coral population.

## 18.608

**Sudden Changes On Coral Reefs At Naval Station Guantánamo Bay (Gtmo), Cuba**

**Ken DESLARZES*[1]**, William PRECHT[2], Martha ROBBART[3]

[1]Geo-Marine, Inc., Plano, TX, [2]Battelle, West Palm Beach, FL, [3]PBS&J, Miami, FL

From 2003 to 2007, spur and groove reefs at GTMO were subject to significant changes including the loss of coral cover and habitat complexity. This resulted in a significant reduction of fish abundance. The main source of these changes was related to a bleaching event associated with the extreme warming of SSTs throughout the Eastern Caribbean in 2005. This mass coral bleaching event and subsequent mortality reduced absolute coral cover from 41.5% to 19.3%; macroalgal cover increased from 27.3% to 37.6%. Also, there was a conspicuous loss of the competitively dominant and structurally complex coral, Agaricia tenuifolia. The significant reduction of coral cover and the concomitant reduction of topographic complexity have led to reefs that can no longer sustain pre-2003 fish population levels. The overall decrease in fish abundance points to coral habitat as a limiting factor in supporting juvenile and adult fish populations. Fish diversity, however, appears to have increased slightly. More diverse herbivorous fishes combined with the increase in algal cover underscores a changing reef environment and a probable phase-shift from a coral-dominated to an algal-dominated reef. Because of restricted access, overfishing is not responsible for the observed reduction in fish stocks at GTMO. Interestingly, the overall small size of the fish both in 2003 and 2007 at GTMO was similar to sizes reported from the heavily overfished reefs of north Jamaica. Because the sea urchin Diadema antillarum was rare in 2007, herbivorous fish assemblages are primarily responsible for the maintenance of algal assemblages on these reefs. Increased diversity and abundance of herbivorous fish may indicate a temporary response to the increased algal cover. However, it is unknown how these species will respond in time and space. Also, will current levels of herbivory be sufficient to prevent further reef degradation especially when confronted with future disturbances?

## 18.609

**Community Structure Of Reef Fish On Three Different Coral Life Form (Branching, Foliaceous, And Massive) At Pari Island, Indonesia**

Hawis MADDUPPA[1], **Unggul AKTANI*[2]**, Harry PALM[3]

[1]Marine Science and Technology, Bogor Agricultural University (IPB), Bogor, Indonesia, [2]Aquatic Living Resources Management, Bogor Agricultural University (IPB), Bogor, Indonesia, [3]Heinrich Heine University-Germany, Duesseldorf, Germany

Indonesia is the world's richest country in terms of reef fish diversity. Nevertheless, reef fish of the Indonesian Archipelago remain poorly known primarily due to the lack of sampling. The objectives of this research were (1) to compare reef fish community structure on three different reef habitats based on types of coral life-forms (Acropora branching-ACB, coral foliaceous-CF, and coral massive-CM) by using a number of community properties, and (2) to investigate seasonal variation in the structure of reef fish communities on the different coral life-forms. This study was carried out from August 2003 to May 2004 at Pari Island in the southern part of The Thousand Islands, off the Javanese North Coast. Three 5x5 m2 permanent quadrant transect were placed at each sampling site, 150 photo transects (1x1 m2) were used to assess the sessile benthic community of the coral reefs at the beginning and the end of the sampling period. Reef fish communities were assessed by underwater visual census. During this study, a total of 13409 individual fishes were counted, representing 208 species belonging to 37 families. In terms of species richness in ACB and CF sites, Pomacentridae (40%) and (48.6%) was the dominant fish family, and Labridae (27.4%) was the dominant family at site CM. Fish community analysis by using PRIMER v5 revealed seven groups of fish communities. The most species rich habitat was ACB with 130 species followed by CM and CF with 117 and 82 species respectively. The sequence of trophic categories at all sites during monitoring was carnivorous (32.9-47.9%), herbivorous (15.9-26.9%), omnivorous (12.6-25.6%), planktivorous (17.3-20.7%), and coralivorous (1.7-8.3%). Average Shannon-Wiener diversity (ln basis) at all habitats ranged from 2.0-2.9 (ACB), 2.4-3.1 (CF), and 2.1-3.0 (CM), with no significant difference between sites.

## 18.611

**Continuous Recruitment Of Hard Corals In North Sulawesi, Indonesia Estimated Throughout The Year With Fluorescence Census Technique**

**Sascha B.C. ROMATZKI*[1]**, Sebastian SCHMIDT-ROACH[1], Andreas KUNZMANN[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany

Recruitment of corals in a low-latitude Indonesian reef was observed by sampling of artificial limestone substrates at four stations situated in the Bunaken National Park and nearby reefs over a 2-year-period. Tiles were removed every 2 months and replaced with new ones. The sampled tiles were examined using standard microscopic techniques. Time of settlement of recruits was determined using size-age-keys from a study using combined fluorescence photo techniques with conventional microscopic examination for the early detection of coral-recruits in the same stations.

So called growth charts were used to determine the time of settlement of *Acroporidae* and *Pocilloporidae* recruits with a weekly accuracy. A total of 4280 *Pocillopora* and 3150 *Acropora* recruits were examined on 1440 tiles. Size of pocilloporid recruits ranged from 0,5 - 8,4 mm, for those of *Acroporidae* from 0,5 - 4,87 mm. Recruits of at least one family were found during each sampling period and in each station on tiles throughout the year. Abundance of *Pocilloporidae* recruits showed no clear seasonality in settlement in contrast to those of *Acroporidae*, who peaked in the months of April /June and November/December of 2006 in all monitored stations. These data suggest that there is a steady recruitment of pocilloporid recruits in the monitored reefs while recruitment for *Acroporidae* is more seasonal, but not necessarily restricted to seasons. Based on the observation of several distinct peaks in recruitment per year in successive years, we believe that there must be several mass spawning events.

## 18.612

**iMPACT OF hURRICANE rITA ON FOUR SHALLOW BANKS IN THE NORTHERN gULF OF mEXICO**

**Martha ROBBART*[1]**, Rich ARONSON[2], William PRECHT[3], Ken DESLARZES[4]

[1]PBS&J, Miami, FL, [2]Dauphin Island Sea Lab, Mobile, AL, [3]Battelle Institute, West Palm Beach, FL, [4]Geo-Marine Inc., Plano, TX

Hurricane Rita, a Category 3 storm, passed within 90 km of several uncharacterized shallow banks in the Gulf of Mexico, including Sonnier, McGrail, Geyer, and Bright Banks; as well as the better-known East Flower Garden Bank. Hurricane-force winds extended 139 km, and tropical storm-force winds extended as far as 333 km from the center of the storm (National Hurricane Center 2007). MMS deemed it necessary to characterize the benthic habitats of these banks using diver and ROV methods across depths (22-27 m, 30-36.5 m, 45-50 m, 55-60 m), to gather baseline data and assess possible hurricane impacts. The study was conducted in April and May 2007, eighteen months after the passage of Hurricane Rita. Analysis of Similarity (ANOSIM) showed these banks were significantly dissimilar to each other based on their benthic communities (Global $R$ = 0.54, $P$ = 0.001). Algal-sponge communities dominated Sonnier, Geyer and Bright Banks, but unique species assemblages characterized each bank. Even though McGrail Bank was almost directly in the path of Hurricane Rita (1.6 km west), no obvious damage to the *Stephanocoenia intersepta*-dominated benthic assemblages at 45 m was documented. Unlike McGrail Bank, East Bank experienced noticeable hurricane damage to scleractinian corals, despite being 92 km away. Results of a wave model study hindcast waves of up to 13 m passing over the reef cap of Sonnier Bank (20 m at shallowest depth) with velocities up to 4 m/s along the substratum. Sonnier Bank exhibited vast areas of bedrock exposed eighteen months after the passage of the storm. Deeper banks may have experienced waves up to 26 m high but were not obviously impacted. Eighteen months after the passage of Hurricane Rita, Sonnier Bank benthic communities continued to recover.

## 18.613

**Status And Conservation Of Coral Reefs in Costa Rica**

**Jorge CORTÉS*[1]**, Carlos JIMÉNEZ[1], Ana FONSECA[1], Juan ALVARADO[1]

[1]Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica, San Pedro, Costa Rica

Costa Rica has coral communities and reefs on the Caribbean coast and on the Pacific side (coast and off-shore islands). Fringing and patch reefs, carbonate banks, and an incipient algal ridge are present along the southern section of the Caribbean coast. Coral communities, reefs and isolated coral colonies can be found along the Pacific of Costa Rica. Coral reefs have been seriously impacted in the last 30 years, mainly by sediments on the Caribbean coast and some Pacific reefs, and by El Niño warming events in the Pacific and in the Caribbean. Recovery has been recorded in some reefs, but it is slow. Monitoring is being carried out at three sites on the Caribbean and three on the Pacific coast. Funding is the main limiting factor for the continuity and expansion of the monitoring programs. In recent years it has been possible to monitor some of the reefs thanks to the funding by the STA-GCRMN node. The government of Costa Rica is aware of the importance of coral reefs and marine environments in general, and in recent years decrees have been implemented (or are in the process of approval) to protect them, but limited resources attend against their proper management and conservation. But more outreach to the general public and reef users is needed; again funding and personnel are scarce for these activities. We propose the organization of a national meeting on coral reefs with all the main actors, i.e., government, non-government organizations, tourist operators, fishers, local associations and interested general public, to come to an agreement on the use of the reefs, and on the funding for research, monitoring, management, and conservation.

## 18.614

**Invertebrates, Communities And Reef Health in Airai, The Republic Of Palau**

**Ann KITALONG*[1]**

[1]The Environment, Inc., Koror, Palau

During 2006 and 2007, Ngarabrekork, a women's group, combined traditional ecological knowledge with standard scientific methodology to study distribution, densities and harvest rates of selected invertebrates at 3 fringing reefs in Airai. Standard replicate transect lines, mobile GPS tracking units and traditional harvesting techniques were used. *Tridacna crocea* and *Tridacna maxima* had similar shell lengths [mean size = 9.7 cm ± 0.58 ($\alpha$ = 0.05, n = 36)] at the western and eastern reefs [mean = 9.6 cm ± 0.34 ($\alpha$ = .05, n = 35)] but smaller lengths at the southern reefs [mean = 7.0 cm ± 0.09 ($\alpha$= 0.05, n =33)]. Women selectively harvested clams with shell lengths equal or greater to 6.5 cm. The catch effort (clams/woman/hr) was higher at less accessible reefs [CPUE = 24.4±13.0 ($\alpha$=0.05, n=4)] than more accessible reefs [CPUE = 3.7±3.9 ($\alpha$=0.05, n=4)]. *Tripneustes gratilla* were more common on the southern reef [(CPUE = 47 ± 31($\alpha$ = 0.05, n = 4)] with a smaller mean diameter [6.3 cm ±0.10 ($\alpha$=0.05, n=233) than urchins on the western reefs [CPUE = 24.6±8.8 ($\alpha$ = 0.05, n = 7) ; mean diameter size = 7.6±0.22 ($\alpha$=0.05, n=40)]. During April 2007, sea urchins were observed spawning. In June 2007, only empty tests [0.10 tests/m2; mean size = 6.0 cm ± 0.31 ($\alpha$=0.05, n=24) were recorded along the eastern reefs. *Actinopyga miliaris* were more common at the eastern reef [CPUE = 41±32 ($\alpha$=0.05, n=3); mean size = 11.65 cm ± 1.5 ($\alpha$ = 0.05, n = 20)]. *Stichopus variegatus* were more common along less accessible [CPUE= 47.3±19.9 $_{(\alpha = 0.05,\ n=3)}$ ] than more accessible reefs (CPUE = 0.75±0.85$_{(\alpha=0.05,\ n=4)}$). Time allocation, reef health and management will be discussed.

## 18.615

**Determination of the Environmental State of Health in Sacrificios Reef Using the AMBI Index**

**Nayeli DOMÍNGUEZ CASTANEDO*[1]**, Alejandro GRANADOS BARBA[2], Vivianne SOLÍS WEISS[1]

[1]Laboratorio de Ecología y Biodiversidad de Invertebrados Marinos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, México, Mexico, [2]Unidad de Investigaciones de Ecologia de Pesquerias, Universidad Veracruzana, México, Mexico

The AMBI (AZTI's Marine Biotic Index) provides a "disturbance classification" of a site which represents the benthic community "health". It is possible to determine the environmental state analizing the macrobenthos strcture because it responds fast to natural or anthropic impacts and it is unable to evade impacts and damage done to the water and sediment quality.

Sacrificios Reef is part of the national park: Parque Nacional Sistema Arrecifal Veracruzano (PNSAV). In this place a protected area and a the most important economic harbor in Mexico meet . We evaluated here the environmental health state of the reef with the AMBI index using the macrofauna present in 4 transects (east, west, northeast and northwest) with an underwater suction device (13.22 dm3) in plain sand, seagrass beds and sand among coral reef patches.

The AMBI values varied from 0.79 to 2.4. These values are relatively low in the AMBI scale (0-7) and show that the environmental conditions in the Sacrificios Reef vary from "Undisturbed" to "Slightly disturbed", the dominant ecological groups being II and III. Those groups are composed by the species sensitive and indifferent to environmental stress. A negative correlation between the AMBI index and the sediment grain size was found. The highest values of the index were located to the north where the seagrass beds and patch reef are more extended. This zone is protected by the reef crest, there is low energy and finer sediments. This tool will allow us to know the environmental condition of the reef and act effectively to avoid damaging it. The AMBI has been shown to be a useful tool to assess the benthic environmental quality of the Sacrificios Reef.

## 18.616

**Coral Reefs in Costa Rican Caribbean: Enough Reason to Redesign Conservation Areas?**

**Isabel CHACÓN-GÓMEZ*[1]**

[1]Masters Degree Program on Marine Science, Universidad Nacional de Costa Rica, Puntarenas, Costa Rica

Costa-Rica holds 0.28 % of the coral reefs on the whole world. In the Caribbean it is one of the smallest countries (51.100 km²) and some of the others, that are much bigger, for example Colombia (2.070.408 km²), hold a smaller percentage (0.20%) of the coral reefs of the world. That means that coral reefs are significant ecosystems in Costa-Rica in proportion with the rest of the country area. Although it is known to be a country full of biodiversity and it has such important marine ecosystems, there are still ecosystems which are not part of conservation plans, such as Marine Protected Areas-MPA. Therefore, agriculture, tourism, fishing and extraction of organisms are becoming threats for some coral reefs along the Costa-Rican Caribbean. With the aim of knowing the conservation status of those coral reefs in the Caribbean of the country, three reef points are going to be surveyed and ecologically compared by studying specially octocoral communities as indicators of the development capacity of those ecosystems under anthropogenic pressures. The reefs that are going to be surveyed are located in three zones with different management categories: Cahuita, a National Natural Park, where no agriculture is developed, fishing is forbidden and some of the tourism and sport activities are regulated. The second one is part of a Wild Life Reserve (Manzanillo), where just some fishing activities and tourism are allowed and the third one is close to Isla Uvita, which is near Limon, one of the most important seaports of Costa-Rica; there is no regulation on the anthropogenic activities. It is expected to find relevant differences between the conservation status of the reefs along the south portion of the Costa-Rican Caribbean, so that a new design of the MPA might be proposed based on the need of protect some important fragile ecosystems.

## 18.617

**Large Daily Seawater Temperature Fluctuation in A Tropical Coral Reef**

**I-Huan LEE*[1]**, Yu-Huai WANG[2], Fung-Chi KO[1], Tung-Yung FAN[1], Wei-Hsien WANG[1]

[1]Institute of Marine Biodiversity and Evolution, National Dong Hwa University, Taiwan, National Museum of Marine Biology and Aquarium,Taiwan, Pingtung, Taiwan, [2]Institute of Applied Marine Physics and Undersea Technology, National Sun Yat-Sen University, Taiwan, Kaohsiung, Taiwan

Seawater temperature plays an important role in coral physiology and coral reef ecology. To understand the temperature variation from the sea surface to 30 m below sea level, where the deep reef exists in a tropical coral reef in Nanwan Bay, Southern Taiwan, temperature sensors were deployed at depths of 5, 10, 20, and 30 m to monitor temperature change. Seawater temperature measurements showed daily drops up to 8℃ and coherent fluctuations of temperature occurred at different depths. The intrusion of cold water lasted for 6 hours in a diurnal cycle. The daily source of cold water is likely the internal tidal flow propagating from the bay mouth where located at the northern tip of Luzon Strait. Seawater mixing due to bottom friction and tidal currents entrained the movement of the lower layer water upward and landward. Seawater temperature changes due to atmospheric force were less than 4℃. The effect of large daily temperature fluctuation on biology of corals and coral reefs is still under current study.

## 18.618

**Assessment Of Reef Area Loss And Implications On Scleractinian Sp. Diversity On Coral Reefs Affected By Terrace-Uplift; Aftermath Of The December 26th 2004 Earthquake, in Andaman Islands, India.**

**Rajkumar RAJAN*[1]**, Satyanarayana CHOWDULA[2], Rajan PONAMKULAM[1]

[1]Zoological Survey of India, National Coral Reef Institute, Port Blair, Andaman Nicobar Islands, Port Blair, India, [2]Zoological Survey of India, General Non-Chordata Section, F. P. S Building, Indian Museum Complex, Kolkata, Kolkata, India

Eleven fringing reefs in North Andaman Islands, devastated due to landmass uplift (~ 1 m) following the Earthquake on 26 December 2004 – off southern Sumatra coast, were surveyed for: (i) estimate of reef area loss (ii) *Scleractinian* sp. mortality, and (iii) diversity and percent cover on the existing reef slope and within the depth of 10 m. The uplift caused the reef crest and part of reef slope in these reefs to be totally exposed, with the estimated loss of 30% of reef area. Loss of reef area was found to be varied between reefs, arbitrated by the uplift and characteristic of reef morphology, and not in proportion to the total reef area (pre-earthquake) in each reef. LIT surveys revealed that exposed reef areas possessed high coral cover i.e., 89.8 ± 2.62%, (killed *Scleractinians* only), as against the 37.92 ± 21.83% in the unexposed/existing reef zones. The high variation in percent cover in the existing zones attributes to the variation in percentage of loss of area in each reef: reefs heavily impacted exhibited lower percent cover in the existing reef zones. Exposed areas showed higher diversity (Simpson $1/D$ = 2.33), in the heavily impacted reefs only; other exposed areas showed only species dominance. Existing reef zones obtained slightly lower indices ($1/D$ = 1.75 ± 0.19), however with relatively high evenness ($E$ = 0.53 ± 0.13). These analyses point out that, the reef cover lost - in proportion to the percentage of loss - manipulated overall species diversity and dominance in these reefs. Loss of dominant species cover (via the exposed areas) will be discernible in the restoration processes as existing reef zones do not exhibit similar species structure. Monitoring studies may, in this case, indicate the influence of other external stressors consequent to the uplift.

## 18.619

**Present Condition Of Coral Reefs And Associated Ecosystems in The Nw Region Of Cuba**

**Gaspar GONZALEZ*[1]**, Fernando BRETOS[2], Consuelo AGUILAR[1], David GUGGENHEIM[3], Ivet HERNÁNDEZ[1], Yureidy CABRERA[1], Noelis SUAREZ-MONTES[4]

[1]Centro de Investigaciones Marinas, University of Havana, Havana, Cuba, [2]Harte Research Institute for Gulf of Mexico Studies, Miami Beach, FL, [3]Harte Research Institute for Gulf of Mexico Studies, Washington, DC, [4]Establecimiento Pesquero de Los Arroyos, Pinar del Rio, Cuba

The main goal of this research was to obtain updated information, which we combined with existent knowledge to prepare a sound ecological baseline for the region. Three sampling cruises were conducted in 2004 and 2006. We sampled a network of 68 fixed stations along a total shelf area of 4050 km$^2$. At each station we measured main abiotic factors (temperature, salinity, dissolved oxygen and pH) using a Hydrolab 4 probe. We made a qualitative and quantitative sampling of substrate type, seaweeds, seagrasses, invertebrates and fishes using visual census techniques. This information allowed us to obtain an estimation of the spatial distribution of biotopes and species assemblages at different scales, with emphasis on coral reefs and seagrass beds. We built a conceptual model for the spatial organization and connectivity of coastal ecosystems, with emphasis on coral reefs, seagrass beds and mangroves. The geographical position of the region suggests it plays an important role in regional ecological connectivity, an aspect we also include in our model. We conclude that coral reefs and associated ecosystems in the NW region of Cuba are well preserved in general terms, although overfishing is a generalized problem and coastal pollution is present in some places near highly populated areas. Tourism development in coastal areas is low and its present impact is negligible relative to the entire region. Oil and gas exploration in the adjacent oceanic Exclusive Economic Zone creates a potential threat to marine biodiversity in this region.

## 18.620

**Effect Of Change in Biophysical Parameters On Status, Health And Distribution Of Corals Reefs in Mahatma Gandhi Marine National Park, Wandoor (India)**

**Mani SAXENA*[1]**, Alok SAXENA[2], Ramesh CHANDRA SRIVASTAVA[3]

[1]Biotechnology, Central Agriculture Research Institute, Port Blair, India, [2]Department of Environment & Forests, Government of India, Port Blair, India, [3]Director, Central Agriculture Research Institute, Port Blair, India

Situated in the South Andaman, Mahatma Gandhi Marine National Park, Wandoor has always attracted researchers for its rich marine biodiversity particularly. MGMNP has a total area of 281.5 km2 of which land area is only 61.5 km2 belonging to 15 islands within the boundary of MGMNP. Different estimates of number of coral species found in MGMNP are available. Study carried out by Department of Ocean Development (DOD) in 2003 showed maximum number of coral species as 58 around Jollybuoy Island while Kulkarni et. al., (2004) recorded 126 species of coral in this Marine National Park. Kulkarni et. al., also recorded various biophysical parameters like salinity and sedimentation rate and studied effect of these parameters on distribution and live coral coverage. The Tsunami which struck this area in December 2004 caused a lot of mortality in the coral cover in this area. It has resulted in shrinking of beaches in some islands while new beaches have developed in other islands. The sedimentation has affected coral adversely. However, the corals are now recovering and recovery is very fast around some Islands. In the present study, biophysical parameters of the sea waters like pH, salinity, sedimentation rate, visibility etc at selected sites have been studied along with the richness of species, distribution pattern and mortality. The initial results show that while diversity of coral reefs has gone down considerably around Jollybuoy and Redskin islands, it has improved considerably at Chester Island. The live coral coverage has increased particularly that of *Acropora* around Grub Island. The changes are found to be mainly due to variation in sedimentation rate.

## 18.621

**Lack Of Coral Reef Resilience in Mpas Of Andaman And Nicobar Islands, India**

**R. JEYABASKARAN*[1]**

[1]Marine Aquarium and Research Centre, Zoological Survey of India, Digha, India

The Andaman and Nicobar Islands reefs were unaffected by the year 1998 bleaching event and 2004 *tsunami* caused damage to coral reefs. Extensive post *tsunami* surveys were made recently in Marine Protected Areas (MPAs) of Andamans, Mahatma Gandhi Marine National Park (MGMNP) and Rani Jhansi Marine National Park (RJMNP) accordingly Great Nicobar Biosphere Reserve (GNBR) of Nicobars. The result showed the decrease of live coral cover from 60% on the year 1999 to 48% in RJMNP and from 51% to 38% in MGMNP. Nevertheless, the scleractinian coral diversity remains unchanged with the presence of 129 species belongs to 44 genera in RJMNP and 115 species belong to 40 genera in MGMNP. The *Porites* spp were the dominant life form category in Andamans with 52% occurrence followed by *Acropora* spp with 20%. Maximum number of 95 species belongs to 37 genera were reported from Jolly Buoy Island which is one of the tourist destination of MGMNP. The Grub Island of MGMNP was unaffected by the tsunami surge, heavily affected by the strong waves prevailed during May 2007. In the year 1999, 54.5% of live coral cover with the presence of 81 species belongs to 31 genera were recorded in GNBR. Among the live corals *Acropora* spp were dominant with 58% occurrence next to *Montipora* spp of 11%. Recent survey result showed the subsistence of few colonies of *Porites* spp in GNBR which was under severe stress. Almost all coral reefs were degraded in GNBR and recovery will not be possible. The other factors related to lack of coral reef resilience are discussed in the paper.

## 18.622

**Beyond Valuation: Using Integrated Social, Economic, And Environmental Indicators To Monitor Reef Management And Environmental Change**

**Linwood PENDLETON*[1]**

[1]Coastal Ocean Values Center, The Ocean Foundation, North Sandwich, NH

To date, nearly 200 valuation studies have been conducted for coral reefs around the world (Brander et al. 2007). These studies have demonstrated the value of reefs and the distribution of these values across users and reef types. Meta-analyses of valuation studies and cross-sectional valuations have attempted to show how attributes of reefs and reef management may affect these values. Valuation studies, however, are not well-suited as means of empirically demonstrating the economic value of environmental change, management, and other time-varying factors. Using data from 3 estuaries in California, we show how simple yet integrated economic, demographic, and environmental indicators can be used to isolate the effects of management and environmental change from other factors. We show how historical narrative can be used to analyze data from a single site while panel data methods can leverage even more analytical information when multiple sites are analyzed together. We argue that the time is right to turn our attention to non-valuation sorts of economic data collection for coral reefs to better understand the economic importance of reefs and the economic effects of management, climate change, pollution and other factors.

## 18.623

**Coral status in St. Martin Island, Bangladesh.**

**Mohammad Zahirul ISLAM*[1]**, Mohammad Sazedul ISLAM[2]

[1]Marine Conservation, Marinelife Alliance, comilla, Bangladesh, [2]Marine Conservation, WCRC, comilla, Bangladesh

Coral reef could not be established due to high turbidity during a major period in St. Martin Island of Bangladesh. 66 species of corals have been identified under 22 genera with 15 families of sclerectinian. Large rocks substrate invites fair recruitment of juveniles observed those are subject to frequent overturning by storm surges. MarineLife Alliance and WCRC conducted coral survey by Manta Tow, Line Intercept Transect (LIT) and ReefCheck Methods during 2005-2007. Dominant hard coral genera are Porites, Favites, Goniopora, Cyphastrea and Goniastrea. The Porites was the most abundant in terms of coverage. The live coral colonies are visible and can be seen along the lower intertidal particularly during low spring tide. The same greater forms present in subtidal up to 400-1000 meter. The entire boulder substrate has coral growth. Coral bleaching has been observed during 1998 onwards and COT has never been spotted. The SST & salinity fluctuate between 240C –280C and 33-38 PPT. The eastern and southern side of Cheradia 6 genera of hard corals are present but surface area coverage was only 4-6 % at northern portion and 7-8 % at east Cheradia zone at about 4- 8 meter depth where Acropora is dominant. At the west of Cheradia coral bed observed 400-500 meter westward and density were 6 - 7 %. Further north near the Barashilerbadth (Northwest rocky shoal) coral are denser, diverse and occupy about 10-15 % area. In general sub tidal zone up to 200 meters seaward almost all rocky substrate supports diverse coral communities. Small coral colonies and recruitments growths are present in the intertidal rock pools at lower portion. The abundance of coral coverage is low in the whole marine area. The density measured as 1-5 colonies/square meter measures in some quadrate data in deferent areas where the coral are more abundant.

## 18.624

**Environmental Endocrine Disruptors: A "real" And Growing Concern Affecting Coral Reefs**

**Brian SHMAEFSKY*[1]**

[1]Biology, Kingwood College, Kingwood, TX

Coastal regions located near coral reefs have seen unprecedented human population growth over the past fifteen years. With this growth comes an increase in agriculture, manufacturing and commercial entities contributing to air and water pollutants that make their way into coral reef water. Many of the pollutants contributing to the environmental degradation are suspect compounds called endocrine disruptors.

Current research shows that many common pesticides and industrial pollutants are found in coral reefs worldwide and may act as endocrine disruptors on coral reef animals. Endocrine disruptors have been correlated with developmental and reproductive defects in wildlife. Invertebrates are particularly sensitive and are used as models for endocrine disrupter studies. Research on laboratory animals shows that these compounds bind to estrogen receptors and either stimulate or inhibit estrogen's effects. Endocrine disruptors have been linked to higher incidents of breast cancer in women and decreased sperm counts in men. An increase in developmental defects in humans is attributed to high levels of endocrine disruptors in the environment.

The endocrine disruptor concern is viewed by some as "unfounded hype" by a small group of researchers. In contrast, the issue has become an important focus for the EPA and international environmental agencies abroad. The prevalence of pollutants shown to have endocrine disruptor capability makes it an issue conservationists must address. Watersheds that feed into coral reefs are highly susceptible to the accumulation of endocrine disruptors.

This presentation will provide a synopsis of environmental endocrine disruptor research. It will show the status of epidemiological studies and laboratory research pertinent coral reef environmental quality. A brief lesson on the mode of action of endocrine disruptors will be presented as well as ample on-line references about endocrine disruptors.

## 18.625

**Patterns in Southeast Florida Coral Reef Community Composition**

**Melissa SATHE*[1]**, David GILLIAM[1], Richard DODGE[1], Louis FISHER[2]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]Broward County Environmental Protection Department, Plantation, FL, FL

The Southeast (SE) Florida coral reef system is the northern extension of the Florida reef tract. This high latitude system lies offshore a heavily populated and urbanized coast and therefore is affected by numerous environmental and anthropogenic stressors. Using annual monitoring data collected since 2000, the southeast Florida reef community was analyzed to investigate patterns in community composition as they relate to habitat and depth. All data was collected by SCUBA divers conducting 30m2 belt transect surveys at 24 sites offshore Broward County, SE Florida within a depth range of 6 to 18 meters. The 24 sites occur on five different reef habitat types: shallow colonized pavement, shallow ridge, linear inner reef, linear middle reef, and linear outer reef. Stony coral data included species colony size, density, diversity, percent cover, and mortality. Sponge and octocoral density were collected to gather a more complete picture of community composition. Multivariate analyses indicate that the reef community on the shallow ridge habitat statistically differs from the linear middle and outer reef communities. When comparing functional group densities, sponge density (versus stony coral and octocoral densities) is an important factor driving this difference with a higher density on the linear reef habitats. Specific species differences in stony coral cover and density were identified among reef habitats. The stony corals, *Montastraea cavernosa* and *Stephanocoenia intersepta*, are two important species contributing to differences among the reef habitats. Both species contribute more to stony coral cover and density on the linear middle and outer reefs than the shallow ridge habitat. A complete understanding of local reef community composition is crucial for optimizing restoration and overall management of the reef resources.

## 18.626

**In-Water Observation Of Immature Green (Chelonia Mydas) And Hawksbill (Eretmochelys Imbricate) Turtles in The Marine Environment Of St. Kitts, Lesser Antilles.**

**Maureen SULLIVAN*[1]**, **Raphaela STIMMELMAYR*[2]**, Vajai LATCHMAN[3]

[1]St.Kitts Reef Ecology Watchgroup, Basseterre, Saint Kitts and Nevis, [2]Ross University Veterinary School, Basseterre, Saint Kitts and Nevis, [3]Kenneth Dive Center, Basseterre, Saint Kitts and Nevis

St. Kitts is a significant nesting destination for hawksbill (Eretmochelys imbricata) and green turtles (Chelonia mydas). Year around sightings of immature hawksbill and green turtles suggest that local reefs and sea grass beds are important nursery areas for these species. As part of a larger marine ecosystem survey project (2006-2007), sightings of sea turtles have been recorded during roving snorkel (day), dive (night/day), and boat (day) surveys. Data collected includes species, estimated straight carapace length (cm), location, time of day, and their in-water behavior (resting, swimming, assisted resting, foraging, surfacing). At present, a total of 69 turtle sightings have been recorded. The majority of sea turtles sighted were immature with estimated carapace length 20-60 cm. Hawksbill turtles are predominant, with very few green turtles observed. Turtles engaged in assisted resting (n=14) were primarily observed during night (n=9) and afternoon (n=4) with only one morning observation; resting was observed primarily during morning (n=5) followed by afternoon (n=2), and one during the night; swimming (n=33) was observed on all time points (morning: n=15; night: n=12), but less often in the afternoon (n=6). Foraging was only observed once. Our preliminary results clearly indicate that St. Kitts' near shore environments are important nurseries for hawksbills. The observed difference in timing of specific in water turtle behavior is intriguing; however, more samples will be needed to see if the unequal distribution will hold. This is the first long-term in water assessment survey of sea turtles in St. Kitts. Sea turtle sighting data will be shared with REEF.org.

## 18.627

**Coral Reef Fishes in The Near Shore Marine Environment Of St. Kitts, Lesser Antilles.**

**Maureen SULLIVAN*[1]**, Gwen TOUZOT-JOURDE[2], Raphaela STIMMELMAYR[2]

[1]St.Kitts Reef Ecology Watchgroup, Basseterre, Saint Kitts and Nevis, [2]Ross University Veterinary School, Basseterre, Saint Kitts and Nevis

Healthy near shore marine environments are important for local tourism industry and artisanal fisheries. Agricultural runoff, soil erosion, over harvesting, boat anchoring, marine sewage treatment and extreme weather events can all have the potential to severely impact these fragile marine ecosystems. St. Kitts is facing numerous challenges to their coastal and near shore marine environment on the southeast peninsula due to marine resource harvests, tourism, commercial and residential development, environmental pollution, and natural disasters. As part of a larger marine ecosystem survey project, fish species and abundance were recorded during roving diver/snorkel surveys (n=100; 2006-2007). Coral reef fish community composition differ between different coral reef sites. For the majority of sites herbivores dominant the composition with few groupers present. The latter in particular hinds are intensively harvested by artisanal fisheries. This is the first comprehensive baseline study on coral reef fish diversity and abundance for the marine environment of St. Kitts. Data will be shared with REEF.org.

## 18.628

**Monitoring Activities in Kiribati 2006: Comparision Of Results With 2004 And 2005**

**Taratau KIRATA*[1]**, CAROLINE VIEUX[2], ERIC CLUA[3]

[1]Fisheries Department, Ministry of Fisheries, Tarawa, Kiribati, [2]SPREP, Apia, Samoa, [3]CRISP, SPC, Noumea, New Caledonia

The Republic of Kiribati is a group of three island groups scattered over 5,000,000 sq. km of ocean. The groups are the Gilberts, Line and Phoenix islands. Kiribati has a population of 92,428 in 2005. Coral reefs are usually atolls with islands surrounding the rim or islands with fringing reefs. A coral monitoring survey was conducted in 2004 where six sites were set-up as part of the Polynesia Mana Node for the GCRMN. The six sites are 1 on Abemama Atoll, 2 on Kuria Atoll and 3 on Tarawa Atoll.

During 2006, early and end of 2005 the sites on Tarawa were revisited for monitoring. These sites were located on North Tarawa, Teaoraereke and Hospital. Monitoring activities was conducted using digital camera for taking underwater pictures of a relatively flat and homogeneous outer reef slope. The pictures are analyzed using CPCe software. Comparison of 2004, 2005 and 2006 results revealed that there was no significant impact on bleaching to sites other than North Tarawa. Although, there is no significant variation to the global coral cover of the other two sites; there has been some significant variation in the coral composition. Its seems that the composition shifted to more tolerate species such as *Porites rus*, and may be the results of an adaptation to the natural disturbances experienced by Kiribati these past few years. New monitoring campaigns in these areas and other places of Kiribati are needed to provide more information on the phenomena and it's extend. Funding for these monitoring activities was available through Kiribati Fisheries Division, CRISP programme and SPREP.

## 18.630

**Singapore Coral Reefs – Status After 40 Years Of Extensive Coastal Development**

**Loke Ming CHOU*[1]**, Karenne TUN[1], Nigel GOH[2]

[1]Biological Sciences, National University of Singapore, Singapore, Singapore, [2]National Parks Board, Biodiversity Center, Singapore, Singapore

Singapore is a small island state with a population of over 4 million living in a land area of less than 700km2. Extensive land reclamation since the late 1960s increased the total land area by 20% to date. It is also one of the world's busiest ports and a major oil refining centre. Despite the extensive coastal development and modification and intensive use of the marine environment, its coral reefs appear to demonstrate some resilience in terms of biodiversity maintenance. Over 60% of its reef habitat is lost, with the remaining subjected to high sediment stress. Although reef area has been reduced, and population abundance decline is apparent, coral species extinctions are not evident. The status of Singapore reefs after 40 years of heavy anthropogenic impacts is examined and the long term future is discussed.

## 18.631

**Declining Coral Health and Fish Diversity in the Solomon Islands, Melanesia**

**Paul MCCURDY*[1]**, Abigail ALLING[2], Orla DOHERTY[2], Mary K OLDS[3], Kitty CURRIER[2], Heather LOGAN[2], Carol MILLNER[2], Paul MCCURDY[1]

[1]Planetary Coral Reef Foundation, Palmerston North, New Zealand, [2]Planetary Coral Reef Foundation, Pacific Palisades, CA, [3]Dustan Lab, College of Charleston, Charleston, SC

Coral reefs harbor ~1-9 million species, including 30% of all marine fish species. Reef health worldwide is declining due to many factors; e.g. pollution, sedimentation, dynamite fishing, and global warming. Using SCUBA, we examined coral health and fish diversity on Sagharughombe Reef, Solomon Islands in 2000, 2002 and 2006. Coral surveys from the studies indicated a significant decline in health over a six-year period. Fish surveys found no clear trend in species abundances and species richness but a significant decline in species diversity over the years. The decline in coral health we observed may have contributed to diminished fish diversity. Another study will be completed in January/February 2008 to monitor coral health and fish diversity trends. To protect marine biodiversity, coral reefs must be better protected and declines in coral health must be halted.

## 18.632

**Contribution Of Global Coral Reef Monitoring Programs in India**

**Krishnamoorthy VENKATARAMAN*[1]**

[1]National Biodiversity Authority, Chennai, India

The diversity of fauna and flora of coral reefs in India is depleting and degrading in terms of quantity and quality in a faster and unprecedented rate throughout India. People living along the coastal stretch of India depend on coral reef ecosystem for their livelihood. The major reef in India is restricted to the Gulf of Mannar, Gulf of Kachchh, Andaman and Nicobar and Lakshadweep Islands. Very little or no challenge is taken to alleviate the effect of human on coral reefs. The study on diversity and status of coral reef ecosystem are inadequate from many areas. Particularly, the status studies on coral reefs in India are only a decade old and this was just introduced by Global Coral Reef Monitoring Network (GCRMN) in 1997. Interestingly, the first status study on coral reef in India coincided with the 1998 bleaching event with out giving the scientists a chance to discern the past status quantitatively. Unexpectedly, this unprecedented bleaching has increased the dead coral cover to 70 + 10 % in some areas (Gulf of Mannar, Lakshadweep and Gulf of Kachchh). Post-bleaching surveys from 1999 to 2007 have shown very good recovery of coral reef fauna in some areas (Gulf of Mannar, Lakshadweep Islands) yet, exact status is not known till today due to lack of coordinated effort, inadequate trained scientific and management personnel and lack incentive for such effort as well as various other reasons of its own kind which is normally predictable for a country like India which is transforming in to a developing country. This paper deal with the how much is the contribution of global programmes on monitoring and where does India stand as well as what India requires for the support of coral reef conservation effort?

## 18.633

**Northern Acehnese Coral Reef And Reef Fish Status**

**Edi RUDI*[1]**, Yudi HERDIANA[2]

[1]Syiah Kuala University, Banda Aceh, Indonesia, [2]WCS Indonesia, Bogor, Indonesia

Northern Acehnese reefs, which are located in western Indonesia, are productive marine ecosystems that are important for the economies of local communities. The catastrophic tsunami in December 2004 affected local communities, and ways in which they utilized marine resources. Impacts on reef resources were patchy although limited data and information on coral reef condition before the tsunami has obviated the need for regular long-term coral reef monitoring to assess their recovery from tsunami impacts and from previous damage caused by destructive fishing and over fishing. The objectives of this study were to provide reliable data and information on benthic hard corals and reef fish in the northern Aceh region of Weh and Aceh islands. Using line intercept transects (LIT) and underwater visual census techniques (VCT) at 21 sites around Weh Island and Aceh Islands, we found that the mean coral reef cover in Weh Island was significantly higher (29.98%-fair condition) compared to Aceh Islands (10.76%-poor condition). Coral reefs at Rubiah Island, Sumur Tiga and Benteng that were protected under the management of Panglima Laot of Sabang were in the best condition. Reef fish abundance in Weh Island (32,505 no.ha$^{-1}$) and biomass (748 kg.ha$^{-1}$) were also significantly higher than in Aceh Islands (abundance = 9,539 no.ha$^{-1}$; biomass = 396 kg.ha$^{-1}$). Fish species from the family Pomacentridae (damsel fish) were highest in abundance and biomass.

## 18.634

**Macroalgal Distribution in A Mexican Caribbean Reef System: A Habitat Complexity Analysis**

**Ligia COLLADO-VIDES*[1]**, Alejandra PIÑON-GIMATE[2]

[1]Biology, Florida International University, Miami, FL, [2]Posgrado, Universidad Nacional Autónoma de México, Mazatlán, Sinaloa, Mexico

Coral reef systems are experiencing a drastic decline world-wide, leading to an increase of macroalgal abundance and a decline of coral and seagrass communities. Macroalgae are important components of coral reef and seagrass ecosystems, they play important roles both positive and negative. Algae inhabiting coral reefs and seagrass beds have a wide variety of forms that give different structural complexity to these habitats. In this study we use architectural and morphological traits to describe and compare the reef and lagoon macroalgal architectures and complexity. This study was conducted at Puerto Morelos reef in the Mexican Caribbean. Macroalgae were sampled in a stratified random sampling design, species were identified at the species level and several morphometirc features were recorded at each organism. A total of 119 species of macroalgae were found. Small size, erect highly branched and dense growth were more frequent in the reef compared to the lagoon where larger, erect, less branched and less dense algae with CaCO3 were found. Species found in both environments show intermediate values for the parameters analyzed. We found that macroalgae provided different levels of complexity at each environment; the scale of analysis was very important as these environments are highly heterogeneous with several layers giving different scales at which each macroalgal group affect complexity, therefore affecting organisms functioning at such scale of complexity. The increase of fleshy macroalgae has been shown to decrease the habitat complexity provided by coral structure, we highlight that the increase of only some macroalgae species will result in a loss of complexity provided by other macroalgae species affecting processes of settlement and recruitment of corals and fishes, and possible creating a positive feedback resulting in coral mortality and reducing resilience of the system.

## 18.635

**Some Ecological Studies On Investigator Reef, One Of The Spratly's Islands, Of The South China Sea.**

**Mohd Rajuddin MOHD KUSHAIRI*[1]**, Mohd Nasir SAADON[1], Kamarulzaman YUNUS[2]

[1]Universiti Industri Selangor, Malaysia, Shah Alam, Malaysia, [2]Universiti Islam Antarabangsa, Malaysia, Kuantan, Malaysia

The first ecological survey was carried out around Investigator Reef, a harsh island that has not been scientifically explored. In addition to a marvelous geomorphological feature it possessed, there are rich corals inhabiting the periphery of this island. A total of 12 families of corals, comprising of 30 genus had been recorded and a total of 79 species of coral fishes were found inhabiting the coral reef. These observations were made within the 20m depth water zone. These findings showed that this relatively small island supports a very rich coral reef ecosystem.

## 18.636

**Developing a Preliminary Index of Coral Reef Health**

**Jason HELYER*[1]**, Lesa MENG[1], James HELTSHE[2]

[1]Atlantic Ecology Division, U.S. Environmental Protection Agency, Narraganset, RI, [2]Atlantic Ecology Division, U.S. Environmental Protection Agency, Narragansett, RI

The development of multimetric indices to communicate ecological condition to resource managers and the public has numerous potential benefits for the management of coral reef ecosystems. We used existing coral reef monitoring data from the Atlantic and Gulf Rapid Reef Assessment (AGRRA) program to develop and evaluate a preliminary "Index of Coral Reef Health" for the Greater Antilles eco-region in the Caribbean Sea. Sites were designated as high or low impact based on predictions from "Reefs at Risk", an on-line GIS database containing information on human threats to coral reefs. Twelve candidate metrics were examined using a step-wise discriminant function (alpha: 0.05) to determine which metrics were most important in distinguishing between high and low impact sites. Three metrics, carnivorous fish density, percent abundance of crustose coralline algae, and coral diversity, were selected by the step-wise function, explaining 48% of the variance and resulting in a 15% error rate when compared to human impact classifications using a cross validation-procedure with discriminant analysis. When the index was calculated and compared to human impact classifications, the overall error rate increased to 16%. Problems encountered using a large-scale regional database to develop an "index of coral reef health" included natural variability of reef ecosystems over wide geographic ranges and evaluating levels of human impact, such as fishing and diving. We believe some of these problems will be reduced by focusing multimetric indices at smaller geographic regions and increasing effort on designating sites based on anthropogenic impact.

## 18.637

**Assessment of Marginal Reef Condition at Multiple Sites Using Coral Population Structure and Vitality**

**Simone OIGMAN-PSZCZOL*[1]**, Joel CREED[1]

[1]Ecologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

Rapid assessments of natural systems that may be quickly degrading are needed. The probable deterioration of a tourist region such is occurring at Armação dos Búzios, Brazil, calls for urgent determination of versatile and efficient methods for monitoring the state of marine benthic communities. By carrying out ecological assessments on eleven subtidal rocky reefs, under different human pressure, this study acquired baseline data on the percentage of cover of the stony corals and the density, colony size, partial mortality of the scleractinian corals *Mussismilia hispida* and *Siderastrea stellata*. *M. hispida* had a lower cover, lower density, greater mean colony size, more negative skewness, higher old mortality and lower recent mortality than *S. stellata*. The rapid assessment of these marginal reefs indicated that half of sites were in poor condition with a high percentage of partial mortality of the stony corals. *M. hispida* showed moderate-to-high levels of old mortality (>30%) at more than fifty percent of the sites of the sites and *S. stellata* showed high levels of recent mortality (>10%) at the majority of sites. Based on the results found and the different life histories of these two species, populations of *M. hispida* seemed to be in a critical state regarding their health and it does not seem likely that the situation will improve in a short term. *S. stellata,* although better adapted to a variable environment, also showed some evidence of mortality.

## 18.638

**Can Patterns in Benthic Communities Be Explained By A Site Specific Environmental Impact Index At A Marginal Reef Site in The Southwest Atlantic?**

**Simone OIGMAN-PSZCZOL*[1]**, Joel CREED[1]

[1]Ecologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

There are many studies which assess both biological and environmental impact approaches at once, but few analyses of biological and impact factors from multiple sites and multiples impacts at once have been carried out. The goal of our study was to quantify the major potential human impacts in the marine coastal zone of Búzios, Brazil; calculate a relative environmental impact index for eleven sites; and then compare the environmental impact index with community and population attributes. By carrying out ecological assessments at eleven subtidal rocky shores, the percentage of cover of the dominant benthic lifeforms; the density, colony size, partial mortality, and the associated fauna (barnacles, crabs and bivalves) inhabiting the living tissues of the two coral species, *Mussismilia hispida* and *Siderastrea stellata* were examined. The environment impact assessment comprised of collecting data in the field and from secondary sources. These data were used to generate a relative environmental impact index for each site. The analysis of human impacts to coral communities suggested that one-third of sites in Búzios are under high or very high proportional stress. One site (Ossos L) had the highest human pressure. The regression analysis indicated that sites with high human pressure had lower live cover and higher percentage of recent mortality and density of *S. stellata*. The corals proved to be good indicators of habitat degradation and the species *Siderastrea stellata* seemed to be the best indicator of the environmental state. The present study has implications for current concerns about environment degradation.

## 18.639

**The Distribution, Abundance And Volume Of The Barrel Sponge Xestospongia Muta At Selected Sites in The Florida Keys National Marine Sanctuary**

**Matthew BERTIN*[1]**, Michael CALLAHAN[1], Jennifer WHEATON[1]

[1]Fish and Wildlife Research Institute, Saint Petersburg, Florida, Saint Petersburg, FL

In 1994, the Florida Keys Coral Reef Evaluation Monitoring Project (CREMP) was initiated to provide status and trends data for the benthic reef resources of the Florida Keys National Marine Sanctuary (FKNMS). Forty sampling sites were selected within the FKNMS. Permanent station markers were installed in 1995 and annual sampling began in 1996. In 2007, an ongoing clionid sponge survey was expanded to include the barrel sponge *Xestospongia muta* in the survey at all CREMP monitoring stations.

*Xestospongia muta* sampling methodology was developed based on existing CREMP project station layout. Three 1-meter-wide belt transects provide the maximum spatial coverage within each station. A diver delineated the survey area by swimming directly above the tape holding a meter stick perpendicular to the tape and parallel to the reef surface for a total station survey area of approximately 66m2. The diver recorded the location and volume of each *X. muta* encountered as well as notes on bleaching, disease, and scleractinian interactions. Because of the morphological plasticity of this sponge, volume was measured by approximation to various geometric solids (Wulff 2001).

The distribution, abundance and volume of *X. muta* were analyzed sanctuary-wide, regionally and by habitat type for 103 sampling stations,. Sanctuary-wide, 89% of *X. muta* abundance and 93% of *X. muta* volume was observed at offshore deep sites. At offshore shallow and patch sites 6% and 5% of total abundance and 5% and 2% of total volume was recorded respectively. No *X. muta* was observed at any hardbottom site sanctuary-wide. At the region level, the Middle Keys had the greatest *X. muta* abundance and volume, although the largest average size of *X. muta* individuals was recorded in the Upper Keys.

## 18.640

**Examination Of Algal Diviersity And Benthic Community Structure At Palmyra Atoll, U.s. Line Islands**

**Cristi BRAUN*[1]**, Peter VROOM[2,3]

[1]University of Hawai'i, Windward Community College, Kaneohe, HI, [2]Joint Institute for Marine and Atmospheric Research, University of Hawai'i, Honolulu, HI, [3]Pacific Islands Fisheries Science Center (PIFSC), Coral Reef Ecosystem Division (CRED), Honolulu

Palmyra Atoll National Wildlife Refuge is located 1700 kilometers southwest of the Hawaiian Islands and is the second largest of 10 atolls under U.S. jurisdiction in the Pacific Ocean. Relatively little is known about algal diversity or community structure at Palmyra, with the most recent, comprehensive algal species lists dating from 1955 and 1966. As part of the National Oceanic and Atmospheric Administration, PIFSC, Coral Reef Ecosystem Division's mandate, rapid ecological assessment surveys are conducted biennially to monitor reef systems and gather baseline data for all U.S. jurisdiction Pacific reefs. In 2006, benthic cover and algal voucher specimens were collected from 13 sites at Palmyra Atoll. *Chondria*, *Microdictyon*, *Heterosiphonia*, *Halimeda*, and *Dasya* were among the 5 most common algal genera found and were recorded from over 75% of sampled sites. *Halimeda* and mixed turf algal assemblages were most prevalent in terms of benthic cover. A preliminary genus-level Cheney ratio of 15, which is above the 6.0 "tropical threshold" indicates a tropical flora, with diversity of Rhodophytes exceeding other algal groups. Algal diversity coupled with percent benthic cover analyses is allowing for greater understanding of overall algal community structure in this remote, protected ecosystem. The compilation of a comprehensive algal taxa list as baseline data will enable future studies to monitor algal community health, detect ecosystem change, and identify possible invasive exotics for management of this remote ecosystem.

## 18.641

**The Status Of Coral Reefs in The Eritrean Red Sea**

**Simon ZEREMARIAM*[1]**, Yassin MOHAMMUD[2], Philipos YEMANE[3], Amanuel GHEBRELUL[3], Yonas AFEWERKI[3]

[1]Eritrean Coastal, Marine and Island Biodiversity Conservation Project, Ministry of Fisheries, Massawa, Eritrea, [2]Eritrean Human Resource Development (HRD / MoF), Massawa, Eritrea, [3]Coastal and Island Management Division, Ministry of Fisheries (CMID/MoF), Massawa, Eritrea

In spite of the significant area coverage within the Red Sea, knowledge on Eritrea's marine and coral reef biodiversity is very limited. Since 2004, we surveyed the major substrate categories, selected reef fish families and indicator reef invertebrates in more than 100 reef sites distributed on inshore, midshore and offshore islands, in a north-south direction throughout the Eritrean Red Sea coast with the aim of assessing the biodiversity, community structure and status of the reefs. Survey results showed a considerable variation in the average live coral cover, ranging from 20 to 89%. Soft-coral cover, however, was low ranging in the average 0 – 20% but varying greatly within sites of the same reefs and between reefs of the same region. Analysis of similarities and multi-dimensional scaling has revealed that these variations become less prevalent with changes in latitude and with distance from the coast (i.e. inshore, mid-offshore, and offshore islands etc…). In general, reef sites within confined locations (in almost the same latitude) showed less variation in their coral cover, reef fish and invertebrate abundances. The abundance of most indicator reef fishes and invertebrates was moderate to good. Most of the reefs were healthy and free of any significant anthropogenic stresses. The findings revealed that the Eritrean Red Sea is among the least impacted coral reef areas in the world and, therefore, of global significance for coral reef conservation.

## 18.642

**Effect Of Sewage Pollution On Coral Reef Sponge Communities At The Western Side Of Havana City, Cuba.**

Zuleika MARCOS[1], **Alcolado PEDRO M.*[2]**

[1]None in this moment, Miami, Cuba, [2]Marine Ecosystems Department, Institute of Oceanology, Havana City, Cuba

Three groups of stations were distinguished according to the distance and position with regard to a submarine sewage outfall in the western Havana City as follows: a group of two stations near the outfall, very affected by pollution; a second one of two stations (Institute of Oceanology and Club Havana stations), slightly affected; and a third group including a comparatively less affected station. The species of sponges *Clathria venosa, Cliona delitrix* and *C. varians* were the main contributors to the differentiation of these groups (>5%). They were also the most abundant in number, next to *Scoplaina ruetzleri*, with prevalence in the most polluted stations, followed by *Iotrochota birotulata* form *typica* that was found fairly abundantly in the slightly affected stations. This study confirmed *C. venosa* as a consistent indicator of high organic pollution. *C. delitrix* was apparently indicative of moderately polluted places, while *S. ruetzleri,* being a eurytopic species, was not a consistent indicator. *C. varians* was not a clear indicator of the outfall effect. Species richness, heterogeneity (Shannon and Weaver's, index) and evenness (Pielou's index) were higher in less polluted. Contrary to great spatial differences, significant temporary differences were not observed in sponge community structure, composition and abundance. The possible favorable changes induced by the outfall built on 2000 were apparently very quick and maybe for that reason they could not be detected after 2002.

## 18.643

**Coral Community Structure Of The Bolinao Reef System, Northwest Philippines**

**Mark Windell VERGARA*[1]**, Wilfredo LICUANAN[2], Porfirio ALINO[1]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]Shields Marine Station, De La Salle University - Manila, Manila, Philippines

Reef-associated fishes account for 55% of the total fisheries catch of Bolinao and provide employment to 31% of the town's population. However, the condition of its reefs has deteriorated and has been considered as one of the most over fished areas in the country. Even though numerous works on coral research has been done in Bolinao - basic information on reef locations, species composition, live coral cover, zonation patterns and other simple reef descriptions has not been documented in detail since the first surveys. To address this, 50 randomly selected sites along Bolinao reef were surveyed using digital photo transects. Using a digital camera attached to a distance bar, photographs of 20m x 0.5m belt transects were taken at 3m depth intervals up to the depth where corals were no longer observed. Initial analysis showed that Bolinao reefs are very different from other Philippine reefs because they are dominated by the blue coral, Heliopora coerulea. Live hard coral cover rarely reached 25% in most sites, in sharp contrast to more than 40% recorded in the previous decades. Although the species list for the area is still being verified against the 1989 list of 275 species, some species previously found to be common were no longer observed (Nemenzophyllia turbida) or have been reduced to small patches (Acropora pulchra). Also, reefs on the eastern part of Bolinao were shallow (3-12m) and characterized by high sedimentation rates and high degrees of exposure to the NE monsoon. On the other hand, western reefs were deeper (up to 30m), had lower sedimentation rates and dominated by the SW monsoon. Differences in community assemblages and zonation patterns will be more evident once the complete survey data is ready for analysis.

## 18.644

**Changes To Macroalgal Species Communities in Shelf Edge Coral Reef Habitats in Southwest Puerto Rico**

**David BALLANTINE*[1]**, Hector RUIZ[1], Nilda APONTE[1]

[1]Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico

Macroalgal species presence and abundance (% cover) was studied in two shelf edge (19-22 m depth) coral reef habitats in Puerto Rico from 2003 through 2007. Cover and species presence were calculated by quantification of digital photographs taken of 0.0625 m2 permanent quadrats. Principal substratum occupying species included Heterokontophyta: *Dictyota* spp and *Lobophora variegata*; encusting calcified Rhodophyta: *Neogoniolithon accretum* and *Peyssonnelia* spp.; cyanobacteria: principally *Schizothrix* sp. and multispecies turf assemblages. Percent cover of dominant species was highly variable temporally, although the principal space dominating species remained the same, despite changes in their relative abundances. Periodic blooms of Cyanobacteria are a recent (since 2003) phenomena and have reoccurred regularly on a seasonal basis. Percent cover of algae in these deep coral reef habitats has steadily increased since 2003 through the present.

## 18.645

***acropora Palmata* Bleaching And Response Varied Across Benthic Zones At Buck Island Reef National Monument (St. Croix, Usvi) During The 2005 Bleaching Event**

**Ian LUNDGREN*[1]**, Zandy HILLIS-STARR[1]

[1]Buck Island Reef National Monument, National Park Service, Christiansted, Virgin Islands (U.S.)

Corals at Buck Island Reef National Monument, located north of St. Croix, USVI, experienced elevated sea surface temperatures in 2005, triggering a mass coral bleaching event. By monitoring three sites before, during, and after the event, National Park Service staff quantified the bleaching extent and the subsequent mortality of *Acropora palmata*. Back reef and forereef sites experienced almost double the mortality that the reef shelf site experienced. Additionally, the backreef site experienced bleaching impact first, followed by the forereef site and the reef shelf. The loss of approximately 66% of live *Acropora palmata* tissue on the back reef, 58% on the forereef, and 36% on the reef shelf is the most devastating loss of *Acropora palmata* at Buck Island Reef National Monument since the white-band disease outbreak of the 1970s. Given the recent listing of this species under the Endangered Species Act, managers might find this information useful to establish critical habitat, and to develop better monitoring protocol.

## 18.646

**The Lingering Consequences Of A Mass Coral Bleaching Event On *acropora Palmata*, At Buck Island Reef National Monument**

**Ian LUNDGREN*[1]**, Zandy HILLIS-STARR[1]

[1]Buck Island Reef National Monument, National Park Service, Christiansted, Virgin Islands (U.S.)

The realized impact of coral bleaching may be more extensive than previously thought. Secondary effects may cause lingering impacts to *Acropora palmata* corals that reverberate and cause continued mortality long after water temperatures cool. Elevated sea surface temperatures at Buck Island Reef National Monument, located north of St. Croix, USVI in 2005 triggered a mass coral bleaching event. National Park Service staff recorded trends of *Acropora palmata* bleaching, mortality, disease, predation, and physical breakage; before, during, and after the bleaching event. The pattern of these variables suggests a succession of interactions initiated by bleaching. Generally, bleaching was immediately followed by maximum breakage, then maximum disease, then maximum predation. As a consequence of these synergistic impacts, mortality remained consistently high for approximately one year after bleaching. These data support recent research that demonstrates how the complex physiological effects from coral bleaching can lead to considerable secondary ecological interactions within the reef community.

## 18.647

**Responses Of Coral Communities in The Florida Keys Following Multiple Stressor Events in 1997-1998**

**Deborah SANTAVY*[1]**, Erich MUELLER[2], Lauri MACLAUGHLIN[3], Esther PETERS[4], Robert QUARLES[1], Mace BARRON[1]

[1]US EPA, NHEERL, Gulf Ecology Division, Gulf Breeze, FL, [2]Perry Institute for Marine Science, Jupiter, FL, [3]NOAA, Florida Keys National Marine Sanctuary, Key Largo, FL, [4]Tetra Tech. Inc., Fairfax, VA

Coral reefs in South Florida have declined over the past 40 years and are projected to continue to deteriorate due to persistent and intermittent exposure to multiple chronic stressors. This study compared changes in the condition of mature colonies (≥ 10 cm) in two regions of South Florida from 1998-2002, following exposure to several large scale disturbances including Hurricane Georges and massive coral bleaching. Coral abundance, diversity measures, disease, and bleaching prevalence on reefs near the remote off-shore islands of the Dry Tortugas were compared to reefs near Key West characterized by higher population density and greater anthropogenic influences. Initially in the spring of 1998, Key West and Dry Tortugas reefs were similar in abundance, species richness, evenness, diversity, dominance, and prevalence of disease at the locations sampled. Prevalence of coral bleaching and disease significantly increased on reefs in both regions during the 1998 summer El Niño event, with Key West reefs exhibiting the greatest prevalence and severity of coral bleaching and disease. Coral abundance significantly decreased in 1998 in both regions, but remained lower only at Key West reefs during the study. The greatest reef degradation occurred after increased sea temperatures led to elevated coral bleaching and disease prior to Hurricane Georges. Acroporids declined near Key West from 45 colonies/site (spring 1998) to ≤4 colonies (2002), whereas Dry Tortugas acroporids initially declined but recovered within 5 years. Key West reefs presumptively lost critical community properties such as regenerative capacity provided by the affected species, as indicated by their inability to recover or return to original conditions. In contrast, Dry Tortugas reefs resisted major changes and maintained coral community properties necessary to persist and regenerate in the presence of similar disturbances.

## 18.648

**Reproductive Failure in *Acropora palmata*, a Threatened Caribbean Coral**

**Dana E. WILLIAMS*[1,2]**, Margaret W. MILLER[3], K. Lindsey KRAMER[4], Abel VALDIVIA[1,2]

[1]Cooperative Institute of Marine and Atmospheric Studies, University of Miami Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [2]Southeast Fisheries Science Center, NOAA Fisheries, Miami, [3]Southeast Fisheries Science Center, NOAA Fisheries, Miami, FL, [4]Pacific Island Network, Inventory & Monitoring, National Park Service, Kona, HI

*Acropora palmata* is thought to be well adapted to survive and even proliferate through fragmentation during physical disturbances such as moderate intensity hurricanes. Since 2004, approximately 200 randomly selected tagged colonies of *A. palmata* and 2250m2 of reef benthos have been monitored in fifteen fixed study plots in the upper Florida Keys (USA). Between July and October 2005, 4 hurricanes passed by this region, producing maximum wind speeds on the reef tract of 44 to 65kts. Surveys of study plots following the storms documented an average loss of more than half of the estimated live tissue area since the initial survey in 2004. The percentage of the population classified as 'branching' colonies decreased from 69% to 39% while 'remnant'-type colonies (isolated patches of tissue on standing skeleton) increased from 10% to 33%. Although some lost branches were present as loose fragments, within 3 weeks after Hurricane Dennis more than 70% of the 380 fragments observed in the study plots were dead or rapidly losing tissue. To date, only 27 fragments attached to the substrate, forming successful asexual recruits. Moreover, of the 18 new small encrusting colonies that were observed in the study plots, only 2 were not attributable to asexual origin (i.e. remnant tissue patches from colonies or fragments previously observed) and therefore are possible sexual recruits. In sum, only 2 potential sexual recruits have appeared in the 3 year span of this study and the 2005 hurricane season resulted in a substantial loss of *A. palmata* from a combination of physical removal and disease-like tissue mortality and few asexual recruits. Furthermore the asexual and sexual fecundity of the remaining population is compromised for the near future due to lack of branches (i.e. 'asexual fecundity') and overall loss of live tissue.

## 18.649

**The Effects of Increased Seawater Temperature upon Butterflyfishes (Family: Chaetodontidae) at the Satsuma Peninsula, Southern Japan**

**Daisuke NASHIKI*[1]**, Satoshi NOJIMA[2], Sekio SHINAGAWA[3], Noritaka MOCHIOKA[1], Shigeo KAWAGUCHI[1], Akinobu NAKAZONO[4]

[1]Faculty of Agriculture, Kyushu University, Fukuoka, Japan, [2]Amakusa Marine Biological Laboratory, Graduate School of Sciences, Kyushu University, Amakusa, Japan, [3]Nutritional and Health, Shimonoseki Junior College, Shimonoseki, Japan, [4]Kyushu University, Fukutsu, Japan

Satsuma Peninsula, which is influenced by the seasonally warm waters of the Kuroshio Current, is located about 70km north of the northern limit of coral reefs in Japanease waters. Many butterflyfishes are seasonal in that they fail to survive lower water temperatures that occur during winter. Recently, the average seawater temperature of the Kuroshio Current has been rising. If seawater temperatures keep rising, butterflyfishes will likely over-winter and reproduce. Habitat structure is important, as well. Many butterflyfish species display preferences for habitat, especially corals. The purpose of this study was to determine the relationship between butterflyfish assemblage structure and coral cover to determine if favorable habitat exists that could be utilized while over-wintering should seawater temperature increase. Underwater video surveys were conducted at 27 stations in September, 2006. From this footage, fish species richness and abundance were estimated. Coral cover was estimated also and partitioned into six categories based upon structural features. The communities at each site were clustered into three groups using ordination and fuzzy *c*-means method based on the similarity of species composition between sites. Fish species were clustered also by the same method into three groups. A significant relationship between one species group and coral cover was found for some structural categories, thus indicating that favorable habitat to butterflyfishes existed. The size of individuals included in this group were mostly small less than 6cm in total length (TL), with one individual only exceeding 10cm TL. This indicated that most individuals had been transported north by the Kuroshio Current within the same year and had not over-wintered, but that over-wintering is possible. If seawater temperatures in winter keep rising, these fishes may over-winter because favorable habitat exists.

## 18.650

**Small-Scale Variations in The Effects Of Coral Bleaching in Rodrigues**

**Emily HARDMAN*[1]**, Nathalie STAMPFLI[2], Jules THOMA[3], Sydney PERRINE[1]

[1]Shoals Rodrigues, Rodrigues, Mauritius, [2]Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, Zurich, Switzerland, [3]School of Ocean Sciences, University of Wales Bangor, Anglesey, United Kingdom

Rodrigues was one of the few reef locations in the Western Indian Ocean to escape the mass coral bleaching event of 1997 – 1998, however shallow reef sites suffered from coral bleaching during 2002, 2005 and 2007. In all years, there were small-scale spatial variations in the severity of bleaching and associated mortality. In 2002 and 2005, bleaching was most severe at the northern reef flat sites with mortality occurring at depths of 0.5 - 2m. In contrast, in 2007 bleaching-induced mortality severely affected one patch reef in the southern lagoon, although nearby reefs (<1km away) were not affected. Temperature data indicate small-scale variations in sea temperature around the lagoon and current data suggest that bleaching tended to occur at sites with the lowest current speeds. Recovery of sites from bleaching also showed small-sale spatial variations. Inshore sites, displayed limited recovery to the beaching events and sites are now dominated by turf algae (>60%) with low live coral cover (<15%) and low numbers of new coral recruits. In contrast, at sites further offshore live coral cover has increased and the sites are dominated by coralline algae with high numbers of coral recruits. This variation in recovery is likely to be due to the proximity to land and increased human impacts such as greater fishing pressure leading to removal of herbivorous fish and increased nutrient and sediment run-off. These additional impacts, combined with high numbers of bio-eroding urchins suggest that if coral bleaching events continue to occur on a regular basis then these inshore reefs could become overgrown by algae and their structural complexity eroded. Rodrigues is a small, isolated island with a limited coral larval supply and such a scenario would leave the island vulnerable to coastal flooding and storm damage.

## 18.651

**Monitoring, Conservation And Future Of Reefs Of India**

**Satyanarayana CHOWDULA*[1]**, Rama KRISHNA[1], Muley E.V. [2]

[1]Zoological Survey of India, Kolkata, India, [2]Ministry of Environment and Forests, New Delhi, India

Rich and varied reefs of India are being studied, well before the first International Coral Reef Symposium was held on the banks of Mandapam in 1969. Reef scientists in India changed gears to pace with the need to protect the reefs. Efforts multiplied, many MPAs in reef areas to halt the degradation and conserve reefs. Yet, the fool-proof blue print is not ready owing to the intriguing site specific anthropogenic threats and also due to interfering new mass destructive threats like coral bleaching and tsunami. Socio-economic and bio-physical monitoring carried out in all the major reef regions of India since 1994 with the updated knowledge through GCRMN gave chance to peep through the gaping holes, identify lacunae, assess true status and prepare an effective conservation strategy. Results include discovery of hidden cancerous middlemen menace, tricky unabated exploitation blinding law enforcing agencies, weaknesses in law enforcement, lack of coordination among operating agencies, lack of awareness among key stakeholders, non-standardised scientific pursuits etc. Bio-physical monitoring results at selected sites during the study period exposes two-way despair to aspire results. Mainland reefs, Gulf of Mannar and Gulf of Kutch are much diverse than expected. Unfortunately, showing losing trend in resilience due to developmental activities. The continental reefs, Andaman & Nicobar which are the best in the Indian Ocean region proved to escape bleaching are subjected to the unexpected assault by the giant Tsunami. Exceptional oceanic atoll reefs of Lakshadweep with managed anthropogenic pressure became a target to recurring bleaching events and showing resilience. A fool-proof protective shield to protect the Indian reefs prepared and the future of the Indian reefs discussed in light of the lacunae discovered from the socio-economic and bio-physical monitoring surveys carried out in the past 14 years.

## 18.652

**Status And Trends Of Colombian Caribbean Coral Reefs**

**Alberto RODRÍGUEZ-RAMÍREZ*[1]**, María Catalina REYES-NIVIA[2], Sven ZEA[1,3], Raúl NAVAS-CAMACHO[1], Sonia BEJARANO[4], Diego L. GIL-AGUDELO[1], Jaime GARZÓN-FERREIRA[1], Nacor BOLAÑOS[5], Alfredo ABRIL[5]

[1]Programa Biodiversidad y Ecosistemas Marinos, Instituto de Investigaciones Marinas y Costeras INVEMAR, Santa Marta, Colombia, [2]Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, Amsterdam, Netherlands, [3]Departamento de Biología y Centro de Estudios en Ciencias del Mar-CECIMAR, Universidad Nacional de Colombia, Santa Marta, Colombia, [4]University of Exeter, Exeter, United Kingdom, [5]CORALINA, San Andrés, Colombia

Six reef areas of the Colombian Caribbean have been monitored annually since 1998, to provide a long-term data base for assessing their dynamics. For each area, two or three reefs (plots) at two or three depth levels were assessed using permanent chain transects (10 m). Overall means indicate that the algae were the most abundant biotic component for the majority of the areas, covering from 30.3 % (Rosario) and 53.3 % (San Andrés). Live coral cover fluctuated considerably, from 10.1 % (Santa Marta) to up to 43.5 % (Urabá). Temporal trends in coral cover were evaluated by repeated measures ANOVA. The model included the effect of depth levels (fixed effect), plots as a nested factor within depths (random effect), and time (repeated factor). Only the Tayrona area showed a significant interaction time x reef(depth). In plots in which significant declines in coral cover were detected, most constituting species did not necessarily follow the overall trend. Only few species such as *Siderastrea siderea* and *Acropora palmata* at a shallow plot, and *Montastraea cavernosa* at two deep plots showed significant decreases. The changes were in part related to the impact of hurricane Lenny in 1999 whilst the remaining decreasing trends were unexplained. These findings indicate that the recent declines in coral cover have occurred at both plots and species levels, suggesting differential responses of corals to current stressor factors. Hence, monitoring programs should be focus on coral resistance and resilience, in order to find key answers for mitigating coral reefs decline and enhancing coral recovery in the current context of climate change.

## 18.653

**Socioeconomic Baseline Report of U.S. Territories and Counties Adjacent to Coral Reef Habitats**

**Steve ROHMANN*[1]**, Kristen CROSSETT[1], Christopher CLEMENT[1]

[1]NOAA, Silver Spring, MD

Managers of U.S. coral reef jurisdictions have recognized the need to collect socioeconomic data for communities near coral reef areas. This information is vital to understanding human dependence and impact on valuable coral reef resources. Most reef managers in U.S. jurisdictions are aware that census data are available, but they lack the time or capacity to collect the data and construct socioeconomic profiles. To meet this need, this project will develop a socioeconomic baseline report for all U.S. territories and counties adjacent to coral reef habitat, including the U.S. Virgin Islands, Puerto Rico, the Florida Keys and southeast Florida, Hawaii, Guam, the Northern Marianas, and American Samoa. The report will include a time series analysis of demographic and housing and development change from 1990 to 2000 and population projections to 2015. Maps depicting these changes will be included. The report will provide a foundation of data that coral managers, local officials, the media, and the general public can draw upon for planning and management purposes.

## 18.654

**Trends in Reef Recovery in Mafia Island Marine Park, Tanzania**

**Haji MAHINGIKA*[1,2]**

[1]Research and Monitoring., Mafia Island Marine Park.Tanzania, Coast Region., Tanzania, [2]Research and Monitoring., Mafia Island Marine Park., Coast Region, Tanzania

The establishment of Mafia Island Marine Park (MIMP) in 1995 opened a new strategy in the conservation of Tanzania Coastal Environment for Coral reefs. Following the 1998 El Nino phenomenon, coral reefs in MIMP were adversely affected. Therefore, coral monitoring was initiated at four sites within MIMP (Utumbi, Milimani, Kitutia and Juani). Monitoring was done biannually from 1999 to 2005 aimed at assessing coral recovery by using Line Intercept Transect. The results showed that recovery of hard corals increased from 15% to 25% and 30% to 43% from 1999 to 2005 for Kitutia and Utumbi sites respectively. Recovery for Milimani and Juani did not significantly improve, probably due characterized high wave and current energy, especially in Juani. This implies that faster recovery in Milimani and Juani could be improved through coral transplantation and/or removal of fleshy algae. Information generated from this study will be useful for conservation and management of coral reef and other associated coastal ecosystems (e.g., mangroves, sea grass beds, etc) for sustainable utilization of marine resources. Environmental parameters such as seawater temperature, tidal currents (water movement patterns), sedimentation and turbidity, rainfall, etc. are also very important and should be monitored as well as correlated with reef benthic monitoring results in explaining biological population dynamics, so as to pinpoint the real cause of changes as still unclear why coral reefs in Kitutia suffered more mortality after the 1998 coral bleaching event.

*Corresponding author: Email: ngika47@yahoo.com; Tel.: +255-784-567272.

## 18.656

**An Assessment Of Chemical Contaminants in The Nearshore Waters Of Vieques, Puerto Rico**

**Andrew MASON*[1]**

[1]NOAA, Silver Spring, MD

The island of Vieques lies approximately 11 km southeast of the main island of Puerto Rico. Beginning in the 1940s and ending in 2003, portions of Vieques were used by the U.S. Navy for the storage and firing of munitions for training purposes. With the departure of the Navy, these areas have now been transformed into the Vieques National Wildlife Refuge operated by the U.S. Fish and Wildlife Service (USFWS). As part of the restoration activities, NOAA's National Centers for Coastal Ocean Science and the Office of Response and Restoration, in cooperation with the USFWS and the U.S. Navy, are conducting an ecological assessment of the nearshore waters of Vieques. The assessment includes the quantification of chemical contaminants in sediments and coral tissues, along with a characterization of coral, algal, fish and macro-invertebrate community structure. To assess chemical contaminants, a stratified random design was used to sample sediments along with tissues of the coral Porites astreoides. Approximately 140 chemical contaminants, including both organic (e.g., polycyclic aromatic hydrocarbons or PAHs, PCBs and pesticides) and inorganic (e.g., trace elements or metals) contaminants are being characterized in both sediments and coral tissues. Residues of energetics (i.e., explosives) are also being analyzed in the sediments. In addition to quantifying contaminant levels, an important goal of the integrated assessment is to determine linkages between contaminant concentrations and indices of coral ecosystem condition (e.g., coral community structure).

## 18.657

**Status Of Coral Reef Ecosystems in Marine Managed Areas in St. Croix, Usvi**

**Sarah HILE*[1]**, Chris JEFFREY[1], Simon PITTMAN[2], Chris CALDOW[1], Mark MONACO[1]

[1]CCMA Biogeography Branch, NOAA, Silver Spring, MD, [2]CCMA Biogeography Branch, NOAA, St. Thomas, Virgin Islands (U.S.)

This poster presents information on the status and trends of coral reef ecosystems in St. Croix, US Virgin Islands (USVI) based on data collected between 2001 and 2006 at 1,275 random locations sampled in and around Buck Island Reef National Monument (BIRNM). Sites were surveyed using a linear belt-transect (100m2) to assess reef fish assemblages and a 1m2 quadrat to characterize benthic communties. Fish assemblages were dominated by herbivorous fishes, with *Halichoeres bivittatus* (73.2%), *Thalassoma bifasciatum* (60.9%), *Acanthurus bahianus* (59.8%) and *Sparisoma aurofrenatum* (52.5%) being the most commonly observed species. Densities of large predators such as the commercially important groupers (*Cephalopholis*, *Epinephelus* and *Mycteroperca*) were low. The lowest densities of grouper were seen in 2001 (approximately 1 fish per 100 m2) and the highest were observed in March 2003 (3 ± 1 grouper per 100 m2). *C. fulvus* was the most common grouper species seen for all years and were larger than the known size of sexual maturity. Fewer *E. gutattus* were observed, and only one juvenile *E. striatus* was encountered during April 2006. Data from benthic surveys show that colonized hardbottom habitats across the study region were generally dominated by algae (turf algae, macroalgae and crustose coraline algae). Live scleractinian coral cover was 5.6% (± 0.5%). The three most abundant coral species groups were *Montastraea* spp., *Porites* spp. and *Diploria* spp. During October 2005, bleaching was observed in 22 species of hard corals at BIRNM and was recorded at 91 of 94 sites with an estimated 53% of the coral cover bleached. The results presented here reflect patterns and trends in coral reef ecosystems observed by other monitoring programs in the US Caribbean.

## 18.658

**"Changing Times, Changing Reefs" A 10 Year Review Of Changes On Coral Cover, Dead Coral/algae And Community Structure in The Bloody Bay-Jackson Point Marine Park, Little Cayman, Cayman Islands, Bwi**

**Croy MCCOY*[1]**

[1]Dept. Of Environment, Cayman Islands Govt., Georgetown, Cayman Islands

We studied local (<5 km) coral reef dynamics in the isolated, highly regulated and Managed, Bloody Bay-Jackson Point Marine Park, Little Cayman, Cayman Islands, BWI, in order to evaluate changes in Live coral cover, dead-coral/algae and community structure over the past decade. The study was carried out at four sites within the MPA: The Meadows (TM), Eagle Ray Wall (ER), Three Fathom Wall (TFW) and Randy's Gazebo (RG). These sites were selected in order to incorporate multiple terrace reef locations, and to include areas broadly representative of the marine park's coral cover, biodiversity and geomorphology. Surveys were carried out in November 1997, 1999, 2000, February 2004 and February 2007. A repeated permanent photo-quadrat method was used along a 50 m transect, yielding 10 stations and 20 images, each covering 2.6 m² for a total of 52 m² worth of images per site. Images were further analyzed to quantify changes over time. Image analysis shows that live coral cover declined at all sites between 1997 and 1999, then remained stable between 1999 through to 2004. We further documented another decline in mean coral cover at all sites between the 2004 and 2007 surveys. Overall, percent dead coral and algal cover increased between 1997 and 1999, but then stabilized between 1999 and 2004. However, two sites (TM & ER) showed a further increase in dead coral and algal cover during the February 2007 survey. We note that that algal abundance was high at the start of the study at all sites, with some sites exhibiting >50% cover. Results from this study provided evidence for a phase shift from a coral-dominated to an algal-dominated reef environment, an event which was probably already in progress prior to the commencement of this study.

## 18.659

**Baseline Assessments Of Coral Communities At Wake Atoll Before And After Supertyphoon Ioke**

**Jacob ASHER*[1,2]**, Susan VOGT[1,2], Jean KENYON[1,2], Bernardo VARGAS-ANGEL[1,2]

[1]The National Oceanic and Atmospheric Administration (NOAA), Pacific Islands Fisheries Science Center, Coral Reef Ecosystem Division, Honolulu, HI, [2]Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu

As part of the Pacific Reef Assessment and Monitoring Program (RAMP), the Coral Reef Ecosystem Division of NOAA's Pacific Islands Fisheries Science Center completed the first comprehensive coral reef ecosystem assessment surveys of Wake Atoll in October 2005 using a combination of 19 towed-diver surveys covering 35 hectares, and 13 site-specific Rapid Ecological Assessment (REA) surveys covering ~0.6 hectares. In August 2006, the category 5 Supertyphoon Ioke passed directly over Wake Atoll. Surprisingly, subsequent Pacific RAMP monitoring surveys in April/May 2007 found that the observed underwater effects were comparatively small and site-specific. Percent cover estimates by towed divers indicated that mean live scleractinian coral cover decreased from 32% in 2005 to 19% in 2007, and mean octocoral cover decreased from 15% in 2005 to 9% in 2007. However, there were no clear indications of large-scale coral destruction. Though several large *Porites* colonies along the eastern shore appeared to have been dislodged and toppled to depths of ~35 meters, these effects were localized to a single towed-diver survey segment covering ~0.27 hectares. Percent cover by scleractinians and octocorals at 12 forereef sites resurveyed in 2007 indicated a general, though statistically nonsignificant decline in coral cover, with the largest decline (average > 37%) noted at three sites in the northwest, north, and east compared to an average decline of 2.7% at the remaining nine sites. An extensive, blanketing cyanobacteria bloom was observed in 2007 during both towed-diver and REA surveys completed near the harbor entrance and at the shipwreck remains of the R.C. Stoner that was not observed in 2005. It is not known whether the bloom was caused by the typhoon (e.g., flushing of nutrients from the nearby harbor entrance, disturbance of shipwreck remains) or some other underlying mechanisms.

## 18.660

**Effects Of Sewage Effluent On Benthic Composition And Fish Assemblage in A Pacific Tropical Lagoonal System**

**Lucy HARRISON*[1]**, Clarissa BEARDEN[2], Peter HOUK[2], Michelle PADDACK[1], Isabelle COTE[1]

[1]Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada, [2]CNMI Division of Environmental Quality, Saipan, Northern Mariana Islands

Eutrophication can negatively impact fish and benthic community composition, yet our understanding of the spatial extent of pollution impacts on reefs at varying distances from point sources is not well known. We investigated the effects of sewage effluent on benthic community composition and fish assemblage structure at sites with increasing distance from a sewage outfall source in a tropical lagoonal environment, Tanapag Lagoon, Saipan, Northern Mariana Islands. Data for enterococci levels in nearshore marine environments were obtained from a 5-year monitoring database of weekly surveys provided by the Division of Environmental Quality in Saipan. Enteroccocci levels were high near the sewage outfall and decreased in a gradient in either direction away from this point. Data on benthic and fish community structure were collected from nearshore lagoonal reefs at 10 sites along this gradient in 2006. Multivariate analyses were conducted to examine whether community composition and fish assemblage varied along this gradient, and whether this variation was correlated with enteroccocci levels. Enterococci levels were found to be a good indicator of sewage inputs into a system as they were detected at biologically significant levels away from the source. Sewage was found to impact benthic community composition. Lagoonal reefs are important nursery habitats for a number of reef fish species and may also provide refugia of bleaching for corals; therefore it is important that terrestrial impacts upon these systems be understood. Results presented support the use of enterococci levels to indicate the extent of marine pollution from anthropogenic sources for coastal communities that monitor enterococci levels regularly (i.e. those involved in the US EPA's Beaches Environmental Assessment, Closure, and Health Program).

## 18.661

**Recent Coral Bleaching Around The Yaeyama Islands in The Ryukyus**

**Takanori SATOH*[1]**, Tomoyo KOBAYASHI[1,2], HAJIME HIROSAWA[1], Mai YAMAMOTO[1]

[1]International Coral Reef Research and Monitoring Center, Ministry of the Environment, Ishigaki, Japan, [2]IDEA Consultants, Inc, Setagaya, Japan

The Yaeyama Islands, including Ishigaki Island and Sekisei Lagoon, is said as one of the most valuable coral reef in the world because this region grows numerous species of corals, over 360 species having been identified.

From the 1970s to the 1980s, the coral reefs of Japan suffered serious damage from outbreak of crown-of-thorns starfish. After that time, the coral reefs gradually recoverd, but they again suffered serious damage from coral bleaching in 1998, which was thought to be caused by an unusual rise in the seawater temperature. At the same time, anthropogenic disturbances such as the red-soil run-off from land development and sewage drove the coral reefs further into a critical state. To conserve the coral reefs, various environmental factors affecting the coral reefs have to be studied, and people fs serious challenge to this problem is required.

In order to promote Global Coral Reef Monitoring Network (GCRMN), The Ministry of the Environment of Japan established gInternational Coral Reef Research and Monitoring Center h in Ishigaki Island. Based on the Center, we have started monitoring to know the present situation around coral reefs around the Yaeyama Islands. All monitoring data has been incorporated and analyzed in a GIS for coral reef management. This monitoring revealed the current state of the coral reefs that suffered seriously from the bleaching in 1998.

We will present recent coral bleaching after 1998, and changes in distribution and relative abundance of corals around the Yaeyama Islands in the Ryukyus.

## 18.662

**Coral Reefs in Singapore: An Assessment Of Their Status And Recommendations For Future Work**

**Jeffrey LOW*[1]**, Robin NGIAM[1], Rachel LIM[1], Loke Ming CHOU[2]

[1]Biodiversity Centre, National Parks Board, Singapore, Singapore, [2]Department of Biological Sciences, National University of Singapore, Singapore, Singapore

Singapore is a small island nation that has seen rapid economic growth since its independence in 1965. Its economic success, however, has come at a cost to the marine environment. More than 50% of its coral reefs have been lost to reclamation and development, and the health of the remaining reefs subjected to sedimentation impact. In spite of development pressures, the reefs have shown a remarkable degree of resilience and interesting observations are still documented. For example, up to 258 (up from 200) species of scleractinian corals were recorded in a recent review, and on-going studies on sponges, gobies and scorpionids will undoubtedly reveal more species.

While much of the work is still conducted independently by separate research groups, there is a trend towards co-operation and pooling of resources in the conservation of this natural resource. Individuals, non-governmental organisations and government agencies are developing rational, science-based programmes that attempt to balance the need for development to sustain Singapore's economic growth with the conservation of this natural heritage.

This paper charts the progress made in marine conservation since the 1980s, and recommends some areas of work that future studies should focus on.

## 18.663

**Riverine Run-Off Threaten Shallow Coral Reef On Lankayan Island, Sabah Malaysia**

**Fung Chen CHUNG*[1]**, Annadel Salvio CABANBAN[2]

[1]Reef Guardian Sdn Bhd, Sandakan, Malaysia, [2]WWF -Malaysia, Sabah, Malaysia

With climatic changes, bringing more rainfall that caused flooding on the mainland and lead to river run-off containing sediments and pollutants outflow to shallow coral reef on Lankayan Island. Reported here mass mortality of reef flat on Lankayan Island followed continuous rainfall on Sandakan Sabah from 2-15 January 2007. Mean water salinity was recorded low 25.4 ppt (SD 3.503, max 29.5 ppt, min 17.5, n = 41) compared to usual. The water was recorded greenish to brownish. The death of the corals, sea cucumbers and giant clams were observed after day 12.The event greatly reduced coral cover on the shallow reef range 0.5-4m. Mean percentage of hard coral cover reduced to 33% (SD= 21, n=49, range 2-77%). Most affected was at the southern of the island in which the *Acropora sp.* were the most recorded dead and *Porites sp.* were less affected. Observation indicated that increasing of development along the coastline particularly involving wetland clearing for agriculture, increasing use of chemicals and discharging of high nutrient sewage effluents from mills will be another threat to coral reefs along the coast in Sabah.

## 18.664

**Algal Takeover in The Coral Reefs Of Eilat (Gulf Of Aqaba, Red Sea): A Disregarded Sign Of Reef Degradation**

**Karnit BAHARTAN*[1]**, Mohammad ZIBDAH[2], Yousef AHMED[2], Alvaro ISRAEL[3], Avigdor ABELSON[1]

[1]Zoology, Tel-Aviv University, Tel-Aviv, Israel, [2]Marine Science station, Aqaba, Jordan, [3]Israel Ocheanographic and Limnological Research, Haifa, Israel

The decrease in coral live cover and extensive degradation of coral reefs is often paralleled by the proliferation of macro-algae, commonly termed a "phase shift". The Eilat coral reefs in the Gulf of Aqaba (Red Sea) serve as a prominent example of reefs that are covered by dense mats of turf algae. Despite the proliferation and potential adverse effects of turf algae, the condition of the Eilat reefs is controversial, with researchers disputing the exact state of health and potential causes of degradation. The aim of the present study was to assess spatio-temporal distribution patterns of algae in the Eilat reefs, and to examine coral-algal dynamics as a potential indicator of reef health. The community structure of stony corals and algae was studied at six sites along the Eilat and Aqaba coasts. Algal cover was found as a stable, non-seasonal array of filamentous perennial species. Our observations revealed a widespread occurrence of turf algae and algal dominancy in the Eilat reefs (up to 72%); whereas the algal cover in Aqaba reefs was significantly lower (up to 6%). The proliferation of algae in several locations along the Red Sea should serve as a warning sign of coral reef degradation, and deserves further research into the exact causes as well as sound countermeasures. Nonetheless, the negative correlation between turf and coralline algae, as well as the negative effects of turf on corals, suggest that turf algae should be considered as an important indicator of the state of coral reefs.

## 18.665

**Recovery Patterns in A Mediterranean Gorgonian Following Repeated Mortality Events**

**Roberta CUPIDO*[1]**, Silvia COCITO[1], Andrea PEIRANO[1], Sergio SGORBINI[1]

[1]Enea - Marine Environmental Research Centre, La Spezia, Italy

Repeated mortality events greatly affected a dense, well structured population of the Mediterranean gorgonian *Paramuricea clavata* in concomitance with water warming in the Gulf of La Spezia (NW Mediterranean). In 2004, after two mortality events (1999 and 2003), more than 74% of all colonies were completely dead and about 22% showed some damage. Damaged colonies presented a bare axis rapidly colonised by pioneering organisms. In order to estimate the recover capability of this *P. clavata* population, a total of 30 damaged colonies were marked and monitored photographically from 2005 to 2007. Digitised slide images were analysed by image analysis software *Sigmascan* TM. Total Living Branch Length (TLBL) of each colony, mean growth rate of primary branches (terminal branches), regeneration and loss of living tissue, production of new branches were calculated. During monitoring period, because of new mortality events, some marked colonies died and were substituted with new ones. In total we monitored 372 primary branches. Except for loss of living tissue that was never observed, all registered parameters showed a positive trend overtime. After two years TLBL exceeds the initial value in all colonies. While growth rate of primary branches was high (1.7 ± 0.2 cm y-1) if compared with literature, production of new branches was extremely variable (5-42 branches col-1). Colonies survived to the new mortality events showed a good ability to regenerate loss tissue, even if highly variable (between 60 and 100% of injured surface). Breakage of branches that did not recover occurred in 90 % of the colonies. In spite of the slow growing and low turnover of the species, *P. clavata* population showed high growth rate and a good ability to regenerate tissue. These patterns of recovery represent valuable strategies to face mortality events.

## 18.666

**Assessing Land Based Inputs To The Coastal Waters Of Broward County, Florida, Usa**

**Nancy CRAIG*[1]**, Nancy GASSMAN[1], Kenneth BANKS[2], Kevin CARTER[1]

[1]Broward County Environmental Protection Department, Davie, FL, [2]Broward County Environmental Protection Department, Plantation, FL

In December 2005, Broward County's Environmental Protection Department developed a pilot monitoring network to determine ambient coastal water quality and to identify potential land-based sources of pollution to the offshore coral reef ecosystem. Sample sites, visited bimonthly, include an inshore station in the Port Everglades shipping channel at 14 meters depth and three offshore sites at nine meters depth over the second of three shore-parallel coral reef tracts. Two sites bracket the channel with the third site further north to minimize influence from the Port outflow. Parameters measured include; total nitrogen, total phosphorus, total dissolved nitrogen, total dissolved phosphorus, dissolved inorganic nutrients, silicate, total organic carbon, dissolved organic carbon, turbidity and traditional physical water column properties.

A surface lens of less saline water (31 to 36 ppt) exits the Port on outgoing tides. The thickness of this lens ranges from a meter to several meters thick. Bottom salinities ranged from 35 to 36 ppt. Port surface samples had higher inorganic and total nitrogen values compared to bottom and offshore stations. Dissolved silicate values ranged from 100 ug/l to >400 ug/l in surface samples in the channel but were generally <30 ug/l at bottom and offshore sites. This surface spike of silicate was not detected at the offshore stations except during the October 2007 sampling event when substantial rainfall coupled with easterly winds appeared to trap a freshwater lens (1 to 2 ppt lower) along the coast. Silicate concentrations at offshore stations were 4 to 5 times higher than in bottom water and previously recorded values.

The data suggest the potential for lateral transport of fresher water both north and south of the Port inlet. A comparison of surface and bottom values suggests the land-based outflow signal attenuates with depth and is not identifiable near the benthic reef community.

## 18.667

**Coral Bleaching Records in Reefs From Eastern Brazil in The Last Fifteen Years**

**Zelinda LEAO*[1]**, Ruy KIKUCHI[1], Marilia OLIVEIRA[1]

[1]Federal University of Bahia - Brazil, Salvador, Brazil

Since 1993, several events of coral bleaching were registered along the coast of Eastern Brazil with recovery of most affected corals. The first occurrence is from the south hemisphere summer of 1993/1994, in Abrolhos region, when sea surface temperature (SST) reached yearly maxima of about 29oC, and bleached corals colonies ranged from 50% to 90%. In 1998, bleaching occurred north of Salvador City and in Abrolhos, when SST increased in mid January and peaked between mid March and April, before declining in late May. SST ranged between 29oC and 30.5oC, 1-2oC higher than the long-term average summer maximum of 28.5oC, causing bleaching in up to 60% coral colonies. SST anomalies higher than 0.5oC occurred in 2001 and 2002 in Abrolhos causing bleaching in an average of 11% corals. In 2003, SST anomalies occurred in Todos Santos Bay (TSB), Tinhare/Boipeba (T/B) and Abrolhos, and were 1oC above the long term average in mid March, with up to 70% of the surface coral colonies bleached in TSB, and *circa* 20% of coral colonies bleached in T/B and Abrolhos. In 2005, Itacolomis and Abrolhos were affected by bleaching due to increased SST in mid-March with a maximum rise of 0.75ºC above the long-term average. Coral bleaching was observed on the Itacolomis Reefs during April, with up to 17% colonies affected. About 28% of coral colonies were bleached on Abrolhos in early May. In 2006 bleaching was mild in Eastern Brazil, with only 6.2±7.1% colonies bleached on the Abrolhos fringing reefs. The coincidence of mass coral bleaching events in Eastern Brazil and high SST during the last fifteen years strongly indicates that these temperature increases are the primary cause of coral bleaching in reefs of the Southwestern Atlantic Ocean.

## 18.668

**Status Of Coral Reefs From Eastern Brazil**

**Ruy KIKUCHI*[1]**, Zelinda LEAO[1], Marilia OLIVEIRA[1]

[1]Federal University of Bahia - Brazil, Salvador, Brazil

Coral reefs along Eastern Brazil are spread over an extension of 800 km from 12° to 18° S. They are the largest and the richest reefs in the whole coast of Brazil, and are the southernmost coral reefs of Western South Atlantic. A monitoring program applying the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol was initiated in 2000, in the Abrolhos National Marine Park, after the creation of the South Tropical America (STA) Regional Node of the Global Coral Reef Monitoring Network (GCRMN), in the end of 1999. From that time up to 2007, several reef surveys were conducted along the coast of Eastern Brazil, most of the investigated reefs being assessed only once. Several parameters of the coral vitality indicate that the nearshore reefs, which are located less than 5 km from the coast and outside the limits of Marine Protected Areas (MPAs), are in poorer condition than the reefs located more than 5 km off the coast and inside MPAs. The nearshore reefs have an average percentage of live coral cover less than 4, the mean density of larger corals (>20 cm) is in the order of 0.4corals.$m^{-2}$, the mean density of coral recruits is <2recruits.m-2, and the percentage of macroalgae is >40, whereas in the offshore reefs the average live coral cover is higher than 10 %, the average density of larger corals is in the order of 1.7corals.$m^{-2}$, the men density of coral recruits is >20recruits.m-2, and the average percentage of macroalgae is <10. The nearshore reefs have been most severely impacted by the effects of direct human activities such as euthrophic waters associated with sewage pollution, higher sedimentation rates and water turbidity, inadequate use of the reefs and over exploitation of their resources.

## 18.669

**Status Of Coral Reefs Health Off South Caicos, Turks And Caicos Islands**

Kate MCCLELLAN[1], **Catherine JADOT*[2]**, Chris SCHELTEN[1]

[1]School for Field Studies, South Caicos, Turks and Caicos Islands, [2]Marine Resources Management, School for Field Studies, South Caicos, Turks and Caicos Islands

The Turks and Caicos Islands (TCI) coral reefs are considered to be among the most pristine coral reefs in the Caribbean. Most coral reef damage is caused by anthropogenic disturbances and the TCI, expecting a tourism boom in a near future, could experience a decline in their coral reefs health. Coral reefs status of 10 sites around South Caicos, TCI, was assessed in order to obtain baseline data. Algal cover, coral composition, coral species richness, and signs of coral damage including disease, recent death, and bleaching, were studied using random quadrats (n=204). Twenty-three different corals were observed, with *Agaracia spp*., *Monsterea annularis*, *Porites porites* and *P. asteroids* observed at every site. Coral cover ranged between 10% and 38%. Algal cover was high (filamentous algae 45.4% ± 2.72, encrusting algae 15% ± 2.11, macroalgae 10% ± 1.18, and blue-green algae 0.5% ± 0.24) and showed significant differences between locations. The sites visited showed a low level of damage and no breakage or live loose coral was reported. The results of this study show a healthy reef community with moderate coral cover, high species diversity and low coral damage. Nevertheless, the algal cover was high and long-term monitoring is required.

## 18.670

**Relationship Between Benthic and Fish Assemblages at Four Coral Reefs in Venezuela**

**Carolina BASTIDAS*[1]**, Sebastián RODRÍGUEZ[1], Denise DEBROT[1], Aldo CRÓQUER[1]

[1]Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela

The structural complexity and the relative cover of benthic categories in coral reefs contribute to their quality as habitats for many species. Among these species, the relative abundance and composition of fish assemblages, have in turn an impact on the benthic categories and, consequently, on reef accretion. Here, we analyzed the relationship between benthic and fish assemblages for two continental and two oceanic reef sites in Venezuela. At each site, data include four yearly samplings of (1) 10 permanent transects of 10 m for the cover of 21 benthic categories using CARICOMP protocol, and (2) 10 belt-transects of 30 m x 2 m for fish abundance and biomass by visual censuses, using the AGRRA fish protocol. Both, the structure of the benthic and of the fish assemblages differed among reef sites rather than between coastal and oceanic reefs. Although, the cover of benthic categories was stable in time, fish abundance showed an interaction between sites and years ($p = 0.001$, PERMANOVA for 60 species of fishes). Despite these temporal differences in fish abundances, there was a relationship between the benthic and the fish assemblages for all years (Relate, $p = 0.01$; for two matrices of similarity i.e. fishes and benthos). This relationship varied not only among fish guilds but also within them. For example, the carnivorous *Haemulon aurolineatum* and *Ocyurus chrysurus* had a strong and a weaker association to the abundance of massive corals, respectively. Among species of scarids, abundances were more dependent on the cover of turf algae and abiotic substrates, particularly for *Scarus iseri*. These trends will allow formulating hypotheses on the role of diet, recruitment, behavior and vulnerability to fishing pressure on this relationship between fish abundances and that of specific benthic categories.

## 18.671

**Making A Rapid Reef Assessment Of The Mexican Caribbean Coral Reefs To Find Potentially Resilient Sites**

**Albert FRANQUESA RINOS*[1]**

[1]Marine Program, Amigos de Sian Ka'an, A. C., Cancun, Mexico

As part of a TNC reef resilience project, a rapid reef assessment was carried out by Amigos de Sian Ka'an and other collaborating organizations between September 2005 and December 2006. The survey included 121 sites distributed along all the continental and insular coast of the Quintana Roo state. The AGRRA v.4 protocol was used by the 31 people involved in collecting data from 452 benthic transects (adding up more than 3,100 coral colonies) and 905 fish transects. The average coral cover did not vary greatly between habitats (Fore reef, Reef flat, Patch Reef & others), with values around 8%. On the other hand, the average percentage of colonies affected by diseases and average percentage of recent dead tissue per colony were also extremely low; not going over 1%. However, these and other values varied greatly among different sites. Therefore, a selection of different indicators was done, and they were then compared with a GIS; taking into account the location of each site. This analysis showed that the few sites with high coral cover (16-29%) were scattered along the state (Cozumel, Banco Chinchorro, and the north, center and south of the continental coast), so they were not aggregated in a single or few areas. The same happened with other indicators like *Diadema antillarum* abundance. However, variables such fish biomass or coral recruitment were only high at certain areas. This is a first step to obtain valuable information from specific reef variables at a regional scale, which could be used as indicators to find potentially resilient sites.

## 18.672

**Bali Barat National Park Coral Monitoring Report,**

naneng SETIASIH[1], Dwi Haryo ISMUNARTI[2], **Naneng SETIASIH*[1]**

[1]Reef Check Foundation Indonesia, Denpasar, Indonesia, [2]Diponegoro University, Denpasar, Indonesia

Bleaching at Bali Barat National Park (BBNP) in 1997-1998 has been reported to have up to 100 % mortality at some cases (Irdez et all, 1998). The park also hit by repeated Acanthaster outbreak (1996, 2004, 2005), and a strong storm (2004).

The monitoring was conducted at 15 segments (inside and outside the park). The segments were chosen based on manta tow result (2001), habitat representatives, and resilience factors: current, mixing water, sedimentation (Salm and Grimsditch, 2006; Marshall and Schutenberg, 2006), and local adaptation.

The method implemented was LIT up to 5 taxa level (oliver et all, 2002), with 3 repetitions at 3 and 10 meter at each segment.

The area showed a generally promising condition. Segments within BBNP had a higher % hard coral (%HC) and bigger colonies' size compare to the adjacent areas, even to Tabuan Island that naturally was one of the most resilience segments in the area.

Further detail analysis showed that each type of habitat (and thus the reef structure) showed different reactions to the mass destruction event and its recovery. The highest %HC and colonies' size segment lay in an area dominated by high resilience taxa. Moreover, in general, almost all the segments had a relatively higher slow growing taxa, which consistent with the recovery after a mass coral bleaching, suggest a shifting community structure.

The monitoring also found that stronger protection area deliver a better %HC and colony size. The findings further strengthen the need to put resilience understanding and management action into the top agenda of every reef manager.

## 18.673

**Status of the Philippine Coral Reefs: 2004-2007**

**Rhia Odessa GONZALES*[1]**, Melchor DEOCADEZ[1], Porfirio ALIÑO[1], Cleto NAÑOLA[2], Hazel ARCEO[3], Rollan GERONIMO[1], Wilfredo CAMPOS[4], Severino SALMO III[5], Andre Jon UYCHIAOCO[6], Clarissa REBOTON[7]

[1]Marine Science Institute, UP Diliman, Quezon City, Philippines, [2]Department of Biological Science and Environmental Studies, College of Science and Mathematics, UP Mindanao, Davao City, Philippines, [3]DAI/USAID - Philippine Environmental Governance 2 Project, Cebu City, Philippines, [4]UP Visayas, Miag-ao, Philippines, [5]Marine Science Institute, Quezon City, Philippines, [6]Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), Quezon City, Philippines, [7]Silliman University Marine Lab, Institute of Environmental and Marine Sciences, Dumaguete City, Philippines

The status of the Philippine Coral Reefs is being updated for almost 3 decades. In 2004, it was reported that Philippine reefs are experiencing a steady-state decline in percent coral cover of excellent reefs, and many of the fair and good reefs are experiencing a shift to degraded state. This paper provides the status of Philippine reefs in the 6 biogeographic regions. It updates the information on the status of Philippine reefs and presents for opportunities, the establishment of a nationwide coral reef monitoring network. We also provide some alternate perspectives on how to face the challenges of reef management through the Marine Protected Areas (MPA) Support Network (MSN).

Data from survey sites of different projects has shown that overall proportions do not change from the general modal categories reported previously: most of the reefs are in poor and fair categories. About 50% of reefs are in fair category (26-50% coral cover), and around 40% in poor category (0-25%), while less than 10% are in good to excellent condition. Though this presents the overall modal state of reefs, further updates in relation to declines or improvements would hardly shift the general trend unless these are based on a systematic monitoring scheme of areas.

Based on the sites monitored from inside and outside the MPA within the MSN, there seems to be more optimistic trends in these areas, i.e. around 60% of areas show steady or improved trends, while less areas have shown declines. Unfortunately, these managed areas represent less than 1% of the actual reefs. Based on data from partners of this network, there are over 1,000 MPAs currently established and about 150 are proposed. Establishing a coral reef monitoring system inside and outside no-take areas in addition to further surveys helps improve our understanding and management of Philippine reefs.

## 18.674

**Monitoring Of Coral Recovery After 97-98 Mass Bleaching Event At, Naneng SETIASIH*[1]**

[1]Reef Check Foundation Indonesia, Denpasar, Indonesia

The aim of the monitoring was to understand the ecological response of the 4 reef systems to the mass bleaching event in relation to different reef habitat and protection level.

LIT up to taxa level 5 (Oliver et all, 2002) was conducted in all parks as the baseline methodology.

Monitoring stations at BBNP and BNP had a diversity of protection level and natural resilience. As the consequences, the result showed a wide range of % hard coral (%HC). On the other hand, stations the other parks were located in a limited human presure areas in the open sea, resulted in almost similar %HC.

All locations showed a good condition of reef. Stations at KSMP and KJMP had a higher %HC, probably indicated that they were not affected by bleaching at 1997-1998, or showed a good recovery. This was confirmed by the relatively large coral colony found and high coverage of Acropora which is highly susceptible to bleaching (Baird and Marshall, 2002).

Despite being badly hit by bleaching and repeated Acanthaster outbreak, an increase from 7% HC (1998) to 25%HC (2006) was noted at BBNP. There were also segments with large coral colonies (>1m) at the park.

Moreover, BBNP and KJMP indicated a higher percentage of high reistant taxa. This is consistent with the development of reef system after a mass bleaching event (Coles and Brown, 2003, Hoeg-Guldberg, 1999, Hughes and Connell, 1999), suggested a community structure's shifting.

BNP located in a naturally higher resilience areas to the other parks. The condition plus the well manage park probably has led the area to be less affected by bleaching.

## 18.675

**Distribution And Abundance Of Sponges Of Minicoy Island, Lakshadweep, India**

**Anita G. MARY*[1]**, Robert SLUKA[2], S. LAZARUS[1]

[1]Institute for Environmental Research and Social Education, Nagercoil, India, [2]Millennium Relief & Development Services, Bellaire, TX

We conducted a survey of the distribution and abundance of sponges of Minicoy Island which lead to the discovery of thirteen species representing eleven genera from nine families. They are *Axinella donnani, A. manus, Dragmacidon agariciformis, Auletta aurnatiaca, Pseudoceratina purpurea, Hyrtios reticulates, H. erectus, Spongia (Spongia) ceylonensis, Terpios cruciatus, Haliclona (Gellius) aff. Cymacformis, Dysidea granulosa, Leucetta chagosensis and Callyspongia (Euplacella) mannarensis*. The distribution of sponges were assessed by using line-intercept transect technique. This was a pioneer study for this area with the discovery of five species entirely new to India and eight species new to the Lakshadweep islands. Images of each species are included to facilitate field identification.

## 18.676

**Variability in Growth Form Of Gulf Of Kachchh Corals, India.**

**Prasanna YENNAWAR*[1]**

[1]Zoological Survey of India, Marine Aquarium and Research Centre, Digha, India

The coral reefs in the Gulf of Kachchh are one of major reefs in the Indian sub-continent, which is under much threat due extreme environmental conditions. The biophysical monitoring study of the coral reefs in the area shows that the corals in this region are mainly massive & sub-massive corals like Porites, Favia, Favites & Montipora spp.). Many coral species are now exterminated like branching corals. The huge reef flats are dominated by one or two species at an instance and are exposed to uniform climatic changes with variable substrates reflected zonation in growth forms. Various topographic zones were compared with dominant species and it is observed that ubiquitous species adopted different forms in different zones of the same reef area. This is because of drastic environmental conditions like high sedimentation rate, extreme temperature conditions, periodical exposure, etc. The area is also highly industrialized with many refineries, submerged oil & gas pipelines, ports, cement, salt, power, ship-wrecking, etc. industries. The paper describes the variability in the growth forms with reference to variable climatic impact.

## 18.677

**Seasonal Bleaching Did Not Impede Coral Growth in Todos Os Santos Bay, Eastern Brazil**

Eduardo CHAVES[1], Pedro MEIRELLES[1], Ruy KIKUCHI[1], **Zelinda LEAO*[1]**

[1]Federal University of Bahia - Brazil, Salvador, Brazil

The linear growth rate of the corals *Siderastrea* spp and *Montastraea cavernosa*, from Todos os Santos Bay, was evaluated in order to verify if there was a relationship between the observed coral growth with variations in the conditions of sea water parameters (temperature, salinity and nutrients), as well as with the occurrence of coral bleaching events. Seventeen colonies of the coral *Siderastrea* spp and nineteen colonies of the specie *Montastraea cavernosa* were marked and observed from December 2005 to April 2007. Coral growth was measured every 15 days using fixed nails on the top of the coral colonies. This technique shows more efficiency in measuring the growth rate of the coral *Siderastrea* spp, once the specie *Montastraea cavernosa* shows resistance to the presence of the nails on the first months of the experiment. Among the measured sea water parameters, only sea water temperature shows relationship with the growth rate of the measured corals. The analyzed coral species grew more during summer time when temperature of sea water reached values up to 29°C. The growth rate of *Siderastrea* spp varied from 0.39±0.51 mm/month during summer (in the southern hemisphere from October to March) to 0.24±0.45 mm/month in winter (from April to September) and of *Montastraea cavernosa* from 0.21±0.41 mm/month during summer to 0.13±0.29 mm/month in winter. Observed bleaching was mild, during summer time, and all affected colonies recovered. During the period of investigation, sea surface temperature anomalies that could have been the major cause of the occurrence of a bleaching event of major scale was not registered in the studied region.

## 18.678

**Mapping Bottom Features Of The Site Selected For The Underwater Observatory in Sharm El Sheikh (South Sinai, Egypt)**

Stefano ACUNTO[1], **Jessika GIRALDI*[1]**, David BALATA[1], Luigi PIAZZI[1], Francesco CINELLI[1]

[1]University of Pisa, Pisa, Italy

A bionomic and topographic map of the site selected for construction of the Underwater Observatory was made as part of the building plan of the structure.

The study area was located at Marsa Ghoslani bay in front of the Visitor Center of the Ras Mohammed National Park (Sharm el Sheikh). This area is characterised by a small fringing reef that, at the depth of ~ 5 meters, reaches a gentle slope rocky bottom covered with sand and scattered coral assemblages.

Underwater visual, photographic and video surveys were made along 6m wide x 50m long belt transects (n=15) perpendicular to the coastline. Visual recording of bottom features included type of substratum (rock, sand and rubble) and type of organisms (hard coral, soft coral). Bathymetric data were obtained measuring depth at each metre along the line. A bionomic and topographic site map obtained from the analysed date (scale 1:100) was used to select the building site for the Observatory. The area was mainly bare rock and therefore, direct impact on benthic organisms resulting from construction was minimised.

## 18.679

**Differentiating Among Global And Local Stressors in Florida Keys (Usa) Coral Reefs Using Coral Regeneration Rates And A Cellular Diagnostic System**

**Elizabeth FISHER-MOSES*[1]**, Cheryl WOODLEY[2], John FAUTH[3], Pamela HALLOCK[4]

[1]Eckerd College, Saint Petersburg, FL, [2]NOAA National Ocean Service, Hollings Marine Laboratory, Charleston, SC, [3]Department of Biology, University of Central Florida, Orlando, FL, [4]College of Marine Science, University of South Florida, Saint Petersburg, FL

Coral reefs are threatened resources in Florida and worldwide, and reef declines are attributed to an array of local, regional and global stressors. Successful management of stressed reefs requires multiple indicators that permit rapid identification and diagnosis of causative agents. We used data acquired from coral regeneration rates, a cellular diagnostic system and public environmental data to differentiate between local (e.g., pollutants) and global (e.g., temperature) stressors. We applied this multi-scale approach at one patch reef in Biscayne National Park (BNP) and four patch reefs in the upper Florida Keys National Marine Sanctuary between 2001 and 2003. Sites were chosen in consultation with resource managers to reflect a spectrum of possible anthropogenic influences based on distance from urbanized coasts. Key Largo (KL) 6 m and BNP are located along heavily developed coastline while White Banks and Algae Reef were adjacent to an intact mangrove shoreline associated with John Pennekamp Coral Reef State Park. No evidence for temperature or light stress was observed during our study. Cellular diagnostic analyses indicated that local stressors, specifically xenobiotics, affected corals at our study sites (particularly Key Largo 6 m and BNP), with the highest stress levels during winter storms and following heavy rainfall. In addition to elevated cellular diagnostic markers, coral colonies at KL 6 m and BNP were clearly stressed as evidenced by highly variable and overall low lesion regeneration rates. Other reef sites experienced relatively favorable conditions as evidenced by consistently high lesion regeneration rates and a high percentage of healed lesions. Further studies are needed to determine what xenobiotics are affecting these corals. Our study emphasized the importance of using a hierarchical, mechanistic approach to assess reef condition. Using this approach provides resource managers with information linking coral ecosystem decline with environmental conditions.

## 18.680

**Coral Cover Evaluation Of Todos Os Santos Bay Reefs After The 2003 Mass Bleaching Event in Southwestern Atlantic**

**Igor CRUZ*[1]**, Amanda NASCIMENTO[1], Camila BRASIL[2], Ruy KIKUCHI[3], Zelinda LEAO[3]

[1]Instituto de Biologia, Universidade Federal da Bahia, Salvador, Brazil, [2]Instituto de Geociências, Universidade Federal da Bahia, Salvador, Brazil, [3]Centro de Pesquisas em Geofisica e Geologia, Universidade Federal da Bahia, Salvador, Brazil

Aiming to investigate the consequences of a mass coral bleaching event observed in Todos os Santos Bay in 2003, reefs were re-surveyed in 2007. The 2003 bleaching event affected 37.6±25.5% coral cover, when sea surface temperature (SST) reached yearly maximum anomaly of about 0.75°C, between 04/01/2003 and 05/04/2003. In 2007 the same eight reef sites were surveyed applying a similar video-transect technique. Six, 20 m long and 0.21 m wide, belt-transects from each reef site were analyzed, and organisms were identified under 20 random points in each image (frame) in a total of 100 frames per transect. For comparing 2003 and 2007 coral cover, T-test was used with an á = 0.05. The results show that living coral cover didn't change significantly (X = 14.0±8.1% in 2003 to X = 13.1±10.2% in 2007, p = 0.836). In 2007 bleaching was mild in Todos os Santos Bay affecting only 10.7±9.8% coral cover of the investigated reefs. Coral reefs from Todos os Santos Bay have been suffering from changes in the bay water quality mainly caused by the increased runoff of pollutant and sedimentation, as well as over exploitation of reef resources using, sometimes, prohibited fishing practices, and coral bleaching seems to be an additional factor. Because of the persistence of Todos os Santos Bay fauna to all these environmental stresses, its coral fauna can be considered as a resilient one.

## 18.681

**A Strategic Approach For Developing A National Baseline Coral Reef Condition**

Patricia BRADLEY[1], **Wayne DAVIS*[2]**, William FISHER[3], Michael MCDONALD[4]

[1]Office of Research and Development (ORD)/NHEERL/AED, U.S. EPA, Key West, FL, [2]Office of Environmental Information, U.S. EPA, Ft. Meade, MD, [3]Office of Research and Development/NHEERL/GED, U.S. EPA, Gulf Breeze, FL, [4]Office of Research and Development/NHEERL, U.S. EPA, Research Triangle Park, NC

The U.S. Congress, American public, and other interested parties want to know the condition of U.S. and territorial coral reef ecosystems. They want to know whether the reefs' conditions are getting better or worse, and whether our programs and policies are making a difference. Many organizations monitor coral reefs, but these efforts generally operate independently of one another, have many different missions and mandates, and are fairly localized. There is a critical need for nationally-consistent, comprehensive, and scientifically-defensible monitoring to detect environmental status and trends for coral reef ecosystems.

We propose to apply the approach developed by the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP): development of unbiased statistical design frameworks, and sensitive ecological indicators that are responsive to a gradient of stressors. This approach has been successfully applied for freshwater, estuarine and forest ecosystems and is transferable to assess coral reef ecosystems at state, regional, and national scales. Developing and maintaining such a coral reef monitoring program requires a partnership among the various federal, state and territorial agencies with responsibilities for coral reefs.

Our first application of this approach is in the U.S. Virgin Islands (USVI). In 2006, indicators were evaluated across stressor gradients using EPA's recently published Stony Coral Rapid Bioassessment Protocol. In 2007, a probabilistic sample design was used to monitor the coral reefs around St. Croix, USVI and a similar design will be used for St. John and St. Thomas, USVI in 2008. These results, coupled with those of other agencies and organizations will provide valid indicators and data for EPA's "Report on the Environment" and begin to address the current condition of the Nation's coral reef ecosystems and the impacts of human activities upon them.

## 18.682

**Seasonal Investigation On Stability Of Coral-Algae Interactions in Fringing Reefs Of The Northern Red Sea**

**Andreas HAAS*[1]**, Florian MAYER[1], Malik NAUMANN[1], Carin JANTZEN[1,2], Mohammed AL-ZIBDAH[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center LMU München, Munich, Germany, [2]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [3]Marine Science Station, Yarmouk University, Aqaba, Jordan

It is reported from many reef locations that corals are replaced by benthic algae, but not very much is known about the factors relevant for the stability of direct interaction between corals and benthic algae in the reef. This paper presents corresponding in-situ monitoring data from fringing reefs in the Northern Red Sea. During four seasonal expeditions, line point intercept and belt transect surveys were conducted at reefs close to Aqaba, Jordan, and Dahab, Egypt. This revealed that 25 % (Aqaba) and 40 % (Dahab) of all observed reef-building corals were in direct interaction with benthic algae. In Aqaba, in between 5 and 10 m water depth, the macro algae *Caulerpa* and *Peyssonnelia* as well as different turf algae consortia represented almost 100% of the algae species involved in direct interactions with corals. The stability of these interactions was monitored at marked locations in the study area during two field expeditions in November 2006 and August 2007. For that purpose the projected total living coral area was measured using underwater photography and subsequent image analysis. In total 40 natural coral-algae interactions were monitored over a total period of 16 months, whereas solitary colonies and algae transplants were used as controls. Stability of coral-algae interaction proved to be highly variable between seasons with fast overgrowth of corals by algae in fall and winter and almost stagnation during summer. The results of this study also indicate that benthic filamentous turf algae are most frequently (up to 80%) involved in interactions with corals and can cause most damage to corals in-situ. Slow-growing massive species showed more resistance against algal influence than branching corals. These findings provide some first fundamental data in order to contribute understanding the underlying mechanisms of phase shifts in coral reefs.

## 18.683

**A Photographic Method For Analyzing Areal Chlorophyll And Bleaching Status Of The Coral Stylophora Pistillata**

**Shachar KOREN*[1]**, Zvy DUBINSKY[2]

[1]Life Science, Bar Ilan University Israel, Kfar-Saba, Israel, [2]Life Science, Bar Ilan Univerity, Ramat Gan, Israel

With the increasing frequency and severity of coral bleaching events, this phenomenon has been documented and studied by scientists around the world. Methods to quantify bleaching status are based on sacrificing the samples being tested or using expensive equipment (like PAM).

In recent years, the performance of digital cameras in image processing has improved and they have become more affordable, thus, a new, economical and nondestructive way to monitor bleaching and recovery processes in coral tissues is becoming available to conservationists and researchers.

In the present study, we report a reliable bioassay for computerized quantification of areal chlorophyll density in corals. Demonstration of the method's robustness and reliability was done by studying experimentally induced bleaching and subsequent recovery in the common Red Sea coral Stylophora pistillata from the Gulf of Eilat (Aqaba). We used a regular digital camera and standard computer software, both inexpensive and easily available. The proposed bioassay could be used on any coral to rapidly and economically gather data on coral bleaching and disseminate them.

We hope that this will help scientists gain real-time information on large-scale bleaching events, even in remote reefs, using inexpensive means

## 18.684

**Quantitative Habitat Characterization And Benthic Assemblage Structure Of Deep-Water Scleractinian Reefs Off Eastern Florida**

**Kartick SHIRUR*[1]**, Charles MESSING[1], Carmen RODRIGUEZ[1], Joshua FEINGOLD[1], John REED[2], Sandra BROOKE[3]

[1]Nova Southeastern University, Dania Beach, FL, [2]Harbor Branch Oceanographic Institute, Florida Atlantic University, Ft. Pierce, FL, [3]Ocean Research and Conservation Association, Fort Pierce, FL

Eight deep-water coral sites were surveyed in November 2005 during 11 dives with the *Johnson-Sea-Link* submersible along the eastern continental margin of Florida from St. Augustine to Miami. Sites included unconsolidated sediment/coral bioherms, rocky lithoherms and the Miami Terrace escarpment. Photographic transects using high-resolution video and digital still images documented each site. Observations were made over a depth range of 282-871 m. *In situ* temperatures ranged from 6 to 9ºC. We examined 31 video transects and extracted over 2500 images for habitat characterization and quantitative analyses of percent coverage by substrate type and densities of major macrobenthic assemblage components using the Coral Point Count software (CPCe). All organisms larger than ~10 cm in each image were identified to the lowest possible taxonomic level. Substrate categories included living and dead standing coral, coral rubble, sediment, rock rubble, and hard substrate (e.g., pavement, boulders). The branching azooxanthellate scleractinian corals *Lophelia pertusa* and *Enallopsammia profunda* dominated five and six sites, respectively. The percentage of live coral varied among sites, regardless of the dominant species in that area. Sites dominated by *L. pertusa* showed greater accumulation of sediment, while *E. profunda* was most often associated with lithoherms, though both species were observed in both habitats. Distributions of corals and other organisms were related to depth, bottom topography and physical environmental conditions. Associated taxa included *Madrepora oculata* (Scleractinia), *Keratoisis flexibilis* and *Plumarella pourtalesii* (Octocorallia), Stylasteridae, and numerous Hexactinellida and Demospongiae (e.g., *Phakellia* sp., *Pachastrella* sp., *Aphrocallistes* sp. and *Heterotella* sp.). The results will be applicable to managers in developing plans for conservation and protection of these fragile deep-water resources.

## 18.685

**2007 Coral Reef Status in The Union Of Comoros**

**Said AHAMADA*[1,2]**

[1]ICZM, ReCoMap, Moroni, Comoros, [2]Marine Environment, AIDE NGO, Moroni, Comoros

AIDE (Association d'Intervention pour le Developpement et l'Environnement) NGO with support from the Indian Ocean Commission, is carrying out coral reef monitoring since 1997 in the 3 Islands (Grande Comore, Moheli and Anjouan) of the Union of Comoros South Western Indian Ocean, following Global Coral Reef Monitoring Network protocols.

Results from 10 sites are discussed in this paper. In 2002 (4 Years after the 1997/1998 bleaching event) coral recovery was very low. Actually (10 years later) the general trend is to the initial status with more than 70% coral cover in some sites as Wani Anjouan, Mitsamiouli Grande Comore and Walla Moheli.

Some sites as Bimbini Anjouan and Chindini Grande Comore show low coral cover around 24% and are under higher pressure as over fishing, sedimentation and trampling.

Coral reef are in better health in sites of the Marine Park of Moheli ( from 50 to 72% coral cover) than in other sites of the same Islands with less than 30% ( Fomboni and Hoani).

Coral bleached (1 to 10%) from recent events as 2004/2005 did rapidly recover especially those with less stress from human activities.

Socioeconomic assessment have also been conducted under CORDIO supervision and are being cross analyzed with the biophysical dada through ARC GIS tools to help take adequate measures for adaptive management of the reefs and associated resources.

## 18.686

**Resilience of a Red Sea Fringing Coral Reef under Extreme Environmental Conditions: A Four-Year Study**

**Zaki MOUSTAFA*[1]**, Pamela HALLOCK[2]

[1]Unaffiliated, West Palm Beach, FL, [2]College of Marine Science, University of South Florida, St Petersburg, FL

A four-year study, which began in summer 2004, collected the first comprehensive time series of measurements from a 0.5 km x 0.1 km fringing reef in the Gulf of Suez (29º 32' N and 32º24' E), Red Sea. This reef occurs near the northernmost extreme latitude for sub-tropical coral reefs. Corals here are exposed to daily water-temperature changes of 2-4ºC, and seasonal variations that exceed 15-20ºC. Salinities are among the highest ever recorded on a reef, ranging between 44 and 45 psu. The reef has been subjected to many new stresses over the past four years, including a newly built major shipping port, rapid coastal urbanization, bleaching, and an oil spill in 2005. Annual reef surveys include random photo quadrats plus fish and coral video transects, supported by a suite of environmental measurements. Results indicate that between 2005 and 2007 there was a statistically significant decrease in reef-health indicators, including a 50% increase in dead and diseased coral, a 58% increase in sea urchins, and decreases in biodiversity and sediment constituent indices, fish abundance, and water quality. Of the approximately 40 known coral species hardy enough to survive in this region, six species make up 94% of the reef's coral cover. Given the extreme natural environmental conditions in which this fringing reef has thrived, the resilience of this community appears to be very high. Unfortunately, this reef and others in the area are now threatened by local anthropogenic impacts. This study establishes a reference point for comparison with similar reefs and will be key to any future conservation and restoration efforts in the area.

## 18.687

**Assessment Of Contaminants in Honolua Bay, Maui: Threat For Coral Reef Organisms?**

**Laetitia HEDOUIN*[1]**, Marc METIAN[1], Ruth D. GATES[1]

[1]Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI

A decline in coral cover in Honolua Bay, Maui, Hawaii, has been reported over the last 10 years. Increasing human activities in the Honolua watershed associated with discharges of sediments from the stream may represent an important threat to this reef ecosystem. High levels of Ni, Co, Cr, and Mn are measurable in sediments from Honolua Bay (e.g. up to 464 µg Ni $g^{-1}$ dwt) as compared to other Hawaiian watersheds (e.g. Molokai, Oahu, < 27 µg Ni $g^{-1}$ dwt) and these concentrations are high enough to elicit adverse biological effects in reef ecosystem. The goals of this work were to determine 1) if the presence of contaminants in Honolua Bay is related to natural and/or anthropogenic sources and 2) whether or not the contaminants are bio-available to the reef biota. Concentrations of Ag, As, Cd, Co, Cr, Cu, Mn, Ni, Pb, V and Zn were evaluated in reef organisms and sediments from Honolua and adjacent bays in the West Maui region. A clear gradient of Ni, Co, Cr and Mn concentrations was observed in sediments from different stations in Honolua Bay; this gradient was not observed in the tissues of marine organisms, where concentrations were uniformly low. These results suggest that the presence of high levels of Ni, Co, Cr and Mn in the sediments of Honolua Bay is mineralogically-controlled and that they are not bio-available to the reef biota. However, high levels of arsenic were detected in the muscles of fish from Honolua Bay suggesting that this contaminant is bio-available in this area. The source of this contaminant is currently under investigation.

## 18.688

**Elkhorn Coral Distribution and Condition Throughout the Puerto Rican Archipelago**

**Michelle SCHÄRER*[1]**, Michael NEMETH[1], Abel VALDIVIA[2], Dana WILLIAMS[2], Margaret MILLER[3], Carlos DIEZ[4]

[1]Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico, [2]RSMAS, University of Miami, Miami, FL, [3]Southeast Fisheries Science Center, NOAA, Miami, FL, [4]Office of Protected Species, Puerto Rico DNER, San Juan, Puerto Rico

The Puerto Rican archipelago contains the greatest extension of Elkhorn coral in the US Caribbean. Accurately determining the current status of this threatened species is difficult due to the lack of baseline information, species specific monitoring and site specific demographic data. This study assessed the current distribution, abundance and condition of *Acropora palmata* in six marine protected areas (MPA) in order to establish a demographic monitoring program. Large-scale surveys were initially conducted throughout potential *A. palmata* habitat using a random sampling approach guided by GIS of bathymetry and benthic habitat. Circular plots of 100 m2 (N=431) were used to quantify colony density, size distribution and condition. Average colony density per MPA ranged from 1.3 to 14.3 col/100m2 and was significantly higher at two west coast sites (Tres Palmas and Arrecifes de Tourmaline). Based on this information, nine permanent plots (150 m2) were established (6 on the west and 3 on the east coast) to monitor temporal variation in demographic variables (following a standardized protocol currently implemented in Florida and other Caribbean locations). West coast sites showed lower predatory snail incidence when compared to east coast sites. However, average live percentage per colony was the highest (85%) in Arrecifes de la Cordillera (east coast). Recent mortality due to diseases was highest in Canal Luis Peña (Culebra, east coast), while recent mortality caused by the boring sponge *Cliona tenuis* was only observed on the west coast. Overall the incidence of WBD was low (0.5% of colonies) suggesting the population in Puerto Rico is healthier than in the upper Florida Keys, where hurricanes and diseases have caused significant mortality. Spatially distinct assessments at the regional level would be useful in order to clearly understand population trends and response to recovery actions.

## 18.689

**Comparison Between Digital And High Definition Video Formats in Coral Video Monitoring.**

**Rob WAARA*[1]**, Judd PATTERSON[1], Matt PATTERSON[1], Andrea ATKINSON[1], Brian WITCHER[1], Andy DAVIS[2], Jeff MILLER[2]

[1]South Florida/Caribbean Network, National Park Service, Miami, FL, [2]South Florida/Caribbean Network, National Park Service, St John, Virgin Islands (U.S.)

Since 1997 the South Florida/Caribbean Inventory & Monitoring Network (SFCN) of the National Park Service has been using underwater video transects collected using Digital Video (DV) cameras in underwater housings for the monitoring of the coral reefs in its network National Parks and Monuments. Advancements in technology have produced additional tools to be used in coral reef monitoring. The development of High Definition Video (HDV) is one of these new tools. The increased image quality, through higher resolution and contrast of the HDV format raises the question of whether the transition to HDV videography for monitoring coral reefs will produce different results from DV.

In the fall of 2007 SFCN began evaluating the use of HDV cameras for use in its coral monitoring program. A side-by-side comparison between DV and HDV was conducted to evaluate the ability to produce a similar image "footprint" with HDV to historical DV format, and determine whether enhanced image quality of HDV translated into increased benthic identifications. As with the change of any method in a long-term monitoring program the introduction of HDV has raised many questions and concerns. This study gives a comparison between HDV and DV formats based on video quality, coverage area, and over all cost effectiveness. Other aspects that are compared are the overall percent coverage of the reef biota by videotaping same site transects and comparing the data collected using each format type.

## 18.690

**Assessment Of The Coral Reefs And Associated Fish Communities Of Vieques, Puerto Rico**

**Laurie BAUER*[1]**, Matthew KENDALL[1], Charles MENZA[1], Kimberly FOLEY[2]

[1]NOAA/CCMA Biogeography Branch, Silver Spring, MD, [2]NOAA/CCMA Biogeography Branch, Beaufort, NC

From the 1940s until 2003, portions of the Island of Vieques, Puerto Rico were used by the United States Navy as an ammunition support detachment and a naval training range. A field survey was conducted in May 2007 to characterize the hardbottom habitats, associated fish communities, and marine debris around Vieques. An important question was how reef community metrics differ in regions that have experienced varying degrees of human activity during the time which the Navy controlled much of Vieques. Another important consideration was the inherent differences in habitat structure, currents and bathymetry between the north and south sides of the island. As such, ten strata were developed to encompass these two criteria, and sites were randomly selected within each stratum for a total of 75 survey locations. Fish community data were analyzed with respect to spatial location, depth, and site-specific benthic habitat characteristics. In addition, the fish community in Vieques was compared to similar hard-bottom communities in the Virgin Islands and La Parguera, Puerto Rico. The results provide natural resource managers with information on the abundance and distribution of marine resources of Vieques and will serve as a baseline from which to monitor changes over time. An island wide characterization of Vieques' reefs and fish communities is timely given the recent land transfer and potential changes in marine zoning.

## 18.691

**Comparison Of Benthic Communities On Four Coral Reefs in The Veracruz Reef System (Mexico).**

Jason JONES[1], Kim WITHERS[1], **John W. TUNNELL*[1]**

[1]Texas A&M University-Corpus Christi, Corpus Christi, TX

The Veracruz Reef System consists of over 20 platform-type emergent reefs. They are split into two groups, northern and southern, by the influence of the Río Jamapa which contributes freshwater as well as municipal, industrial and agricultural pollutants to the waters around the reefs. Four reefs, Anegada de Adentro and Blanquilla in the northern group and Anegada de Afuera and Enmedio in the southern group, were characterized using photo-transect techniques during Fall 2002. Scleractinian cover ranged from less than 1% on the shallow reef at Anegada de Adentro in the northern group to about 13% in the deepest areas of Anegada de Afuera in the southern group. Generally, scleractinian cover was greatest at deeper depths, on reefs that were furthest from shore and in southern group. Historically, coral cover on all reefs has declined dramatically since previous surveys in the 1960s (40-50%), 1970s (17-53%) and 1980s (12-44%) when scleractinians dominated benthic communities. Algae, particularly turf and crustose forms, currently dominate reef benthic communities, with greater than 50% cover on all reefs and at all depths. Numerous natural impacts (low salinity, heavy sedimentation, diseases, winter cold fronts, hurricanes) and anthropogenic impacts (coral mining, dredging, landfill, ship groundings overfishing, coral and shell collection, others) have in combination undoubtedly caused much of this decline.

## 18.692

**Patterns Of Coral Distribution in The Bay Islands (Honduras)**

**Pedro PORTILLO*[1]**, Yolande BOUCHON-NAVARO[1], Pierre LEGENDRE[2], Max LOUIS[1], Claude BOUCHON[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe, [2]Département des Sciences Biologiques, Université de Montréal, Montréal, QC, Canada

The present work explores the factors controlling or influencing the coral species distribution on the reefs of the Bay Islands (Honduras) which belong to the Meso-American coral reef system. For that, the distribution of coral assemblages was examined in the three Bay Islands (Utila, Roatán and Guanaja). Presence-absence data from 41 species observed from 92 sites were subjected to canonical analyses. Nineteen environmental descriptors were used as explanatory variables in the analyses. They were separated into three sets: reef habitat descriptors (depth, geomorphological characteristics of the reef sites), geographical factors (latitude, longitude, seaward or leeward side of the islands) and anthropogenic influence (nutrients, bacterial pollution, chemical contaminants). In a first step a variance partitioning of the presence-absence data was conducted among the three sets of environmental descriptors. This revealed that the geomorphological descriptors of the reefs accounted for 20% of the variance of the data and that geographical and pollution factors had a negligible influence on the qualitative distribution of the corals.

A canonical redundancy analysis (RDA) was then performed between the presence-absence data and the geomorphological descriptors of the reefs. The results showed an ordination of the coral species from shallow habitats (reef flat, lagoon) to deep or cryptic habitat (outer reef slope, wall, steep slope). In complement, the "sites by species" table was submitted to a cluster analysis. Groups of coral species characterizing the reefs of the Bay Islands were identified by the calculation of Kendall coefficients of concordance and their validation by permutation tests. This analysis revealed the existence on the reefs of the Bay Islands of three groups of coral species significantly correlated, which corresponded to an assemblage of species of shallow habitats, an assemblage of deep or shadowed habitats and an intermediate one.

## 18.693

**Climate Change : A Threat For The Coral Reefs in The French West Indies**

**Claude BOUCHON*[1]**, Pedro PORTILLO[1], Yolande BOUCHON-NAVARO[1], Max LOUIS[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe

Since 2002, a long term monitoring program has been set up in the French West Indies (FWI) in the framework of the Global Coral Reef Monitoring Network (GCRMN). Benthic coral communities and reef fish assemblages have been monitored twice a year on nine reef sites located in the islands of Guadeloupe (5 sites), Martinique (2 sites) and St-Barthélemy (2 sites). These studies revealed the existence of degradations of the coral communities resulting from causes, which originate in the early 80's. Nevertheless, the state of health of the studied coral communities remained stable from 2002 to 2005, year marked by an exceptional warning of the seawater temperature.

In 2005, seawater temperature exceeded 29°C from mid-May to mid-November, with maximum values reaching 31°C, generating a massive bleaching of the corals. According to the reef, 50 to 80% of the coral species were affected by the phenomenon and about 50% of the coral colonies bleached. At the end of November 2005, the observed mortality of the corals was relatively low (maximum 7%). But a phenomenon of delayed mortality developed during 2006, with a paroxysm in July, in spite of a return to normal seawater temperatures. The phenomenon regressed at the end of that year. Coral mortality (Scleractinians and Hydrocorallians) was minimal on the reef flats and shallow lagoons where corals support important variations of their ecological conditions. Conversely, on the outer reef slopes, coral mortality fluctuated between 25 to 50%. The observed mortality was more important for coral communities impacted by pollution than for healthy ones. On the whole, the reefs of the FWI lost about 30% of their coral coverage in one-year time.

No noticeable consequence on the reef fish assemblages has been observed, probably due to the fact that the reef architecture has not yet been altered.

## 18.694

**Monitoring Seawater Temperature And Coral Community Response Across Fiji – An Archipelago-Wide Monitoring Programme**

Edward LOVELL[1], Helen SYKES[2], **Victor BONITO*[3]**, Zaidy KHAN[4], Norman QUINN[5]

[1]School of Marine Studies, University of the South Pacific, Suva, Fiji, [2]Marine Ecology Consulting, Suva, Fiji, [3]Reef Explorer Fiji, Coral Coast, Fiji, [4]Foundation of the Peoples of the South Pacific, Suva, Fiji, [5]University of West Indies ( UWI) Discovery Bay St. Anns, St. Anns, Virgin Islands (U.S.)

Coral bleaching had a substantial impact on Fiji's coral reefs in 2000 and 2002. To better assess this phenomenon in terms of description and prediction, a temperature monitoring programme was established. Forty-eight loggers are spread across twenty-five sites in the archipelago compiling a description of the coastal seawater temperature regime for Fiji's reefs. Loggers are deployed primarily on the fore reef between 5 – 10m depth, however two sites (Votua and Suva Harbor) have loggers deployed across a range of reef habitats. With a ten-year temperature record , the programme is currently expanding to other South Pacific countries through the Global Coral Reef Monitoring Programme. The programme involves participation by resorts, dive operators, non-government organisations and private researchers who deploy and maintain loggers and monitor sites for coral bleaching. Comparison of in-situ temperature records with broad-scale satellite data and fine-scale habitat assessment has revealed reasonable congruence between satellite generated SST's and mean in-situ readings, however, the temperature regime varies across reef environments and locations within the archipelago. Reef flat temperatures along the Coral Coast have been documented to range over 14°C annually and over 9°C daily exceeding 36°C and dropping below 23°C, while fore reef temperatures at 10m depth at the same reef had an annual range of only 6°C and daily maximum range of 3.5°C. Gaining a better understand of both broad- and fine-scale temperature regimes across Fiji's reefs and their effects on coral communities can make important contributions to marine conservation efforts by assisting with the identification of reef areas that are either less prone or resilient to bleaching.

## 18.695

**Cozumel Island, México: A Disturbance History**

**Patricia ALVAREZ DEL CASTILLO*[1]**, Hector REYES[2], Lorenzo ALVAREZ[3], Maríines MILLET[4]

[1]Biologia Marina, Universidad Autonoma de Baja California Sur, La Paz, Mexico, [2]Biologia Marina, Universidad Autonoma de baja California Sur, La Paz, Mexico, [3]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, [4]Monitoreo y Vinculacion Cientifica, Parque Nacional Arrecifes de Cozumel, Cozumel, Mexico

Hurricanes impact reef communities and their effects are clearly observed in the landscape and reef structure, especially when the storms are intense and frequent. This study aims to determine the damage caused by hurricanes "Emily" and "Wilma" in 2005 over the landscape structure of Cozumel Reef National Park, México, and describe the recovery process. We conducted samplings at six reefs located in the PNAC during seven months between May 2005 and May 2007. At each reef, six 30-m point-intercept transects were run parallel to the coast, at depths between 10 and 15m, and the type of substrate found every 25cm was recorded. The bottom elements that were quantified were coral, sponges, macro algae, algal mat, blue green algae, coral with recent death, rock, sand and others. Landscape structure was quantified with the Pielou´s evenness index (J´), and changes were evaluated with non-metric multi-dimensional scaling (NMDS) and the Bray-Curtis similarity coefficient. The results show a significant decrease in the percentage of live cover, and an increase in the percentage of sand and rock. Corals were the most affected group decreasing from 24% to 10% in cover after the two hurricanes; fortunately, cover has increased to 16% by May 2007. Significant differences were found in the landscape evenness, being lower in July 2005; the high similarity of J´ between May 2005 and May 2007 indicates a clear trend of recovery in the reefs. The NMDS show that the two hurricanes affected Cozumel reefs with varying intensity, with "Wilma" having an impact four times higher than "Emily". A clear improvement in biotic condition was observed by October 2006, but in 2007 the recovery rate decreased remarkably. We estimate that the reefs may return to their original condition in a maximum of 38 months, starting in May 2007.

## 18.696

**Standardized Certification To Increase Coral Monitoring Data Quality And Extent Surveys Location And Numbers**

**Naneng SETIASIH*[1]**

[1]Reef Check Foundation Indonesia, Denpasar, Indonesia

In Indonesia, coral reef areas spread widely. Most of it located far from government and or management reach, as well as cost extensive. Moreover, the number of surveyors are also limited. This condition gives Indonesia lack of coral data and information that can represent a global general status.

Reef Check (RC) method was developed in 1997 to outcome the problem. Since then RC has been developed and run in more than 82 countries, including Indonesia, resulted in a widest global coral reef data of the world.

However, RC method credibility is oftenly challenged, especially the data quality. Many of the RC surveyors are divers or snorkelers without basic training in coral reef, leads to a question in the data resulted. The condition has lead many reef managers reluctant to use regular divers as RC surveyors.

Since 2005, RC survey was restructurised. A certification level, its curricula, and a standardized training were developed. The certification system was adopted from diving certification system. Each level has its own skills and specification that has to be tested to gain the high quality of data. The first level is called RC Ecodiver one stars. There are 5 level available, with the highest one called RC trainer. RC trainer could run the first 3 certification level, as well as running an independent RC survey. This system can provide RC dive operator with alternative products for its customers.

Since its implementation in Indonesia in 2006, there were 10 dive operators joint the certification, resulted in 18 RC trainer and 175 RC Ecodivers. As the dive operator paid for the training, there was a significant amount of the total RC survey and training reduction cost compare to before 2006. The system also added more sites and more players for reef monitoring in Indonesia.

## 18.697

**Assessing The Ecological Status Of Reef Building Coral Communities Of Pohnpei, Micronesia, As A Tool For Conservation**

**Eugene JOSEPH*[1]**

[1]Marine Program, Conservation Society of Pohnpei, Kolonia, Micronesia

Assessing the Ecological Status of Reef Building Coral Communities of Pohnpei, Micronesia, as a Tool for Conservation

Pohnpei is the capital state of FSM and lies approximately 5 degrees north of the equator, about halfway between Hawaii and Australia. Despite the gains in coral reef conservation and management in Pohnpei, significant gaps in understanding of the biological adequacy of the Marine Protected Areas (MPA) network still exist. From 2005 to 2006 a Rapid Ecological Assessment (REA) of biodiversity and status of reef-building corals and coral communities of Pohnpei, Federated Sates of Micronesia (FSM) was undertaken because of a lack of adequate biological data to support Pohnpei's network of MPAs. The objectives of the REA were to assess coral community types, their status and health, the extent of impacts from natural and anthropogenic disturbances and rank the coral reefs for biodiversity conservation value. A team of experts conducted the assessment providing key findings and recommendations along with an overview of the status of Pohnpei's biodiversity and areas of biological significance.

The REA highlighted the main threats to Pohnpei's reefs. Sediment runoff and dredging have caused a major loss of coral cover and diversity at worst affected sites, which have a high cover of fine silt and low water clarity, hindering recovery. Crown of thorns starfish (COTs) were widely distributed, being present in high abundances (approaching outbreak) at several sites. The three major forms of disturbances, sedimentation run-off, dredging (coral reef mining) and predation, have affected species composition and the overall structure of coral reef communities.

Reefs in the Pohnpei lagoon require a more concerted conservation effort. The collaboration between local village communities, government, and non-government will contribute to the future viability of the coral communities and their associated species. This will in turn contribute to the sustainability of fisheries.

## 18.698

**Distribution Of Seagrasses in Coral Reef Area And Their Relationship With Coral**

**SAYUKO NINOMIYA*[1]**, TAKAHIKO INOUE[1], TERUMASA MORISHIGE[1], YOSHIKATSU NAKANO[2], Preetica SINGH[3], YUKA YANO[3], MAKOTO TSUCHIYA[3]

[1]TOKYO KYUEI CO., Ltd, Kawaguchi, Japan, [2]University of the Ryukyus, JAPAN, Motobu, Japan, [3]University of the Ryukyus, JAPAN, Nishihara, Japan

In Okinawa, southern Japan, well-developed coral reefs are extending, and seagrasses are growing in moats. In the present study, we observed and analyzed the growths of seagrasses in some new aspects. While each seagrass species has a characteristic distribution pattern, the area of distribution is generally restricted by water flow environment and substrate type. Large waves generated by a typhoon may be turned into strong currents when passing through the reef crest, and hence seagrass beds of, such as, Cymodocea serrulata may be peeled off from the sea bottom, reducing their distribution areas. We, therefore, analyzed critical current speeds regulating the distribution of seagrasses. In an area where substrate contains rich dead coral gravels, Thalassia hemprichii, that is considered to adapt to such a substrate, was found to form a stable meadow. It was also found that live branching coral, Montipora digitata, contributed to the stability of a seagrass meadow. Further, in areas where the seagrass and the coral coexisted, symbiotic relationship was observed between them.

## 18.699

**Temporal Overview Of Impact Of The 1997-1998 Mass Bleaching On Recovery Of Two Palawan Reefs: Outer Bacuit Bay, El Nido (Palawan Shelf), And Off-Shore Tubbataha (Sulu Sea).**

**Karen Lou FRANCISCO*[1]**, Porfirio ALINO[1], Miledel Christine QUIBILAN[2], Wilfredo LICUANAN[1,3]

[1]UP Marine Science Institute, Quezon City, Philippines, [2]Conservation International, Quezon City, Philippines, [3]Br. Alfred Shields FSC Marine Station, De La Salle University, Manila, Philippines

Impacts of the 1997-1998 mass-bleaching event can be translated to reduced reproductive capabilities and contribution of surviving adult coral colonies, affecting chances of recovery for the coral reef community. For the Palawan shelf reefs of El Nido and the off-shore reefs of Tubbataha in the Sulu sea, the bleaching event was recorded to significantly reduce live coral cover. Six to eight years after, there was a significant difference in recovery rates for both reefs. The diminished, algal-dominated condition of El Nido's reefs post-bleaching corresponded significantly to reduced density of surviving recruits/settlers observed in the 10x10x2 concrete blocks markers monitored every 2 years (1998-2004). Observed changes in the adult benthic community were similarly reflected at small spatial scales (i.e., blocks). Loss or reduction in occurrence of benthic groups (soft corals) and life forms (coral massive) were observed post-bleaching, coincided by increased occurrence of rubble, algal assemblage and sponge -- all representative of an unstable reef environment. Moreover, shifts in relative abundance of benthic algal groups towards macroalgae and algal assemblages in 2002 and 2004 decreased opportunities for successful coral recruitment. Positive correlations were noted with adult coral abundance and coral recruit/settler density. Off-shore Tubbataha reefs (Sulu sea) on the other hand were reported to recover from the mass-bleaching event, as indicated also by a higher and more diverse block recruit/settler density in 2006. Pre-bleaching conditions (i.e., higher coral cover) and relative isolation (from anthropogenic disturbances) of these reefs could have contributed to its recovery rate. Moreover, recruits/settlers observed in Tubbataha exhibited higher post-settlement survivorship and/or faster growth rates than those of the El Nido. In addition, the infrequent occurrence of disturbances post-bleaching in Tubbataha allowed for its further recovery. All these factors contributed to the observed difference between the reefs of El Nido and Tubbataha.

## 18.700

**From Biophysical Research To Mpa Rating – What's The Trend in South-Cebu's And Siquijor's Mpas?**

**Martina KELLER*[1,2]**, Matthias WOLFF[2,3], Rizaller C. AMOLO[1]

[1]Coastal Conservation & Education Foundation (CCEF), Cebu City, Philippines, [2]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [3]Charles Darwin Research Station, Quito, Ecuador

Many local governments recognize no-take marine protected areas (MPAs) as effective tools to address habitat degradation and loss as well as decline in reef fishery production.

In South-Cebu an Siquijor (Visayas, Philippines) alone are over 50 MPAs assisted by their LGUs and the Coastal Conservation and Education Foundation (CCEF). They were established to improve marine habitats and increase fishery resources.

But how are their MPAs doing?

This work assesses the data of MPAs from the CCEF Marine Protected Areas Rating and Database System, provincial governments' reports and technical reports on the current status of MPAs in the said region including trends in MPA rating levels, fish density (inside MPA) and live hard coral cover (inside MPAs) on the reefs off South-Cebu and Siquijor.

50% of the MPAs have an area between 10 and 15ha. Biophysical monitoring data in some MPAs showed an increasing trend in both coral community and reef fish population.

All data was gathered 2005, 2006 and 2007 through the LGUs with the help of MPA rating and fishery survey forms, as well as the Research Monitoring Team (REMOTE) of CCEF via underwater visual census in order to obtain fish density and live hard coral cover data.

## 18.701

**The Distribution, Ecology And Management Status Of Offshore Reef Habitats in Sri Lanka**

**NishanPERERA*1**,ArjanRAJASURIYA2

1ProjectSeahorse,MountLavinia,SriLanka,
2NationalAquaticResourcesResearchandDevelopmentAgency,Colombo,SriLanka

Sri Lanka has a variety of reef habitats that are categorized based on substrate composition. While true coral reefs are among the best known, sandstone reefs, rocky habitats, and offshore coral communities are prominent features within the coastal waters of Sri Lanka and constitute the most extensive reef and hard bottom habitats in the country. Many of these reefs are located offshore, at depths greater than 15m. They are distinctly different from other coral reefs in their habitat and community structure and support diverse faunal and floral communities. Live hard coral coveron offshore habitats is generally low with most ranging from 1% to about 15% while a few habitats may contain 30% to 40% hard coralc over. Most corals are massive, sub-massive and encrusting forms. Fish assemblages tend to be dominated by the families Acanthuridae, Ceasionidae, Labridae, and Pomacentridae. Relatively large numbers of carangids, lethrinids, pomacanthids, serranids, and scarids are also present. Therefore these reefs are important for fisheries, including export oriented spiny lobster fishery and ornamental fishery. However, most offshore reefs have not been adequately studied and there is limited information on their extent, biodiversity and ecology. Consequently, they have received less attention in management efforts and legislation, and are not adequately represented within existing Marine Protected Areas. In addition, to natural reefs, numerous shipwrecks function as artificia reefs and provide refuge for diverse faunal assemblages, and along with offshore reefs are important for recreational diving and tourism. Offshore reefs in Sri Lanka are currently threatened by a variety of anthropogenic and natural impacts that have lead to habitat degradation and depletion of fishery resources. An overview of the distribution, ecology, and management status of offshore reef systems, and the ecological significance of shipwrecks as artificial reefs in Sri Lanka arepresented.

## 18.702

**Evidence Of An Outbreak Of Crown-Of-Thorns Starfish (Cots) in French Polynesia: Observations Between 2005 And 2007**

**Bernard SALVAT*[1]**, Yannick CHANCERELLE[2], Thierry LISON DE LOMA[2], Lucie PENIN[1], Céline STIEVENART[1], Franck LEROUVREUR[2], Annie AUBANEL[3], Christian MONIER[4], Elodie LAGOUY[5], Mehdi ADJEROUD[1]

[1]Biologie et Ecologie Tropicale et Méditerranéenne, Université de Perpignan, Ecole Pratique des Hautes Etudes, UMR 5244 CNRS-EPHE-UPVD, Perpignan, France, [2]Centre de Recherches Insulaires et Observatoire de l'Environnement, Moorea, French Polynesia, [3]Serive de l'Urbanisme IFRECOR, Tahiti, French Polynesia, [4]Service de la Pêche, Tahiti, French Polynesia, [5]Reef Check Polynésie, Moorea, French Polynesia

Outbreaks of *Acanthaster planci* (COTS) in French Polynesia were observed in 1969 and between 1980-1984 where concentrations as high as 110 ind/hectare were observed at Tahiti and Moorea in 1984. Subsequently, outer reef slopes have recovered their pre-outbreak percentage coral cover. According to a general survey carried out at the end of 2006, COTS have increased in abundance on islands of both the Society (Tahiti, Moorea, Bora Bora, Raiatea, Huahine) and the Austral archipelagos (Rurutu), but not for the Tuamotu atolls (Manihi, Rangiroa, Tikehau, Fakarava). In order to evaluate the distribution and abundance of COTS at an island scale, a « manta tow » was developed to survey the outer reef slope along the 95 km perimeter of Moorea. This method consists of evaluating feeding marks and after establishing the correlation between feeding marks and COTS abundance, the density of COTS is calculated. Results from 2006-2007 show a mosaic distribution of COTS around Moorea. The outer slope of Moorea, between 10 and 30 m in depth was divided into sectors 250 m long, parallel with the reef crest. Only a few sectors (10 out of 395), mainly on the North and East coasts, show COTS concentrations above 17 ind, which is lower than in 1984. Other sectors show lower concentrations, of which 117 sectors had less than 2 COTS. A comparison of COTS densities between November 2006 and April 2007 does not indicate that the COTS outbreak is progressing. Nevertheless on some sectors with COTS, coral cover, mainly *Acropora and Pocillopora*, has been reduced by up to 50 %. Future surveys are planned to monitor this event and its consequences.

## 18.703

**Status Of Shallow Water Coral Communities in Little Cayman in 2006-2007**

**Lindsay HUEBNER*[1]**, Carey BATHA[1], Max MULLEN[1], Roy DUCOTE[1], Vania COELHO[1,2]

[1]Central Caribbean Marine Institute, North Coast Road, Cayman Islands, [2]Natural Sciences and Math, Dominican University of California, San Rafael

This study focuses on a comparative analysis of the coral populations in shallow water reefs (1-2 m deep) of Little Cayman, Cayman Islands, in 2006 and 2007. The purpose of this comparison is to understand the temporal dynamics of shallow reef coral communities and analyze the possible influence of the proximity to no-take reserves located in deeper reefs. We conducted surveys of 4 fringing reefs on the north and south sides of Little Cayman, near and far from marine no-take zones located in deeper water (9-15m). Live coral cover, coral diversity, disease, bleaching, mortality, diameter and height were measured of colonies found under 10 m line transects randomly placed on the reefs. We also recorded fish bites and sponge and tunicate overgrowth on corals. A total of 36 and 75 transects, and 458 and 553 corals were analyzed in 2006 and 2007 respectively. We found a statistically significant decline in live coral cover, from 14.8 to 9.5%, a small but significant decrease in mortality from 33.1 to 28.3%, and an increase in sponge overgrowth from 0 to 1.5%. Mean diameter and height were similar over time (~ 36 cm and 18 cm, respectively). No significant differences were observed for bleaching (~3%), disease (~0.5%), fish bites (~0.3%) or tunicate overgrowth (none), however partial bleaching was more common in 2007. No main change in relative abundance of coral genera composition was observed, with *Porites* being the most abundant genus (~ 40% of the corals). Distance from marine no-take reserves had no distinguishable effect on the parameters analyzed in this study.

## 18.704

**Algal Cover And Coral Recruitment in Shallow Reefs in Little Cayman in 2006-2007**

**Lindsay HUEBNER*[1]**, Carey BATHA[1], Max MULLEN[1], Roy DUCOTE[1], Vania COELHO[1,2]

[1]Central Caribbean Marine Institute, North Coast Road, Cayman Islands, [2]Natural Sciences and Math, Dominican University of California, San Rafael

In this study we analyzed algal cover and coral recruitment in shallow water reefs around Little Cayman, Cayman Islands, in 2006 and 2007. We also examined if marine no-take zones had an influence on adjacent shallow water sites (1-2 m deep) regarding upright (fleshy and calcareous) and encrusting calcareous algal cover, as well as coral recruitment. We conducted surveys of 4 fringing reefs (1-2 m) on the north and south sides of Little Cayman, near and far from marine no-take zones located in deeper water (9-15 m). Ten meter long line transects were randomly placed on the reef, and algal cover and number of coral recruits were recorded in quadrats 25 x 25 cm placed every other meter along the transects. In addition, the number of damselfish and *Diadema* found 0.5 meter from the transect line was also noted. A total of 36 and 75 transects, and 180 and 375 quadrats were analyzed in 2006 and 2007 respectively. From 2006 to 2007, there was a significant decrease in fleshy upright macroalgal cover from 17.2 to 12.1% and an increase in upright calcareous macroalgal cover from 5.0 to 7.0%. No other statistically significant changes were observed. From one year to the next mean encrusting calcareous algal cover varied from 9.1 to 5.6%, total upright macroalgal cover from 22.2 to 20.4%, number of recruits from 0.04 to 0.09 per quadrat, *Diadema* from 2.3 to 1.8 per transect, and damselfish from 2.6 to 3.2 per transect. Proximity to no-take zones had no clear effect on the parameters analyzed during the study period.

## 18.705

**Spatial And Temporal Recovery Patterns Of Coral Reefs Within The Gulf Of Oman (Uae) Following The 2007 Cyclone Disturbance**

**Kristi FOSTER*[1]**

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL

In June 2007 Cyclone Gonu, the most powerful storm in the region in 60 years, impacted reefs in the United Arab Emirates along the Gulf of Oman coastline. The extent of destruction of the reef corals varied considerably depending on site, taxa and colony morphology. The most severely damaged sites were completely razed. These included areas that had been dominated by tabular *Acropora clathrata*, some larger than 2m in diameter. Moderately damaged sites included areas of dense monospecific stands of *Pocillopora damicornis* from which individual colonies were dislodged or broken. The least damaged sites included areas with massive colonies of *Platygyra* and *Favia* spp. that survived relatively unscathed, showing little or no signs of scouring or partial mortality. This study describes quantitatively the first stage of recovery of these reefs, two months and twelve months following the cyclone disturbance. Monitoring stations have been installed near Dibba and Fujairah along the northern and southern sections of the UAE coastline, respectively. Each station consists of two primary components; (i) transect markers that create a "Mercedes star" pattern for repetitive photographic surveys along three 10m2 rays, and (ii) a settlement plate rack with horizontal and vertical limestone tiles. Analyses of the transect photographs provide spatial and temporal comparisons such as coral area cover, colony size frequency distributions and colony growth rates. Examination of the settlement plates indicates coral larvae recruitment into the area, which may also indicate future shifts in community structure. Site data such as hourly seawater temperatures measured approximately 0.5m above the reef, sea urchin densities, and rugosity (topographic complexity) are evaluated in relation to the spatial and temporal patterns. While this study focuses on the short-term recovery of these reefs, future studies may continue to track their long-term progression at the permanent monitoring stations.

## 18.706

**Coral Reef Monitoring in the OECS and Tobago**

**Marcia CREARY*[1]**, Joseph MCGANN[2]

[1]Centre for Marine Sciences, University of the West Indies, Kingston 7, Jamaica, [2]MACC Project, Belmopan City, Belize

The objectives of this project was to expand the coral reef monitoring programme started under the CPACC (Caribbean Planning for Global Climate Change) Project to the countries of the Eastern Caribbean. The Centre for Marine Sciences (CMS) of the University of the West Indies (UWI) Jamaica was contracted by the MACC (Mainstreaming Adaptation to Climate Change) Project to oversee this process. Sixteen participants from seven Eastern Caribbean countries (Antigua, Dominica, Grenada, St Kitts and Nevis, St Lucia, St Vincent and Tobago) were trained in coral reef monitoring, using the video monitoring protocol developed under CPACC, in St Lucia during September 2007. Following the training, each country selected a monitoring site and monitoring was conducted (during the period September to November 2007) at these sites under the supervision of resources persons from the CMS. The videotapes were processed and the data are being analysed at the CMS.

This paper will discuss the results of the monitoring exercise for each of the seven countries with reference to the recommendations coming out of the CPACC pilot phase. The paper will go further to highlight the challenges encountered in establishing a regional monitoring programme that meets the needs of the participating countries and will make recommendations on how to use the lesson learnt to ensure country buy-in and continuity.

## 18.707

**Recovery And Current Status Of Coral Reefs Of The Gulf Of Mannar, Southeastern India**

**Edward JK PATTERSON*[1]**, G. MATHEWS[1], Jamila PATTERSON[1], Jerker TAMELANDER[2], Dan WILHELMSSON[3], Olof LINDEN[4]

[1]Suganthi Devadason Marine Research Institute, Tuticorin, India, [2]IUCN Global Marine Programme, Dar es salaam, Tanzania, [3]Stockholm University, Stockholm, Sweden, [4]International Maritime Organization, World Maritime University, Malmo, Sweden

The Gulf of Mannar (GoM) is one of the four major reef areas in India, located on the mainland Southeastern coast and encompassing coral reefs around 21 uninhabited islands. Surveys in 2003-2005, and during March and November 2007 were carried out to assess reef status and trends and population structure. An increase in mean live coral cover from 36.98±13.12% to 41.11±11.62% was observed possibly due to a reduction in human disturbance in the area, in particular a complete halt to coral mining, in combination with high recruitment rates. *Montipora* sp. dominated the assemblages of recruits, with a mean recruit density of 1.98±0.43 per m2 followed by *Acropora* sp. (1.77±0.25 per m2). Other common genera among the recruits included *Pocillopora* sp., *Echinopora* sp., *Porites* sp., *Favia* sp., *Favites* sp., *Pavona* sp., *Merulina* sp., and *Hydnopora* sp. The new recruits represented 6 families and 10 genera. The recruit size class data was derived from very short time series, but fast growth in species such as *Pocillopora* sp., *Montipora* sp. and *Acropora* sp. was evidenced by a shift of cohorts from smaller to larger size classes, e.g. the percentage of recruits in the 0-5 cm size class went from 64.11 in March to 37.23 in November, while share of recruits in the 6-10 cm size class increased from 32.55% to 51.02%; 11-20 cm from 3.37% to 10.71%; and 21-40 cm from 0% to 1.04%. Although a significant increase in live coral cover on the reefs was indicated, efforts have to be taken to manage the reefs in GoM from compounded threats of direct local stress and climate change.

## 18.708

**The Effects Of 2004 Tsunami On Seaweed And Seagrass Community in The Inter-Tidal Rocky Shore And Shallow Sub-Tidal Coral Reefs**

**Anchana PRATHEP*[1]**, Piyalap TUNTIPRAPAS[1], Anuchit DARAKRAI[1], Pimonrat THONGROY[1], Jaruwan MAYAKUN[1], Bongkot WICHACHUCHERD[1], Sutinee SINUTOK[1]

[1]Department of Biology, Prince of Songkla Unviersity, HatYai, Thailand, HatYai, Thailand

The 26th December, 2004 tsunami hit 6 Andaman provinces in southern Thailand, caused great damage to life, property and coastal resources. Here we examined the effect of tsunami on seaweed and seagrass biodiversity at 2 sites: 1) Talibong island, Trang province and 2) Sirinart Marine National Park, Phuket province. These two study sites are monitored by seaweeds and seagrass research unit, Prince of Songkla University for over 3 years, thus the baseline data before the tsunami are provided. At Talibong island , fifteen of 50 cm x 50 cm quadrats were mapped and monitored in the shallow sub-tidal coral community, seaweed diversity and abundance in each plot were investigated. While, Ten of line transects were used to investigate diversity and distribution of seaweeds and seagrasses at Sirinart Marine National Park, an inter-tidal habitat. These dataset would allow us to assess the effects of tsunami on diversity, percentage cover of seaweed and seagrass before and after the tsunami; and the effects of the tsunami on the different sites. The results showed that diversity and percentage cover of seaweeds and seagrasses dropped by 50% after the tsunami at both sites. There were differences in the effect of tsunami on seaweed and seagrass species, depending on morphology and structure. Seagrass could recover after a few months after the tsunami, while seaweeds have not recovered yet after two years of tsunami catastrophe. We also reported the status of nearby coral reefs community, which hit by the tsunami, some of which were badly effected and showed no recovery yet.

## 18.709

**Change And Resilience At Stetson Bank, A High Latitude Coral Community in The Gulf Of Mexico**

**George SCHMAHL*[1]**, Jennifer DEBOSE[1], Emma HICKERSON[1]

[1]NOAA, Flower Garden Banks National Marine Sanctuary, Galveston, TX

Stetson Bank, located near 28.2° N, 94.3° W in the northwestern Gulf of Mexico, 70 miles offshore of Galveston, Texas, is an uplifted claystone feature associated with an underlying salt dome. Rising from surrounding water depths of over 180 feet, Stetson Bank crests within 50 to 80 feet of the surface. Due to the influence of the warm, clear waters of the Gulf Stream loop current, Stetson Bank supports a well-developed benthic community comprised of tropical marine sponges, coral and other invertebrates. Living coral cover can comprise up to 30% of the reef surface. The predominant species is the hydrozoan *Millepora alcicornis* (fire coral), although eleven other species of hermatypic corals have been documented. Sponges, primarily *Chondrilla nucula*, *Ircinia strobilina*, and *Agelas clathrodes*, comprise up to another 30% of the substrate. A long-term monitoring program was initiated in 1993 consisting of over 60 permanently marked stations on the reef surface that are photographed annually and analyzed for changes in community structure and benthic cover. Until 2005, the benthic community of Stetson Bank showed remarkable stability. However, in the summer of 2005, significant mortality of coral was documented in association with a major bleaching event in the Gulf of Mexico. In addition, the area was subject to significant coastal runoff resulting from two major hurricanes (Katrina and Rita). The living cover of fire coral at Stetson Bank was significantly reduced as a result of these impacts. Sponges were not significantly affected. Surprisingly, by 2007, coral cover had substantially recovered. The resiliency demonstrated at Stetson Bank is hypothesized to be due to its offshore location, relative stability of most environmental factors, and depth. Although subjected to similar water temperature regimes in previous years, the synergistic effect of both coastal runoff and elevated temperature may have contributed to mortality in 2005.

## 18.710

**Corals And Coral Reefs Of The National Marine Sanctuary System: Living Laboratories For Coral Reef Science And Conservation**

**William KIENE*[1]**

[1]South East, Gulf of Mexico and Caribbean Region, NOAA/National Marine Sanctuary Program, Galveston, TX

The US National Marine Sanctuary System is the largest network of marine protected areas in the world, managing an unprecedented range of temperate and tropical marine ecosystems. Differing in their physical, biological, and human settings, the sanctuaries are linked by common local and global threats to their integrity. As a consequence, the sanctuary network provides an important living laboratory for exploring the biological, ecological and social consequences of environmental disturbances and change to marine ecosystems, and of the management actions that respond to them.

The Sanctuary System embraces coral reef ecosystems representing a wide range of reef assemblages, biological diversities, and settings. The Florida Keys, Flower Gardens Banks, Fagatele Bay National Marine Sanctuaries, and the Papāhanaumokuākea Marine National Monument are widely separated coral reef management areas encompassing a range of Pacific and Caribbean coral reef assemblages that face comparable environmental threats. Gray's Reef National Marine Sanctuary, at the northern margin of Atlantic coral development, is a sensitive gauge of environmental change and the subsequent response by a reef ecosystem. The deep-water coral ecosystems of the Olympic Coast and other sanctuaries are buffered from some of the stresses faced by shallow water coral ecosystems and are important measures of the breadth of change to the global ocean.

This large system of protected areas is a crucible for investigating reef ecosystem vulnerability and resilience at sites with different biological structures and diversities. Through its network of facilities, interagency partners, research vessels, scientists, and outreach capability, the Sanctuary Program seeks collaborations to understand the functions and responses of key ecological relationships in its different settings, and to help design, implement, and evaluate conservation strategies for an important set of the world's coral reefs.

## 18.711

**Long-Term Monitoring Of A High-Latitude Coral Reef System Off Southeast Florida, Usa: A Partnership Between Academia And Resource Management**

**David GILLIAM*[1]**, Kenneth BANKS[2], Michael CALLAHAN[3], Chantal COLLIER[4], Richard DODGE[1], Louis FISHER[2], Jennifer WHEATON[3]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania, FL, [2]Broward County Environmental Protection Department, Plantation, FL, [3]Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, St Petersburg, FL, [4]Florida Department of Environmental Protection, Coral Reef Conservation Program, Miami, FL

Significant coral reef community development exists along the eastern shelf of the United States from the Dry Tortugas through the Florida Keys (Monroe County) and Southeast (SE) Florida (Miami-Dade, Broward, Palm Beach, and Martin Counties). State and county resource managers have partnered with academia to monitor the health of the SE Florida reef system. Since 2000, more than 20 sites have been monitored annually offshore Broward County. Quantitative data includes stony coral species cover, colony size, density, and condition (bleaching, disease, etc.) and gorgonian and sponge density. The SE Florida Coral Reef Evaluation and Monitoring Project (SECREMP) was established in 2003 as an expansion of the Florida Keys Coral Reef Evaluation and Monitoring Project (CREMP). Thirteen SECREMP sites are monitored annually across the 4 SE Florida counties. The stony coral, gorgonian, sponge, and other functional group cover data collected within the SECREMP sites and the Keys CREMP sites provides status and trend information for the entire Florida reef tract. The SE Florida reef system typically has 2-4% stony coral cover with more than 30 stony coral species and a diverse assemblage of octocoral, sponges, and fishes. Since their inception, monitoring efforts have shown relatively stable levels in stony coral cover and density. However, there have been many impacts to the SE Florida ecosystem resulting from its proximity to the highly developed and urbanized SE Florida coast. These reefs are influenced by many factors including commercial and recreational fishing and diving, major shipping ports, sewer outfalls, ship groundings, and coastal construction activities. SE Florida's coral reef ecosystems generate $1.1 billion in annual income and support 36,000 jobs in the region. The uniqueness and value of these resources to the community demands sustained cooperative monitoring efforts and increased investigations into limiting environmental/ecological processes.

## 18.712

**An Investigation Of Eight Years Of Coral Reef Data From Melanesia And South East Asia: Vitality, Percent Coverage, Reef Area And The Effects Of A Tsunami**

**M. Katie OLDS*[1]**, Phil DUSTAN[1]

[1]Grice Marine Laboratory, College of Charleston, Charleston, SC

Coral reefs are the most biologically diverse and ancient ecosystems on earth. Recent reports show that coral reefs are facing significant environmental stresses most of which are of anthropogenic origin. The Planetary Coral Reef Foundation (PCRF) set up a long-term coral reef data collection project using methods developed by Dr. Phil Dustan in 1995. Since 1995 PCRF's research vessels have visited coral reefs worldwide, and in some cases have returned to several study sites to create a timeline of data for particular reefs. In this study we aim to analyze the data from repeated study sites to determine long term change on those reefs regarding vitality, percent live hard coral coverage and reef area. Data analysis will be compared to predicted changes set forth by the model "Reefs at Risk" (Bryant et al. 1998). In this study we also aim to determine the effects of the tsunami event on 1 April 2007 in the Solomon Islands. The epicenter of the earthquake was only kilometers away from the study site in the Solomon Islands for which we have three pre-tsunami data sets. We will return to the Solomon Islands for the final, post-tsunami study. Findings of this study will distinguish local and planetary stresses to coral reefs and reveal the levels of these stresses coral reefs may have faced over the past eight years.

## 18.713

**Diversity And Spatial Distribution Of The Macrobenthic Organisms At The Ponta Verde Coral Reef, Maceió, Alagoas, Brazil**

**Monica CORREIA*[1]**

[1]Biodiversidade & Ecologia, Universidade Federal de Alagoas, Maceió - Alagoas, Brazil

The macrobenthic spatial distribution at the Brazilian coral reefs is poorly known, but in these ecosystems have high endemic Scleractinia corals and others invertebrate. In this paper, the macrobenthic spatial distribution on the intertidal zone at the Ponta Verde coral reef, Maceió city, Alagoas State, northeast of Brazil, was characterized. The qualitative and quantitative data were obtained by the video-transect technique, along 7 transverse transects and 3 other parallel transects to the coastline, during low tide when of approximately 1 km2 the reef platform was exposed. There were 26 macrobenthic taxa chosen for spatial distribution analysis, based on the coverage percentage. The Surf System 6.04 Program was used to identify the patches and other analyses were based on the Bray Curtis index with UPGMA. The data showed some different patches, with the most significant quantitative taxa registered being *Zoanthus sociatus* and *Palythoa caribaeorum* for the macrofauna, and among the macroflora, *Halimeda opuntia* and *Sargassum cymosum*. Species richness was noted to have a progressively diminished the reef border. Shannon diversity index indicated an independent behavior of the total number of taxa and also evenness. The cluster analysis identified seven associations of which the most significant were the Scleractinia corals *Agaricia agaricites* - *Porites* spp at the north zone and also along the reef border two associated organisms *Palythoa caribaeorum* - *Gelidiela sp* and *Caulerpa racemosa* - *Bryopsis* sp were observed. The hypothesis of macrobenthic heterogeneous colonization by patches was confirmed at the Ponta Verde coral reef, on the coast of Maceió city. The spatial distribution was related to the capacity of these organisms to survive the environmental stress caused by the tide variation and hydrodynamic intensity, but the effects made by human action should still be considered, because this coral reef is located on an urban site.

## 18.714

**Pacific-Wide Status Of The Rare/endangered Humphead Wrasse (Cheilinus Undulatatus) And Bumphead Parrotfish (Bolbometopon Muricatum)**

**Brian ZGLICZYNSKI*[1]**, Robert SCHROEDER[2], Marc NADON[2], Benjamin RICHARDS[2]

[1]Coral Reef Ecosystem Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Coral Reef Ecosystem Division, JIMAR-Univ. of Hawaii and NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI

Biennial in *situ* surveys (2002-2007) of the International Union for Conservation of Nature (IUCN) Red Listed humphead wrasse (*Cheilinus undulatus*, IUCN: endangered) and bumphead parrotfish (*Bolbometopon muricatum*, IUCN: vulnerable) were conducted at 32 U.S. Pacific Islands including portions of the Line and Phoenix Islands, Wake Atoll, and the American Samoa and the Mariana Archipelagos. Belt Transect, Stationary Point Count (SPC), and Towed-diver survey methods were use to assess abundances of these fishes. Both species were not commonly observed at any of the islands, with *C. undulatatus* observed at 22 (69%) of the islands and *B. muricatum* encountered at only 6 (19%) of the islands and atolls within the known range of the species during the survey period. Densities for both species were higher at remote sites (i.e., sites geographically located far from human population centers and direct anthropogenic impacts) than around population centers. Highest densities were found at Wake Atoll with 1-12 *C. undulatatus* and 1-7 *B. muricatum* observed per ha. These observations provide the first comprehensive report on the status of these two live reef fishery targets in the U.S. Pacific Islands and provide a scientific baseline for their management.

## 18.715

**Effects of Indigenous Communities and Agriculture on Coral Reef Composition in the Western Gulf of San Blas, Panama**

**April HELMS*[1]**, Michelle DARE[2], Shara JONES[3], James ENGMAN[1]

[1]Department of Biology, Henderson State University, Arkadelphia, AR, [2]Department of Plant Biology, University of New Hampshire, Dover, NH, [3]College of Law, Lewis and Clark College, Portland, OR

Reefs in the autonomous Kuna Yala region of Panama have been considered less impacted than most in the Caribbean, due to reduced levels of fishing pressure, and minimal development, deforestation and agriculture in adjacent coastal areas. Sites near densely populated Kuna islands lacking wastewater treatment, or near agriculture, however, may have potential for significant impact and degradation. In July of 2005, 2006 and 2007, reef community composition was surveyed at twelve near-shore sites in Kuna Yala, and one site in adjacent Colon Province, where coastal populations and anthropogenic disturbance are much higher. Sites were classified *a priori* as *less impacted, more impacted* or *highly impacted*, based on proximity to population centers, agriculture and sources of mainland runoff. Seven sites in Kuna Yala were considered less impacted, five more impacted. The Colon site was considered highly impacted. Data for each site/date were obtained by point sampling techniques using freeze-frame images from replicate video transects over shallow (1-5m), well-developed reef. A 6-factor Principal Components Analysis (PCA) was conducted using Shannon diversity of coral, percent coral cover, algal abundance, dead coral cover, abundance of branching coral (*Acropora* spp.) and abundance of weedy coral (*Millepora* spp. and *Agaricia* spp.) as variables. The first two axes of ordination explain 78% of the variation, and clearly segregate sites based on impact levels. Community composition of the most degraded site within Kuna Yala is similar to the highly impacted Colon site in its abundance of fleshy algae (46%), low coral cover (21%), dominance of coral by weedy species (80%) and virtual absence of branching coral colonies. Highest coral cover (65%) and lowest fleshy algal cover (6%) were observed at a relatively remote site (Hollandaise Reef) classified as less impacted.

## 18.716

**Population Status Of Acropora Corals in The Florida Keys**

**Steven MILLER*[1]**, Mark CHIAPPONE[1], Leanne RUTTEN[1], Dione SWANSON[2]

[1]Center for Marine Science, University of North Carolina - Wilmington, Key Largo, FL, [2]RSMAS, University of Miami, Miami, FL

Population declines of staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*) are often-cited examples of Caribbean reef changes since the 1970s. Disease, bleaching, and localized effects from storms and predation have been the principal agents of change. Both species were formally added in 2005 to the U.S. Endangered Species List as threatened based upon range-wide population declines and poor recovery. A spatially intensive survey of the habitat distribution, colony abundance, size, and condition of both species was undertaken, first in the upper Florida Keys at 107 sites during 2006, followed by a larger-scale survey of 235 sites spanning over 200 km of the Florida Reef Tract in 2007. A two-stage stratified random sampling design incorporated multiple habitats and no-fishing management zones from the inner shelf margin to the deeper (15 m) fore reef. Four belt transects 15-m x 1 m in dimension yielded data on species presence-absence, colony numbers, size, and condition, as well as data on depth, vertical relief, and the prevalence of *Coralliophila* predation. *A. cervicornis* was more widely distributed among sites and habitats, but less abundant per site, than its congener. *A. cervicornis* was particularly abundant on patch reefs, with a maximum site-level density of 1.22 colonies/m2 and surface area coverage of 2%. In contrast, *A. palmata* was most abundant on shallow spur and groove reefs, with site-level densities up to 1.25 colonies/m2 and surface area coverage up to 25%. Although the prevalence of disease-like conditions is relatively low, both species continue to suffer predation by corallivorous snails and damselfishes, as well as physical impacts from lost fishing gear. Predicting the future of these two species in Florida requires information about both their present-day ecology and geologic history in the region.

## 18.717

**The Jamaica Coral Reef Monitoring Network (Jcrmn)**

**Marcia CREARY*[1]**

[1]Centre for Marine Sciences, University of the West Indies, Kingston 7, Jamaica

The Jamaica Coral Reef Monitoring Network (JCRMN) was launched in June of 2003 by twelve agencies, institutions and organizations involved in coral reef monitoring, research and/or management. The genesis of the JCRMN was borne out of the need to gather information about the coral reefs surrounding the island of Jamaica, particularly on the south coast. The primary objectives of the JCRMN are to stimulate interest in the monitoring of the Jamaican coral reefs, train persons in coral reef monitoring methodologies and to develop a sustainable coral reef monitoring programme for the island.

Since its inception the JCRMN has been able to acquire funds to conduct monitoring in the Portland Bight Protected Area on the south coast to provide information for planning and management. They have also participated in training and monitoring in Haiti and reconnaissance visits to the Pedro Cays, 50 miles south of Jamaica. In addition, approximately 30 divers, including members of Environmental Non-Governmental Organizations (ENGOs), hotel resorts and scuba diving clubs, have been trained in the Reef Check Method of coral reef monitoring. Of significance is that all the persons taking part in the monitoring exercises do so on a voluntary basis, allowing the funds received by the JCRMN to be used for diving and monitoring equipment, boat usage and other expenses. Despite the success of the network the development of a sustainable monitoring programme based on external funding and volunteer divers remains the biggest challenge facing the JCRMN. The JCRMN is coordinated through the Caribbean Coastal Data Centre (CCDC) of the Centre for Marine Sciences at the University of the West Indies, Jamaica.

## 18.718

**Long-Term Benthic Monitoring in The Tortugas, Florida: Protected Vs. Open Areas**

**Greg PINIAK*[1]**, Shay VIEHMAN[1], Christine ADDISON[1], Nicole FOGARTY[2]
[1]NOAA, Beaufort, NC, [2]Florida State University, Tallahassee, FL

Energy flow across reef-sand boundaries is critical to understanding reef function, as many fish species shelter on the reef but forage in adjacent soft-bottom habitats. As the majority of the Tortugas Ecological Reserve (TER) is non-coral habitat, the structure and composition of fish communities near the reef interface may be a likely area to detect a reserve effect. To test this hypothesis, ten permanent monitoring sites were established along the deep (15-32 m) reef-sand interface in each of three management strata—TER, Dry Tortugas National Park (DTNP), and unprotected areas. Percent cover for benthic taxa was determined from 2001-2007 via point-count techniques using digital imagery collected along the same 30-m transects used for fish community surveys. Macroalgae were the most common biological component, with an average cover of 25-33% in a given year. Coral cover was 5-6% in each year but was highly variable among sites, ranging from 0-24.5%. Coral cover in TER was typically twice that of the other strata, but statistical tests for management effects and temporal trends were generally insignificant due to variability associated with the random site selection techniques. After re-analysis of data using multivariate techniques to compare sites independently of management regime, soft substrate, macroalgae, and coral explained the majority of the variability among sites in principal component analysis and were the major clustering factors in Bray-Curtis similarities, although the relative roles of the major benthic categories were inconsistent over time. Logistics and bottom time constraints required that benthic and fish data be collected simultaneously; consequently this study demonstrates the challenges created when field sampling approaches are driven primarily by fish community surveys rather than optimized for benthic data collection.

## 18.719

**Monitoring and Assessment - The Caribbean Coastal Data Centre**

**Marcia CREARY*[1]**
[1]Centre for Marine Sciences, University of the West Indies, Kingston 7, Jamaica

The Caribbean Coastal Data Centre (CCDC) is in its seventh year having evolved from being the Data Management Centre (DMC), archiving data for the CARICOMP project, to being the repository of data from a number of local and regional studies. With respect to CARICOMP, the CCDC continues to process and archive data on the coastal ecosystems (coral reefs, mangroves, seagrass and water quality) from institutions around the region. The expanded portfolio of the CCDC includes the housing of data from other local and regional sources such as AGRRA, CPACC, the Northern Caribbean and Atlantic Node of the GCRMN among others. One of the important initiatives of the CCDC is the establishment of the local arm of the Global Coral Reef Monitoring Network (GCRMN, the Jamaica Coral Reef Monitoring Network (JCRMN), formed in 2003 in an effort to establish a comprehensive coral reef monitoring programme for Jamaica. The composition of the network includes academic, governmental and non-governmental institutions involved in the management and monitoring of the islands coastal resources. Volunteer divers, using the Reef Check methodology assessed 16 sites around the island and five sites in Haiti.

## 18.720

**Effects Of Benthic Cyanobacteria On Se Florida Coral Reef Gorgonian Populations**

**Vanessa BRINKHUIS*[1]**, Jenna LUEG[1], Lauren FLOYD[1], David GILLIAM[1]
[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL

In 2002, the presence of benthic cyanobacteria (genus *Lyngbya*) was observed within annual coral reef monitoring sites off Broward County, southeast Florida. Thick filamentous mats were observed entangled and growing upon gorgonians (sea whips, fans, plumes and rods) and substratum within the permanent monitoring transects. The observed effects of *Lyngbya* on gorgonians included smothering of tissues causing bleaching and/or necrosis, which appeared to lead to partial mortality or complete mortality in severe instances when the entire colony was covered. The annual coral reef monitoring protocol includes taking images along permanent 30 m2 belt transects. From 2000 to 2007 images from 20 monitoring sites were analyzed to determine the percent of gorgonians present with *Lyngbya*, and NCRI developed CPCe software was used to estimate *Lyngbya* percent cover. Gorgonian densities within the belt transects were recoded in situ. From 2002-2007, *Lyngbya* was present in a least 6 monitoring sites. The height of the *Lyngbya* bloom occurred in 2003, which had the highest yearly percent cover (15%) and greatest occurrence within the monitoring sites (present at 16 of 20 sites). Two sites that exhibited the highest percent cover of *Lyngbya* in 2003 (87% and 71%) experienced a decrease in gorgonian density the following year. Most other sites with moderate *Lyngbya* percent cover followed this trend as well. The ability to capture these types of events is an important part of coral reef monitoring projects. This information will aid resource managers in making policy decisions on issues such as water quality which affect the health of coral reef resources.

## 18.721

**Monitoring, Reporting, And Conservation: A User's Guide For Applying Results From *the State Of Coral Reef Ecosystems Of The United States And Pacific Freely Associated States* To Coral Reef Management**

**Jeannette WADDELL*[1]**, Alicia CLARKE[1]
[1]Center for Coastal Monitoring and Assessment, NOAA, Silver Spring, MD

NOAA's publication of a series of reports that uses ecosystem monitoring data to describe the current condition of U.S. coral reef ecosystems represents a significant contribution to the conservation and management of the nation's coral reefs. The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005 and 2008 reports integrate the key findings of coral reef ecosystem monitoring programs undertaken by Federal, State, Territorial, Commonwealth, non-governmental, private, and academic partners. Data from the various monitoring efforts are organized into jurisdictional chapters to characterize local impacts of key threats, summarize the results of assessment and monitoring activities, and describe local and national management actions to conserve coral reefs. Since publication of the 2005 report, monitoring data have been used to justify a number of conservation management initiatives in U.S. jurisdictions, as illustrated through examples from Hawaii, American Samoa, and other locations. Ongoing monitoring and assessment programs continue to provide data that further support conservation efforts by helping to identify the scope and magnitude of key threats and quantify ecosystem responses to them, delineate specific areas where negative impacts have and have not occurred, share successful conservation approaches, and compare costs and benefits of particular management strategies. In addition, the report educates scientists, managers, decision makers, and the public about the deteriorating condition of U.S. coral reefs while motivating them to take action to conserve these precious natural resources.

## 18.722

**Quantitative Underwater Ecological Surveying Techniques (Quest): The University Of Hawaii Marine Option Program -Training Tomorrow's Underwater Scientists**

Jeffrey KUWABARA[1], **Donna BROWN*[2]**

[1]Marine Option Program, University of Hawaii, Honolulu, HI, [2]Marine Option Program, Maui Community College, Kahului, HI

The University of Hawaii Marine Option Program (MOP) offers a unique reef monitoring class each summer on Hawaii's Kona Coast called QUEST (Quantitative Underwater Ecological Surveying Techniques). For two weeks, students learn a variety of surveying methods, safe scientific scuba diving practices, teamwork, and leadership skills. Preparation for this course includes a University of Hawaii Scientific Diver in Training authorization and learning to accurately identify some 200 species of common Hawaiian reef fishes, invertebrates, and seaweed. First year students work as part of a team to collect and analyze data, and to write and present scientific reports. Second year students gain valuable leadership skills by acting as team leaders. This class serves as a source of well trained scientific divers for Hawaii's Division of Aquatic Resources, the National Marine Fisheries Service's Honolulu Laboratory, and various diving projects at the University of Hawaii. QUEST exemplifies the Marine Option Program's mantra of experiential ocean education.

## 18.723

**The Effects Of Hurricane-Deposited Mud On Coral Communities in Florida**

**Cheryl MILLER*[1]**, Vladimir KOSMYNIN[2]

[1]Coastal Eco-Group Inc., Fort Lauderdale, FL, [2]Bureau of Beaches & Coastal Systems, Florida Department of Environmental Protection, Tallahassee, FL

Reefs and hardbottom communities with variable coral cover are widespread in the upper shelf of Florida. From August 14 to September 26, 2004, four hurricanes (Charley, Frances, Ivan, and Jeanne) impacted the Florida shelf and coastline. Widespread accumulation of mud on nearshore hardbottom was recorded during biological monitoring surveys for beach nourishment projects from Cape Canaveral to Miami along the Atlantic coast and from Naples to St. Petersburg along the Gulf of Mexico coast. Permanent video transects and photo surveys were used for this study along with in-situ measurements of mud layer thickness. The surveys have indicated the deposition of a relatively thin layer of fine sediments over extensive areas of hardbottom and thick accumulations at the base of scarps and ledges. Storms suspend this fine material, resulting in turbid nearshore waters for long periods. The effects have been lethal for many filter-feeding species, while photosynthetic activity and recruitment opportunities were reduced for most benthic species. Measurements of mud accumulation were performed in 2006 and 2007 on a nearshore artificial reef in Indian River County. Monitoring demonstrated significantly higher cover and diversity of macroalgae at the artificial reef placed in 2005 as compared to the portions of reef placed just prior to the 2004 hurricanes. The high adhesive capacity of the mud particles has enabled sediments to survive as a compact layer through the winter storms of 2004 through 2007. The 2007 monitoring data suggests significant mortality of octocoral recruits due to the smothering effects of mud, indicating that octocorals are not surviving beyond two to three years in this environment. It is possible that the impact is even more widespread than suggested by these surveys. It is hypothesized that the sediments were transported by hurricane-generated waves and currents from the deeper parts of the shelf.

## 18.724

**Preliminary Assessment Of Elkhorn Coral (Acropora Palmata) in Caye Caulker Marine Reserve And Adjacent Waters**

**Ellen MCRAE*[1]**

[1]The Siwa-ban Foundation, Caye Caulker, Belize

Elkhorn Coral (*Acropora palmata)* is a robust branching coral species occupying areas featuring high levels of wave action such as reef crest and flat areas, in shallow (1-17, optimally 1-5 m) water. The species along with its congener *A cervicornis* was recently listed (ESA) due to decline throughout its range. Two major weather events -Hurricanes Mitch (Oct 1998) and Keith (Sep-Oct 2000)- as well as close passes by other more recent tropical storms and near-miss hurricanes and other climate change driven events have combined with other direct and indirect impacts on and near the 7-km-long island of Caye Caulker to cause noticeable yet unquantified reduction in the abundance and quality of reef corals in the area during the past 25 years. No rules against extractive activities other than general Fisheries Regulations have as yet been enacted within Caye Caulker Marine Reserve (CCMR), however they have been proposed and await passage by GOB. Shallow backreef, patch and crest habitat were surveyed Oct-Dec 2003 preparatory to a project updating the Integrated Management Plan for CCMR and its terrestrial counterpart Caye Caulker Forest Reserve. Visual surveys were undertaken in shallow (1-6m) reef habitats using mask and snorkel. Abundance, condition and size of Elkhorn colonies/stands were assessed. 15 of 18 sites (83.3%) evidenced living *A palmata* in some form. Most of these sites (66.6%) featured recruits/young colonies, while extensive living or partially living stands including resheeted areas of *A palmata* were noted on 33.4%. Further survey has been designed to confirm current status of these sites as well as visit areas not visited during the initial REA. An investigation into the physical and biological forces acting on certain well-preserved sites is herein proposed to determine factors present at these sites.

## 18.725

**Status Of Coral Reefs in The British Virgin Islands**

**Clive PETROVIC*[1]**, Trish BAILY[2], Shannon GORE[3]

[1]Econcerns, Ltd., Road Town, Virgin Islands (British), [2]Ecosail, Ltd, Road Town, Virgin Islands (British), [3]Conservation & Fisheries Dept., Govt of the BVI, Road Town, Virgin Islands (British)

Approximately 60 small islands and cays comprise the British Virgin Islands. Located on the eastern portion of the Puerto Rican Bank,this archipelago occupies 150 km2 of land on a shallow shelf of over 3000 km2. Most of the reefs in the Territory remain in relatively good condition, although there has been significant localized deterioration. Natural events, such as the passage of numerous Tropical Storms and recent bleaching have caused considerable damage around the larger islands. Anthropogenic impacts are the major cause of reef deterioration in the Territory. These impacts have increased dramatically in the last two decades. Certainly, the greatest threats to the reefs come from land-based sediments. Construction activities on small islands, where erosion control measures are virtually non-existent, release sediments into coastal waters. Sewage treatment remains in the planning stages. Thus, run off from septic tanks and sewage outfalls introduce excess nutrients into marine systems. Since landfills and incineration are inadequate to cope with the increasing solid waste disposal problems, oil, hazardous materials and other pollutants frequently contaminate near shore marine communities. Overfishing of commercially important reef species continues to be a problem and is aggravated by the demands of a booming tourism industry. Additional impacts include anchor damage by yachts, snorkelers on sensitive reefs, and coastal dredging projects. Despite these problems, efforts are underway to address specific issues and minimize impacts. Legislative reforms and enforcement of existing regulations are underway. Government departments and NGO's are increasing committments to environmental protection. Initiatives are underway to deal with sewage and solid waste disposal. Long term reef monitoring by the Conservation Department, National Parks, Guana Island Sanctuary, Reef Check, and others is providing data for future management decisions. Collaborative arrangements combining local organizations with external expertise from the UK and elsewhere are essential for the success of reef conservation efforts.

## 18.726

**Status Of Near Shore Reefs in The Bahamas: Past And Present Impacts On Benthos And Fish**

**Kathleen SEALEY*[1,2]**, Nicolle CUSHION[1], Vanessa NERO[3], Kathleen SEMON[4]

[1]Biology, University of Miami, Miami, FL, [2]College of The Bahamas, Nassau, Bahamas, [3]Biscayne National Park, Miami, FL, [4]Smithsonian Marine Station, Fort Pierce, FL

A decadal-long study of the near shore reefs on six islands throughout the Bahamian archipelago was completed to understand the variability and structure of these reef habitats most vulnerable to impacts of coastal development. Corals and other benthos existing in near shore habitats experience any negative impacts stemming from onshore development. Reefs occurring close to coastlines naturally face: 1) high sea surface temperatures of extremely shallow waters, 2) periodic high turbidity caused by heavy rainfall or storm events, and 3) high nutrient efflux from land-based detritus. Near shore reefs should therefore act as more sensitive indicators of impacts attributable to land-based sources of pollution and coastal development as they are inherently less sensitive to both acute and chronic stressors. Consequently, near shore fringing and patch reefs, as well as near shore hard bottom (hardbar) communities were mapped and evaluated for the islands of Guana Cay (Abacos), North Andros, South Andros, New Providence, Eleuthera, and Exuma. Multi-year surveys of benthos (coral and algae) as well as fish were analyzed looking at historial disturbances (hurricanes or major dredging events), current land use and rank of coastal impacts. The islands varied in location and size; there are island-specific reef species assemblages, and these unique assemblages are altered most significantly by recent hurricane events and major changes in coastal land use. Differences in near shore reef assemblages are seen both on a north-south as well as east-west gradient. A comparison of within vs. between island differences illustrated the importance of long-term environmental history of any given island system. Degraded (low diversity and abundance of benthos and fish) near shore reef habitats occur adjacent to islands with the most altered coastal zone, and appear to be particularly vulnerable to invasion of invasive species (such as Indo-Pacofic lionfish).

## 18.727

**Biological Characterization Of Coral Reefs, Coral Communities And Associated Habitats Of The Northwestern Gulf Of Mexico**

**G.P. SCHMAHL*[1]**, Emma HICKERSON[1], Douglas WEAVER[1]

[1]Flower Garden Banks National Marine Sanctuary, Galveston, TX

Rocky outcrops and hard-bottom banks are common on the continental shelf throughout the northwestern Gulf of Mexico (NWGOM). The biological communities associated with these features range from tropical coral reefs to coralline algae reefs, and deep coral habitats. The reefs and banks of the NWGOM were thoroughly studied in the 1970's and 1980's, and resulted in the first comprehensive classification of benthic communities associated with these features. Select sites in the NWGOM have been the focus of recent mapping, remotely operated vehicle (ROV) and submersible surveys, and biological sampling by the Flower Garden Banks National Marine Sanctuary (FGBNMS). These recent efforts have identified the need to moderately revise the previous biological characterization scheme. A new habitat classification system is proposed that incorporates the new information. This update will include charts depicting the major biological zones within the FGBNMS, along with a description of each zone, including major habitat types, associated biological communities, and geomorphological descriptors. Representative high resolution images of each zone will also be presented.

## 18.728

**Impacts Of Non-Point Source Sewage Pollution in Elkhorn Coral (Acropora Palmata) Assemblages Of The Southwestern Puerto Rico Shelf.**

**Edwin HERNANDEZ-DELGADO*[1]**, Betzaida SANDOZ[2], Michelle BONKOSKY[2], Jose NORAT[2], Hernando MATTEI[2]

[1]Biology, University of Puerto Rico, San Juan, Puerto Rico, [2]Environmental Health, University of Puerto Rico - Medical Sciences Campus, San Juan, Puerto Rico

Non-point source sewage pollution is a major cause of concern, particularly near coral reefs and reef-associated communities. Sewage negative effects are typically associated to chronic eutrophication and water turbidity. These conditions can produce variable system-specific responses, as well as cascading direct and indirect effects that could result in major long-term phase shifts in coral reef benthic community structure. This study was aimed at documenting what is the actual ecological condition of eight coral reef communities located across a non-point source sewage pollution gradient along the southwestern Puerto Rico shelf. Emphasis was placed on shallow-water (<5 m) reef assemblages formerly dominated by threatened Elkhorn coral, Acropora palmata. This study showed unequivocal evidence that coral reefs along a significant portion of the southwestern Puerto Rico shelf are being severely impacted by non-point source sewage pollution, mostly from human origin. The combination of historic natural factors (i.e., hurricanes), with long-term non-point source sewage pollution pulses, and other potential anthropogenic reef degrading factors, such as sedimentation pulses and overfishing, have contributed to a dramatic phase shift in coral reef community structure. Phase shifts have favored dominance by macroalgae and non reef-building taxa, particularly at inshore locations. Acropora palmata and crustose coralline algae (CCA) are dominant at offshore remote reefs. Maroalgae, zoanthids and octocorals are dominant at inshore stressed sites. Such degradation is already beyond recovery for most inshore reefs. Further, there was no significant difference in benthic community structure, as well as in most individual community parameters, between management regimes (i.e., Marine Protected Area vs. non-MPAs). Coral reef communities within local MPAs are also undergoing severe degradation as a result of non-point source sewage pollution and points out the lack of adequate management of water quality degradation across the region. Non-point source pollution is a key stressor structuring local coral reef communities.

## 18.729

**Status Of Coral Reefs in North East Asia**

**Tadashi KIMURA*[1]**

[1]Japan Wildlife Research Center, Tokyo, Japan

To monitor and evaluate the condition of coral reefs of the world, Global Coral Reef Monitoring Network (GCRMN) has established Node and Regional Coordination System to enforce coral monitoring in individual countries. China, Korea and Japan form North East Asian Region of the GCRMN system.

Since the latest global report on coral reef status was published in 2004, the condition of corals in this region has been still under high pressure of several disturbances. Outbreaks of crown of thorns starfish have been recorded in subtropical area in China and Japan. In Hong Kong predation of Drupella damaged corals in Marine Protected Area. Overgrowth of a sea anemone, *Condylactis nanwanensis,* killed corals in southern Taiwan. Recently coral bleaching has been occurred frequently in Japan and mass bleaching was observed in Japan and Taiwan in 2007. Coral disease is another major issue on coral destruction. A large-scale of disease was observed in Taiwan and Japan since 2005.

Because of these pressures on coral reefs, most of the countries in this region have focused on management activities to conserve the corals. New and enlarged MPAs have been designated in China, Taiwan and Japan for protection of coral reefs. Integrated approach on coastal management has been introduced in Taiwan, China and Japan. In Taiwan a coral reef early warning system has been proposed to cope with the impact of climate change.

## 18.730

**Community Structure Of Reef Fishes in A Tropical Upwelling Area, Gulf Of Papagayo, Pacific Costa Rica**

**Helena MOLINA-UREÑA*[1]**

[1]CIMAR / Biología, Universidad de Costa Rica, San José 11501-2060, Costa Rica

Gulf of Papagayo (GP), on the North Pacific coast of Costa Rica, displays a seasonal coastal upwelling during dry months. Between May 2005 and February 2006, 66 visual censuses were conducted at 7 rocky reefs, depths ranging 1.0-15 m (4 GP sites, 2 inside Culebra Bay, and an onshore site ~30 Km south). The 16,307 fishes identified increased previously reported species and families for the GP region 32%, to 99 and 37, respectively. Five families, Pomacentridae (4 spp), Haemulidae (2), Apogonidae (1), Clupeidae (1), Labridae (2), and Carangidae (1), accounted for ~ 80% of the fish. Fish assemblages were site-specific. Significant site-month interactions were found in diversity = 2.32 ± 0.37 SD, range 1.36 - 2.95), evenness (E = 0.81 ± 0.08, range 0.47 - 0.94), and species richness (S = 19 ± 6.2, range 7 - 32). A pinnacle reef was the richest site during upwelling months, while an onshore bay site consistently showed low richness ($P<0.05$). Habitat characteristics explained differences better than site-to-site distance. Although the first two axes of a Principal Component Analysis accounted for only 25% of the variation, results suggested an influence of rugosity, live coral cover, and depth (Axis 1), followed by slope, month, and javascript:setValue(document.forms[0],''*);*

*[0],'<'*); Stop algal cover (Axis 2). Pelagic species were more common at outer reefs during upwelling months, while the two onshore rocky sites assemblages were very similar year round, despite being 30 Km apart. The fast onset and increase of *s[0],'<'*);UpdateCharCounts(document.frmUpload)

Italic Stop cover at several study sites confirmed concerns about the risk of invasion.

## 18.731

**Spatial And Temporal Patterns Of Coral Bleaching Around Buck Island Reef National Monument, St. Croix, Us Virgin Islands**

Randall D. CLARK[1], Christopher F.G. JEFFREY[1], **Kimberly WOODY*[1]**, Zandy HILLIS-STARR[2], Mark E. MONACO[1]

[1]NOAA, Center for Coastal Monitoring and Assessment, Biogeography Branch, Silver Spring, MD, [2]National Park Service, Christiansted NHS/Buck Island Reef NM/Salt River Bay NHP-EP, Christiansted, Virgin Islands (U.S.)

Limited information currently exists on the recovery periods of bleached corals as well as the spatial extent, causative factors, and the overall impact of bleaching on coral reef ecosystems. During October 2005, widespread coral bleaching was observed within the Buck Island Reef National Monument (BIRNM) St. Croix, USVI. The bleaching event was preceded by 10 weeks of higher than average water temperatures (28.9-30.1oC). Random transects (100m2) over hard bottom habitats (N=94) revealed that approximately 51% of live coral cover was bleached. Twenty-five of 30 coral species exhibited signs of bleaching and species-specific bleaching patterns were variable throughout the study area. Although a weak but significant negative relationship ($r2=0.10$, $P=0.0220$) was observed, bleaching was evident at all depths (1.5-28m). Bleaching was spatially auto-correlated ($P=0.001$), indicating that corals located in the seaward portion of the study area were most affected. Improved coral condition was observed upon subsequent monitoring missions (December 2005, March and October 2006) using similar methodology. Bleached coral declined significantly and comprised 28%, 15%, and 3%, respectively, of total coral cover observed among transects. No spatial or depth correlations were observed in post-bleaching monitoring. Mortality estimates as a response to the bleaching event were not quantified; however, total coral cover for *Agaracia* spp. and *Porites porites* were significantly lower in October 2006, one year after the bleaching event. Mean live coral cover has decreased by 23% in the BIRNM study area since 2003. Turf algae cover has been variable but has increased since the bleaching event.

## 18.732

**Status And Impact Of Industrialization On Coral Reefs in Gulf Of Kachchh, Gujarat, India**

**Dishant PARASHARYA*[1]**, Deepak APTE[1]

[1]Bombay Natural History Society, Mumbai, India

India has four major coral reef zones viz. Coral reefs of Andaman and Nicobar Islands, Lakshadweep Island, Gulf of Mannar, Gulf of Kachchh in Gujarat state. Coral reefs of Gulf of Kachchh are the northern most, falling almost on tropic of Cancer. In fact they are the northern most reefs of the Asian continent. They have been subjected to a number of natural as well as anthropogenic threats recently, such as bleaching due to global warming, excessive industrialization on coast, offshore drilling and tourism. The environmental conditions are harsh in this region with high temperature, salinity and turbidity. In fact even the tidal amplitude is so high that the reefs are exposed completely at least twice a day. Hence the coral species found here are the ones which have high tolerance capacity towards environmental fluctuations. Industrialization is fast developing in this zone. The main aim of the research is to assess the present status of coral reefs in Gulf of Kachchh and to study the impacts of high industrial activity going on along the coastline of this fragile zone. The data has been collected by random stratified sampling technique and has been compared with the previous published data. Live coral cover is high at Poshitra and adjoining reefs and low at reefs adjoining Goose and Pirotan Island. There is a direct correlation between industrialization and live coral cover. The area around Pirotan, Goose and Narara islands is under high industrial activity as well high anthropogenic activity whereas the reefs adjoining Poshitra are comparatively under low industrial activity, hence the species diversity as well as the live coral cover is high in this region.

## 18.733

**The Power Of Volunteers – Applications Of The Reef Volunteer Survey Project Fish Monitoring Program**

**Christy PATTENGILL-SEMMENS*[1]**

[1]Reef Environmental Education Foundation (REEF), Key Largo, FL

The Reef Environmental Education Foundation (REEF) is an international, non-profit, marine conservation organization supporting hands-on grassroots activities designed to educate and engage local communities in conservation-focused activities. REEF links the diving community with scientists, resource managers and conservationists through the Volunteer Survey Project, which has trained and involved over 10,000 divers and snorkelers in marine life identification and the collection of useful population and distribution data. This citizen science program has generated one of the largest marine life databases in the world, with over 100,000 surveys conducted to date. REEF data have been used by resource agencies, fisheries management councils and scientists to address a variety of questions, including evaluating the effects of no-take reserves, conducting fisheries-independent stock assessments and identifying areas with especially large varieties of fish. REEF surveyors have also been instrumental in the identification and removal of non-native species and in the discovery of new species. REEF survey participants use standardized survey and training materials, including a data entry scanform or an online data entry interface, underwater survey paper, waterproof identification cards, and image-based training curricula. REEF processes and error checks incoming survey data using an integrated data management system and the REEF database interface on the REEF Website (www.reef.org) enables visitors to generate a variety of summary reports.

## 18.734

**Impacts Of Coastal Development On Ecosystem Structure And Function Of Yucatan Coral Reefs, Mexico**

**Yves-Marie BOZEC*[1]**, Gilberto ACOSTA-GONZÁLEZ[1], Enrique NÚÑEZ-LARA[1], Jesús Ernesto ARIAS-GONZÁLEZ[1]

[1]Lab. Ecología de Ecosistemas de Arrecifes Coralinos, CINVESTAV-Unidad Mérida, Mexico, Mérida, Yucatan, Mexico

Improved reef management requires the development of ecosystem-based approaches to understand how disturbances affect the structure, function and resilience of coral reefs. Here we report the results of a multi-site comparative analysis of coral reef structure and function along a disturbance gradient of coastal development in the Yucatan Peninsula (Mexico). From north to south, the 400 km-long Caribbean coast of Yucatan can be divided into three zones: (1) the Riviera Maya, with heavy tourist development; (2) the Sian Ka'an Biosphere Reserve, a protected area; (3) the Costa Maya, with relatively little development. Previous benthic surveys and fish counts (4 reef sites in each zone) were used to assess ecosystem metrics and functional components of the reef habitat and fish community. Results showed considerable changes in the structure of coral reefs along the disturbance gradient. Reefs in the Riviera Maya displayed an algal-dominated state with, in some places, a very low coral cover and low levels of fish biomass and diversity. From north to south, macroalgal cover decreased progressively, and highest coral cover was observed inside and south to the Sian Ka'an Biosphere Reserve. In Costa Maya reefs, habitat structure exhibited a more balanced equilibrium between macroalgae, corals and free space. As a result, massive tourism-driven coastal development is likely to have caused a coral-to-algal phase shift in northern Yucatan reefs. Functional redundancy (i.e., the number of taxonomically distinct species that exhibit similar ecological functions) increased in southern regions, suggesting a different functioning of reefs exposed to low levels of coastal development. We stress that functional redundancy may be central for coral reefs to resist phase shifts, and that assessing key functional components of reef ecosystems should improve the management of coral reef resilience.

## 18.735

**Recovery Of Tsunami Affected Coral Reefs At Mu Koh Phi Phi And Mu Koh Surin, The Andaman Sea**

**Chaipichit SAENGHAISUK*[1]**, Rattika PETTONGMA[1], Kacharat PHORMKHUNATHON[1], Bancha LAWANG[1], Thamasak YEEMIN[1]

[1]Biology, Marine Biodiversity Research Group, Bangkok, Thailand

The 2004 Indian Ocean Tsunami caused severe damage of certain reef sites, especially those located in Mu Koh Phi Phi and Mu Koh Surin, the Andaman Sea. The present study aims to investigate recovery processes of the tsunami affected coral reefs. There was increase in live coral covers at the study sites of Mu Koh Phi Phi. Coral recruits of *Montipora* spp., *Echinophyllia* spp., *Porites* spp., and *Acropora* spp. were obviously observed. Live coral covers of the severe affected reef sites of Mu Koh Surin, especially those located in channels between islands which lie in east-west direction such as channel between South Surin Island and Torinla Island, were unchanged. However densities of juvenile coral colonies on natural substrates seemed to be increasing. The dominant juvenile colonies were *Acropora* spp., *Pocillopora* spp. and *Porites* spp. The settlement plate experiments showed that there was much variation of coral recruitment rates, the highest at Ao Maeyai and the lowest at Ao Jak. The main groups of coral recruits on settlement plates were *Porites, Acropora* and *Pocillopora*. The present study explains natural recovery trends at certain affected reefs. Coral larval supply from some reefs in the area could encourage coral recovery. Certain reef sites which had suffered high impacts should be closed to assist natural recovery without human interference. If the affected coral reefs are appropriately managed, coral recovery could be observed in a few years.

## 18.736

**Coral Community Structures Of Shallow Reefs And Pinnacles At Kood Island, The Eastern Gulf Of Thailand**

**Jamrearn BUARUANG*[1]**, Makamas SUTTHACHEEP[1], Paulwatt NUCLEAR[2], Danai SAMBUNRUANG[1], Chaipichit SANGHAISUK[1], Thamasak YEEMIN[1]

[1]Department of Biology, Faculty Of Science, Ramkhamhaeng University, Bangkok, Thailand, [2]Department of Science, Rajamankala Institute of Technology, Bangkok Technical Campus, Bangkok, Thailand

There are many shallow coral reefs and coral community on pinnacles around Kood Island and its vicinity where are located at the borderline between Thailand and Cambodia, in the eastern part of the Gulf of Thailand. Changing land use practices on Kood Island have resulted in inputs of sediment into the nearshore water. The present study provides data at the initial phase of an ecological monitoring program with special emphasis on a new discovered scleractinian coral community on pinnacles. The surveys at eight study sites of shallow reefs around Kood Island, Raad Island and Mai Si Lek Island show that live coral cover ranges from 2.6 to 62.4%. The dominant coral species were *Porites lutea* and *Diploastrea heliopora*. Structure of a new discovered scleractinian coral community, about 100 m. from shoreline of Ao Phak Waeng, Kood Island was studied in details and first reported. The coral community was 8 – 10 m. in depth and is well developed in good condition on rocky and sandy substrates. Live coral cover was 62.6% while dead coral covered only 1.2%. The most dominant coral was also a massive coral, *Porites lutea*. Other abundant corals found in the area were *Porites rus, Astreopora myriophthalma, Pavona decussata, Hydnophora exesa, Diploastrea heliopora* and *Echinopora lamellosa*. The dominant macrofuana were giant clams, boring bivalves and a sea urchin (*Diadema setosum*). It is expected that there are several undiscovered coral communities around Kood Island and its vicinity. Surveys, mapping additional coral reef areas and long-term monitoring programs are required.

## 18.737

**Demographic Comparison Of The Threatened Coral Species, Acropora Palmata, in The Eastern Caribbean.**

**K. Lindsey KRAMER*[1]**, Dana E. WILLIAMS[2,3], Margaret W. MILLER[4], Chantele BÉGIN[5], Jessica FRY[5], Abel VALDIVIA[2,3]

[1]Pacific Island Network Inventory and Monitoring Program (PACN I&M), National Park Service (NPS), Kailua-Kona, HI, [2]Cooperative Institute for Marine and Atmospheric Science (CIMAS), University of Miami, Miami, FL, [3]Southeast Fisheries Science Center (SEFSC), National Oceanographic and Atmospheric Administration (NOAA), Miami, [4]Southeast Fisheries Science Center (SEFSC), National Oceanographic and Atmospheric Administration (NOAA), Miami, FL, [5]Seamester, Sarasota, FL

Elkhorn coral, *Acropora palmata,* once served as a critical structural framework builder on coral reefs, providing protective habitat for most other reef organisms. In the past 30 years, disease, hurricanes, and other stressors have driven dramatic population declines of *A. palmata* throughout the Caribbean. In 2005 and 2006, we established 22 fixed monitoring plots in Curacao, Tortola, Bequai (Saint Vincent Grenadines), and Antigua. In areas where *A. palmata* was present, we randomly established three 7m radius permanent survey plots, and within in each plot, 12-15 colonies were randomly selected for tagging and specific monitoring according to a standardized protocol currently implemented in Florida and Puerto Rico. Each tagged colony has been measured annually and examined for signs of disease, predation, bleaching, fragmentation, and other threats. Additionally in Curacao, total colony abundance (recruitment and loss) within each survey plot was determined annually. Preliminary analysis suggests that three-spotted damselfish (*Stegastes planifrons*) and associated colony 'chimney' formation were present at low levels in Antigua and Bequai (<12% of tagged colonies), and at moderate levels in Tortola and Curacao (>20%). Colonies with damselfish territories tended to be spatially clustered. White pox (WPx) was more commonly observed in Curacao, affecting 22% of tagged colonies in 2006, compared to 3-5% of colonies in other regions. Notably, colonies in Curacao with WPx often had both active and healing lesions. The corallivorous gastropod, *Coralliophila abbreviata*, and associated feeding scars were present in all regions, but were more common in Antigua, affecting 24% of tagged colonies, compared to 11-15% in other regions. In 2006 at all sites, colonies experienced a moderate level of fragmentation; more than 20% of all tagged colonies showed signs of fragmenting at least one branch. Annual monitoring at all sites will continue as funding allows.

## 18.738

**Morphological Variation In The Reef Zoanthid *Palythoa Caribaeorum* In A Brazilian Harbor Area**

**Diego COSTA*[1]**, Paula GOMES[2], André SANTOS[3], Natalia VALENÇA[4], Natalia VIEIRA[4], Carlos PERÉZ[5]

[1]Zoology Department, Federal University of Pernambuco, RECIFE-PE, Brazil, [2]Biology department, Federal Rural University of Pernambuco, Recife, Brazil, [3]Biology department, Federal University of Pernambuco, Recife, Brazil, [4]Zoology Department, Federal University of Pernambuco, Recife, Brazil, [5]Biology Department, Federal University of Pernambuco, Recife, Brazil

Variations of polyp morphology (diameter, area, height and number) of the zoanthid *Palythoa caribaeorum* from reefs of the Brazilian Northeastern Coast (Suape South and North Points and Gamela) were analyzed seasonally (dry and wet seasons). Two samples (10 x 10 cm) were collected from five colonies of each site at both seasons. The populations showed larger, higher and fewer polyps at the dry season than at the wet season. An explanation to the seasonal morphological differences found in polyps is that they would be related to different stages of the reproductive cycle. On the other hand, the continuous dredging carry out for the harbor complex near Suape South Point causes increased water turbidity due to sediment resuspension. The high sediment rates justify the great annual size found for polyps of Suape Southern population located in front of the harbor. This could represent an ecological strategy of the species to avoid that accumulations of sediment over the polyps cause them to suffocate or die. The Southern site of Suape reef showed annual homogeneity for different morphological parameters of *P. caribaeorum*, while the Northern site and Gamela reef showed the same seasonal pattern. Human impact on Suape South Point due to harbor activity modifies the ecological parameters that affect the biology of local populations. In fact, harbor areas around the world show great homogeneity throughout the year, which may be due to continuous, uniform impact offsetting the expected seasonal variations. The environmental homogeneity at the harbor reflects on the homogeneous polypal morphometric parameters at Suape South Point indicating, perhaps, a different biological strategy (e.g. growth and reproduction).

## 18.739

**Reef Check Surveys in Japan -Focus On Okinawa Area**

**Mariko ABE*[1,2]**, Yasuaki MIYAMOTO[3], Megumu TSUCHIKAWA[3], Chihiro NISHIHARA[1], Akira IGUCHI[1], Nobuo WATANABE[3]

[1]Okinawa ReefCheck and Research Group, Okinawa, Japan, [2]University of the Ryukyus, Nishihara, Japan, [3]Coral Network, Tokyo, Japan

Reef Check (RC) is a global coral reef monitoring programme started in 1997 and since that time surveys have been conducted throughout Japanese waters. RC surveys have previously found that coral reefs around Okinawa islands to have suffered severely from the 1998 bleaching event. The results of several recent RC surveys around Okinawa mainland demonstrated clear difference in the recovery of live coral cover and the abundance of coral reef organisms among reefs. Reefs formed far away from Okinawa mainland (Yonasone, west side of Iriomote Island) showed the highest recovery rates while reefs closer to the mainland had intermediate (Odo Reef) and low (Henoko) recovery rates. Another survey site of remote island (Kanokawa, southern side of Iriomote) showed slower recovery than that of Yonasone, even though it locates closely, and judging from long term RC data we can conclude that this survey site is susceptible to Typhoon damage. These comparisons among coral reefs give us overview of changes in coral reef ecosystem in Okinawa and display clear difference of reef resilience.

We advocate RC is not only useful for a scientific programme but also effective for raising public awareness. Recently local people of Awase, Sunabe, Yoron and Oura bay voluntarily started introducing Reef Check into their usual activity. In this presentation, the status of coral reefs based on RC data and the current activities through RC in Okinawa will be presented. Current activities include the big finding of massive blue coral (*Heliopora coerulea*) colony whose approximate sizes are 80m long, 27m width, 11m high, but had been unknown deep under the Oura bay's water until one of RC teams found this coral recently.

## 18.740

**Comparative Structure Of Fish And Benthos Assemblages in Belize And Brazil.**

**Burton SHANK*[1]**, Les KAUFMAN[1], Rodrigo MOURA[2], Ronaldo FRANCINI-FILHO[3]

[1]Biology, Boston University, Boston, MA, [2]Marine Ecosystems, Conservation International, Belo Horizonte, Brazil, [3]Biology, Universidade Federal da Bahia, Salvador, Brazil

Comparative multivariate analysis of reef survey data from five Marine Managed Areas (MMAs) in Belize and two in Brazil reveals the relative states of reefs in different locations, common coral reef processes, and common effects of managed areas. Though survey methodologies and species lists were different for the two regions, we find that combining disparate data sets was possible by classifying species into functional groups and correcting for sampling effort. Within benthic assemblages, inherent differences between the two regions were removed by the first Principle Component. Datasets from the two regions overlapped on the second and third PC with reef benthos in Brazil being more variable than Belize. Comparison highlighted the existence of different alternative (non hard coral) benthic community phases in Belize and Brazil. Within fish assemblages, the two MMAs from Brazil segregated both from each other and from Belize along different PC's, one MMA having a higher overall biomass and the second MMA having a different trophic structure. Canonical correlation analysis between benthic assemblages and fish trophic structure yielded two significant axes, both indicating a positive relationship between algal biomass and herbivore density with little influence from coral cover or predatory fish biomass. We interpret this as evidence for nested processes predominating at within vs. between region scales. Despite varied methodologies and inherent variation in species composition, synthesis of multi-regional monitoring data can yield meaningful, fine-scale inferences regarding the global state and trajectories of coral reef systems. Our results suggest that with appropriate within-site designs to account for local background variation, such comparisons can also shed light on the effects of resource management on trophic dynamics and benthic processes.

## 18.741

**Preliminary Results Of A Monitoring Programme For Shallow Coral Communities Influenced By The Petro-Chemical Industry in The Easter Region Of Venezuela**

**Manuel GONZÁLEZ-RIVERO*[1,2]**, Ana HERRERA-REVELES[1,3], Beatriz SIEGERT-SALAZAR[1,4], Estrella VILLAMIZAR[1,3], Mario YALLONARDO[1], Ismael HERNÁNDEZ[1,3], Miguel CASTILLO[1]

[1]Fundación Universidad Central de Venezuela, Caracas, Venezuela, [2]School of Biosciences, University of Exeter, Exeter, United Kingdom, [3]Instituto de Zoología Tropical, Universidad Central de Venezuela, Caracas, Venezuela, [4]Universidad Simón Bolívar, Caracas, Venezuela

Since 2004, a monitoring programme is being carried-out to evaluate the coral communities at Las Isletas de Píritu, an area directly influenced by the Petro-chemical industry on Eastern coast of Venezuela. This research was aimed at evaluating the health state of the coral systems within the area and establishing a methodology for monitoring them in order to identify the main factors of any possible disturbance. An annual evaluation was carried-out at 8 localities, using observation squares of 1m2, at depths of between 3 and 7m. The variables studied where: benthic community coverage, density of recruits and incidence of disease. Based on the data obtained from the first evaluation carried-out (2004-2005), a comparative analysis was done between 2006 and 2007, using a paired sample design to compare the annual variations in the variables. The main results were: 1) the coral communities are of path type and heterogeneous, in which there is a considerable coverage of death coral (68.3±9.3%). 2) The richness in species and the density of coral recruits showed comparatively low values (13sp and 2.2±1.0 ind/m2). 3) *Siderastrea siderea* and *Diploria strigosa* were the dominant species, which are typical of areas directly influenced by upwelling phenomena. Some locations, however, showed evidence of a recuperation of *Acropora palmata* populations. 4) In terms of coverage, the main benthic groups were Hard Corals (5.7±5.6%), Hydrocorals (7.5±3.8%) and incrusted Zoanthids and Octocorals (8.8±4.8%). 5) Up to date, no evidence has yet been found of any disease in the colonies evaluated. 6) Considering the variables employed, a high degree of deterioration was found. 7) No evidence has yet been found, however, in any of the variables under study, between from 2006 to date (t-student, $p<0,05$). Further studies will be required, however, to establish stronger predictive criteria about the changes that these ecosystems are undergoing.

## 18.742

**Continued Degradation Of Tobago's Coral Reefs Linked To The Prevalence Of Coral Disease Following The 2005 Mass Bleaching Event**

**Simon HARDING*[1]**, Jan-Willem VAN BOCHOVE[1], Shay O'FARRELL[1], Owen DAY[2], Keith GIBSON[1], Katherine YATES[1], Peter RAINES[1]

[1]Coral Cay Conservation, London, United Kingdom, [2]Buccoo Reef Trust, Carnbee, Trinidad and Tobago

In the summer of 2005, the Caribbean region experienced a widespread coral bleaching event. In order to determine the extent and effect of this event on the reefs of Tobago, the Buccoo Reef Trust (BRT) and Coral Cay Conservation (CCC) conducted a targeted coral reef survey programme at 22 sites around the island between October and November 2005.

A two-phase campaign was launched. In Phase I the reefs were assessed to establish their current status. In Phase II, a long-term monitoring programme was installed in order to monitor the reefs to record subsequent degradation or recovery from the event.

Results from Phase 1 found overall mean bleaching of hard corals to be 66%. Although bleaching by geographic region was found to be consistent with sites exhibiting greater than 85% bleaching throughout the area, some local reefs on the northeast of Tobago had less then 20% bleaching, perhaps indicating localised tolerance. Bleaching was also found to be highly variable, both between and within species. Notably, *Acropora palmata* stands all appeared to be unbleached. No significant coral diseases were observed during Phase 1 surveys.

Results from Phase 2 indicate a high prevalence of coral disease at many sites throughout the area. Yellow Blotch Disease was commonly seen on *Montastrea* species. There were also high levels of White Plague Disease and *Aspergillosis*. Initial findings suggest that diseases were generally prevalent on reefs adjacent to areas of high coastal development and/or agricultural land use.

## 18.743

**Sediment Accumulation Rates And Coastal Land Use Change Impact in Abrolhos Reef Complex, Brazil**

**Augusto NETTO*[1]**, Roberto ARGOLLO[2], Ruy KIKUCHI[1]

[1]Geophysics and Geology Research Center, Universidade Federal da Bahia, Salvador, Brazil, [2]Institute of Physics, Universidade Federal da Bahia, Salvador, Brazil

The effects of sediment influx on coral reefs are important factors limiting the development of this ecosystem. In the southeastern state of Bahia, Brazil, during the last fifty years, rapidly increasing human pressure, due to deep changes in the coastal zone land use threatened coral community of the coastal arc of Abrolhos Reef Complex. This work evaluates sedimentation rates in one sediment core in the river mouth, in Caravelas strandplain, and in four cores of the coastal arc of Abrolhos. Sediment accumulation rates were determined by measuring 210Pb decay. The resultant rates vary between 6.68 mm.yr-1 in the river mangrove systems, and 1.28 mm.yr-1 in the reefs distant 80 km from the coastline. However, no trend change was recorded along the core, thus challenging the idea that deforestation in the last century has impacted negatively reef environment, or else, no measurable impact was found in sedimentation rates, yet. This lack of change may result of a sedimentary fencing role by oceanographic processes such alongshore currents, or else, of mangrove systems buffering the river sediment discharge. Thus, the deforestation of mangrove forests observed in the last decade and the possibility that shrimp farming might begin in the coastal area adjacent to Abrolhos reefs is a gloomy scenario to these reefs.

## 18.744

**Historical Impacts On Coral Reefs At Rosario Islands, An Mpa in The Colombian Caribbean**

**Oscar DELGADILLO*[1]**, Paula ZAPATA-RAMÍREZ[1,2]

[1]Marine Biology, UJTL, Bogotá, Colombia, [2]UJTL, Bogotá, Colombia

The degree of natural and anthropogenic impacts on coral reefs at Rosario Islands does not have been established in spite that the research in this area began in 1960. We attempt to determine the extent of the different impacts on this ecosystem in the last 30 years. Five stations with distinct coral reef development and historical research were assess at two depth levels (6 m and 12 m) with the quadrant method (80 m2 per station) to record coverage percentage of main categories and secondary components. Actual information and historical data were evaluated with graphics, cluster and similarities analysis (ANOSIM) to define distribution patterns and differences in coverage through time and between stations. Time series analysis for historical data of sedimentation and chlorophyll concentration as well as the graphic tendencies observed in population growth, tourist income, water temperature, nutrients concentration and dredging volumes, were performance to find out its relationship with changes in benthic coverage. A decrease in coralline coverage in all stations in the eighties and a slightly recuperation in the last 15 years was evident, particularly in two stations declared intangibles islands. On the other hand, a consistence change in dominance of coral species, high algae and abiotic substrate coverage, mainly in stations nearest to human presence (overpopulation, fishing pressure, sewage discharges, tourism and nautical activities), high sedimentation and chlorophyll concentration, suggest that each station have different responses to the magnitude of the impacts with regard to their own features which is a key point for conservation strategies.

## 18.745

**Reef Structure Of Anegada: 30 Years Of Change**

**Shannon GORE*[1]**, Mervin HASTINGS[2]

[1]Conservation & Fisheries, Government of the British Virgin Islands, Cruz Bay, Virgin Islands (U.S.), [2]Conservation & Fisheries, Government of the British Virgin Islands, Road Town, Virgin Islands (British)

The low-lying island of island Anegada in the British Virgin Islands is fringed with the Horseshoe Reef that extends 51km and is one of the largest continuous reefs in the Caribbean. However, few studies of this particular reef exist today, possibly due to its remote location where dangerous northern Atlantic swells occur. A study from 1975 was replicated to produce a semi-quantitative measure of the diversity and abundance of coral species and reef structure that exists today. This study was combined with a literature review of all reef related research on Horseshoe Reef that was compiled and analyzed to create a timeline of how the reef has changed over the past 30 years. Natural events such as storms and disease outbreaks were added to the timeline to help identify why changes occurred. Key threats to the future of the reef and island itself are identified and recommendations are made for management plans.

## 18.746

**Decade-Long (1998-2007) Trends in Live Coral Cover On A Tropical Eastern Pacific Coral Reef At Gorgona Island, Colombia**

**Fernando A. ZAPATA*[1]**, Alberto RODRÍGUEZ-RAMÍREZ[2], Raúl NAVAS-CAMACHO[2]

[1]Department of Biology, Universidad del Valle, Cali, Colombia, [2]Instituto de Investigaciones Marinas y Costeras, Santa Marta, Colombia

Coral reef ecologists face the challenge of assessing the extent to which natural, human-induced disturbances or their interactions are responsible for the increasing deterioration of coral reefs worldwide. In response, the National Monitoring System for the Coral Reefs of Colombia (SIMAC) was established to document long-term trends, identify their causes and assess coral reef responses to perturbations. On the Pacific coast, data on live coral cover have been collected yearly during one decade (1998-2007) on 20 permanent 10-m transects located at two depths in two sites of La Azufrada reef, Gorgona Island. Overall live coral cover has shown a significantly declining trend, particularly since 2004, from 55.6% in 1998 to 37.2 % in 2007. Although this trend has been temporally consistent between sites, it has not been so between depths. While coral cover has always been greater on deep than on shallow plots, the temporal patterns of variation at each depth have been nearly opposite. On shallow plots coral cover declined from 1998 to 2001, increased until 2004, and declined again reaching the lowest mean values (17.0%) of the decade in 2007. In contrast, coral cover on deep plots (59.5% in 1998) slowly increased until to 2002, declined until 2004 and stabilized thereafter above 55.5%. Major reductions in coral cover, particularly on shallow plots, coincided with the occurrence of major natural perturbations such as the 1997-98 El Niño warming and subaerial tidal exposures, which might explain the observed differences between depths. Besides strong El Niño warming events, which caused 85% coral mortality in 1983 but only 6% mortality in 1998, recurrent subaerial exposure appears to be the major cause of coral cover decline on shallow areas at La Azufrada. Locally-produced human perturbations are minimal although high sedimentation resulting from forest clearing in the 1960s still affects the northern site.

## 18.747

**Long-Term Spatiotemporal Dynamics Of Benthic Organisms At Andros Island Reefs**

**Brooke GINTERT*[1]**, Nuno GRACIAS[2]

[1]Marine Biology and Fisheries, University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, [2]Universitat de Girona, Girona, Spain

In reef environments, both biotic and abiotic factors can significantly impact the distribution of benthic organisms. Benthic communities of Caribbean coral reefs have undergone extensive changes in composition in the recent past due to disease, bleaching, and other natural and anthropogenic influences. Despite extensive research into the causes and effects of such changes, little is known about how these events have influenced the spatial distributions of benthic organisms within reefs. At Andros Island, Bahamas the spatial arrangement of benthic organisms within 10x10-m reef plots has been mapped over a 35 plus year period, providing a unique dataset to evaluate log-term changes in spatial patterns of reef organisms. Beginning in the 1960's -1970's all benthic organisms within the 10x10m survey plots were censused and mapped by hand. These plots were monitored over time and resurveyed in 2007 using 2-D video mosaicing technology in which high resolution video was used to create spatially explicit mosaic images of the permanent survey plots at the original survey scale. Spatial arrangements of benthic organisms were assessed using spatial analysis for distance indices (SADIE) for both historic hand drawn images and the newly created video mosaics. These indices were then used to test the persistence of organisms and spatial arrangement patterns over the 35 plus years. This analysis indicates that the degree of change in spatial arrangement of benthic organisms over the study period is variable and species dependent. The data presented here represents the first long-term assessment of benthic spatial pattern dynamics on the reef communities at Andros Island.

## 18.748

**Status And Trends Of Coral Reef Systems From Natural Reserves in Puerto Rico: Evaluating Resilience, Bleaching Mortality And The Influence Of Mesoscale Eddys**

**Jorge GARCIA-SAIS*[1]**

[1]Marine Sciences, University of Puerto Rico, Mayaguez, Lajas, Puerto Rico

A total of 12 reefs from six Natural Reserves (Isla Desecheo, Rincon, Mayaguéz, Guánica, Isla Caja de Muerto and Ponce) are included in the National Coral Reef Monitoring Program of Puerto Rico sponsored by NOAA and administered by the PRDNER. Baseline characterizations and subsequent annual monitoring surveys of reef substrate cover by sessile-benthic categories have been performed since 1999 at Isla Desecheo and Mayaguez, and since 2004 at other Natural Reserve sites. The sessile-benthic community at the reef systems of Puerto Botes and Puerto Canoas (Isla Desecheo), Tourmaline Reef (Mayaguez), Cayo Coral (Guánica), West Reef (Caja de Muerto – Ponce), and Derrumbadero Reef (Ponce) presented statistically significant reductions of live coral cover during the study period. Differences of live coral cover between monitoring surveys were mostly associated with a sharp decline measured during the 2006 survey, after a severe regional coral bleaching event that affected Puerto Rico and the U. S. Virgin Islands during August through October 2005. The decline of (total) live coral cover at the reef community level during 2006 was largely driven by mortality of Boulder Star Coral, *Montastraea annularis* (complex), a highly dominant species in terms of reef substrate cover and the principal reef building species. The most drastic declines of live coral cover at the community level (>50%) were measured from Derrumbadero (Ponce) and Puerto Canoas (Isla Desecheo), which were the reefs with the highest live coral cover in the monitoring program. The massive bleaching of corals coincided with an extended period of elevated sea surface temperatures (SST) between August and late October, 2005 associated with the warm water mass of a mesoscale anticyclonic eddy moving north-westerly from South America and impacting the south coast of Puerto Rico and the USVI.

## 18.749

**Dynamics Of Coral Communities in Sekisei Lagoon, Okinawa, Japan**

**Tadashi KIMURA*[1]**

[1]Japan Wildlife Research Center, Tokyo, Japan

Sekisei Lagoon is one of the Barrier Reef located between Ishigaki and Iriomote islands at the south end of the Ryukyu Archipelago. The lagoon has the most diverse coral communities in Japan contains more than 300 species of hermatypic corals. This high diversity of coral species maintains the coral communities distributed around Kyushu, Shikoku and mainland Japan along the Kuroshio Current flowing from south to north. These coral communities associated with marine organisms create beautiful underwater scenery. In Sekisei Lagoon four marine protected area named "Marine Parks" have been designated in 1977 under the Iriomote National Park. For the management of Sekisei Lagoon including the marine parks coral monitoring has been conducted since 1983 to understand the condition of corals. The coral communities at each monitoring station are identified into 6 types depending on the dominant group of the communities (I: branching Acropora dominant, II: branching-table like Acropora dominant, III: table like Acropora dominant, IV: specific species dominant, V: mixed communities (no specific coral species dominant), IV: soft coral dominant. *Acanthuster planci* out broke in this area from 1974 to 1985 and most coral communities were destroyed by their predation. Corals recovered their percent coverage more than 50 in 1995. However, *Acanthuster planci* population has been increasing since 2000. Coral damages by high water temperature were observed in this area in 1998, 2001, 2003, 2005, 2006 and 2007. Coral diseases such as Black Band Disease and White Syndrome are major threats on corals in Sekisei Lagoon since 2003.

## 18.750

**10 Years Reefcheck Surveys in Japan**

**Mariko ABE*[1]**, Yasuaki MIYAMOTO[2], Megumu TSUCHIKAWA[2], Chihiro NISHIHARA[1], Akira IGUCHI[1], Nobuo WATANABE[2]

[1]Okinawa ReefCheck and Research Group, Okinawa, Japan, [2]Coral Network, Tokyo, Japan

Reef Check (RC) is a global coral reef monitoring programme started in 1997 and since that time surveys have been conducted throughout Japanese waters. Coral development pattern of Japanese water is unique. Due to strong Kuroshio Current, running from southern places such as the Philippines to the northern part of Japan. Therefore we have expanded our RC area to temperate area where coral communities develop. In 1997, the number of the survey sites was only two, but it increased up to 42 points in 2006.

The Summary of 10 years Reef Check survey is as follows ;

- Tracked 1998 global bleaching event
- Tracked 2007 bleaching event of Yaeyama area
- Recorded rough tendency of coral coverage changes
- Recorded relationship between some indicator species and reef's health
- Expanded survey sites

We advocate RC is not only useful for a scientific programme but also effective for raising public awareness. Recently local people of Awase, Sunabe, Oura bay (Okinawa) and Yoron (Kagoshima) voluntarily started introducing Reef Check into their usual activity and they also introduced additional surveys and activities as well. In this presentation, the status of coral reefs based on RC data and the current activities through RC in Okinawa will be presented. Current activities include beach clean up activities by high school students of Yoron island, 'my quadrat activity' in addition to RC by Sunabe's local NGO.

## 18.751

**The Results Of The First Comprehensive Benthic Assessment Of The Coral Reef Habitats Of Bermuda**

Thaddeus MURDOCH[1], **Annie GLASSPOOL*[2]**, Mike COLELLA[3]

[1]BREAM: Bermuda Reef Ecosystem Assessment and Mapping Programme, Bermuda Zoological Society, Flatts Village, Bermuda, [2]Bermuda Biodiversity Project, Bermuda Zoological Society, Flatts Village, Bermuda, [3]Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commision, St. Petersburg, FL

Bermuda supports the most northerly coral reef system in the world, with 22 species of Caribbean hard coral. Its unique location may allow Bermuda's coral reef to survive the impending global changes to ocean climate and chemistry that appear to be causing the decline of reefs in the Caribbean and elsewhere.

A comprehensive survey of the ecological condition of reefs across the entire 1000 sq. km platform was lacking until the BREAM: Bermuda Reef Ecosystem Assessment and Mapping program, described here, was initiated in 1999. The purpose of the BREAM program is the interdisciplinary assessment of benthic habitats and associated biota, using aerial mapping, geographical information systems and database management, and proven scientific protocols.

Coral reefs were categorized into component habitat types, representing lagoonal patch reefs, rim reefs, and fore-reef habitats at 10-m and 20-m depth. To date the rim reef habitat has been completely surveyed, with 24 sites assessed. The lagoonal reefs have been surveyed at 42 sites, evenly distributed across the Platform. 16 out of 25 forereef sites at 10-m depth have been surveyed. 25 forereef sites at 20-m have yet to be surveyed.

Results indicate that coral cover for the lagoon ranges from 10 to 45%; rim reef sites vary from 20 to 40%, while 10-m forereef sites exhibit coral cover values of 35 to 75%. Seven species dominate most reefs across all habitats, with 17 additional species present but less abundant. Two species of hard coral, Porites furcata and Mussa angulosa, which represent new records for Bermuda were found, both with very limited distributions.

Data from this comprehensive regional assessment is crucial in guiding both scientific research and long-term monitoring, as well as the management of the coral reefs and associated marine habitats of Bermuda.

## 18.753

**Temporal Changes in Coral Communities Associated To Thalassia Testudinum Meadows At The Inner Bay Of Mochima, Venezuela**

**Sheila M. PAULS*[1]**

[1]Instituto de Zoologia Tropical / Escuela de Biologia, Universidad Central de Venezuela, Caracas, Venezuela

The coral communities associated to meadows of *Thalassia testudinum* at the inner zones of the Bay of Mochima, Venezuela (10° 20' – 10° 24' N and 64° 19' 30" – 64° 22' 30" W) had been assessed at three sites in 1982. After 25 years, the three localities were evaluated again to detect and compare possible changes. At each sampling site six transects were fixed perpendicular to the coastline, and richness, density and coral cover percentages were measured, as well as those of substrate cover (sandy, rocky or *T. testudinum*). From 1982 to 2007 live-coral cover increased from 14 to 17 % and seagrass areas rose from 69 to 74 %, with a concomitant decrease of dead-coral cover (from 11.3 to 2.4 %), rocky substrate (from 5.5 to 1.15 %) and sand patches (from 3.0 to 1.2 %). On each date, the recorded coral diversities were 16 and 17 species, respectively. The most abundant species on both surveys were *Millepora alcicornis* with a relative cover of 84.8 and 89.1 %, respectively, and *Porites porites* with 7.1 and 3.7 %, respectively; noteworthy, both species are branched colonies that can get rid more easily than bulky colonies of the sediments deposited on them during the rainy season. Other coral species showed a coverage of less than 5 % and while massive, they were of small sizes, indicating periodic disturbances in the area. Overall, the recorded changes were not too pronounced, probably due to the protection conferred by the inner bay waters, which are calm and relatively isolated from oceanic currents and waves.

## 18.754

**Habitat validation and resource assessment of a grouper spawning aggregation and mesophotic coral reef Marine Protected Area in the US Virgin Islands**

**Tyler SMITH*[1]**, Jeremiah BLONDEAU[1], Richard NEMETH[1], Jacqulyn CALNAN[1], Elizabeth KADISON[2]

[1]Center for Marine and Environmental Analysis, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [2]Center for Marine and Environmental Studies, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

A random stratified sampling design was employed to 1) validate high resolution benthic habitat maps created using side scan sonar together with multi-beam and 2) conduct an assessment of the resources inside a marine protected area, including benthic structure, coral health, fish diversity and fish biomass. The Marine Conservation District (MCD) is a 41 km2 reserve that has been seasonally closed since 1990 and permanently closed since 1999 and was designed as a refuge for a large coral reef ecosystem and a spawning aggregation of red hind (*Epinephelus guttatus*). The MCD was stratified into four habitats (coral, pavement, sand, and algae) with each stratum having a minimum of twenty random sampling locations. Assessments were conducted between depths of 32 to 50 m and were performed by divers using technical NITROX and closed circuit rebreathers. The amount of coral reef based on the benthic habitat maps severely underestimated the true area of coral reefs by more than 100%. Assessment of the fisheries resources revealed that the coral habitat was home to a large abundance of commercially important groupers and snappers, suggesting its importance as a habitat and foraging area. Furthermore, the closure may act as an important spawning area for species in addition to red hind. The expanded coral reef habitat revealed in this study potentially expands the migratory corridors for red hind and other fishes, and showed increased potential area for supporting recovering spawning aggregations. A large, unexplored area on the Puerto Rican Shelf, outside the MCD, is certain to contain similar mesophotic coral reefs and will be discussed.

## 18.755

**Coral Community Composition in St. Croix, U.s. Virgin Islands in Relation To Sources Of Major Anthropogenic Impacts**

Matthew DRAUD[1], **Longin T. KACZMARSKY*[2]**

[1]Biology, C.W. Post - Long Island University, Brookville, NY, [2]Biological Sciences, Florida International University, Miami, FL

We surveyed coral community composition at inshore and offshore reefs totaling 48 sites on the north and south coasts of St. Croix. Our aim was to probe for impacts of a large multi-use industrial site on the south shore. We selected sites spanning east and west of the outflow of the major watersheds on each coast. We hypothesized that the watersheds would have similar effects on coral abundance and diversity around the outflow regions, and that differences detected in relative community structure, especially those localized to the industrial area, could be attributed to anthropogenic stress from industrial activities. The study sites also spanned east and west of, and were directly within the outfall plumes of, major sewage outfalls on both coasts, which allowed us to estimate the effects of raw sewage effluent on coral community structure. We identified, measured, and examined the health of over 10,000 corals from which we calculated disease prevalence, colony density, relative abundance, and size-class distribution. The major watersheds had similar impact on coral cover and diversity along both shores. Inshore sites along both shorelines had very low live cover of the endangered Acroporids in areas where they were once very abundant. For five important reef building species, in both inshore and offshore sites, we found substantially lower relative abundance of coral recruits in study sites near the industrial area and near both sewage outfalls as compared to study-wide coral recruit abundance and as compared to recruit abundances at selected sites distant from the perceived sources of stress. Disease prevalence was elevated substantially at sites immediately downstream of the sewage outfalls on both coasts as compared to similar sites immediately upstream of the outfalls.

## 18.756

**Structure And Health Condition Of Four Sponge Communities In The Archipielago De Los Roques National Park, Venezuela**

**Estrella VILLAMIZAR*[1]**, Maria Cristina DIAZ[2], Jeannette PEREZ[3], Humberto CAMISOTTI[4]

[1]Instituto de Zoologia Tropical, Universidad Central de Venezuela, Caracas, Venezuela, [2]Museo Marino de Margarita, Venezuela, Boca de Rio, Venezuela, [3]Laboratorio de Ecosistemas Marino Costeros, IZT, Universidad Central de VenezuelaI, Caracas, Venezuela, [4]Ciencias Marinas, Fundacion Cientifica Los Roques, Caracas, Venezuela

The sponges, stony corals and soft corals are among the groups most diverse, abundant and of highest biomass in the coral reefs. However, in Venezuela there is no information about the health condition of the sponge communities. The National Park Archipiélago de Los Roques is the most developed coral reef complex in Venezuela. Elsewhere, in 1999, according to the health condition of their corals, it was ranked as the fourth reef more healthy among 21 from the Caribbean Region. In this study we attempt to know the health condition of the sponge communities of four coral reefs of Los Roques: Dos Mosquises Sur, La Pelona, Boca de Cote, and Madrisquí (nor-east). Madrisquí is located close to the only populated center of the park (Gran Roque), an important source of impacts over this reef. At each reef three belt transects (10 x 2 m) were ramdomly fixed, and the composition, abundance, richness and health condition of the sponges evaluated. The richness and average abundance of the sponge communities were significantly different ($p<0.05$); Madrisquí with the highest average abundance, followed by La Pelona, Boca de Cote and finally, Dos Mosquises Sur with the lowes abundance of sponges. The species that shown evident signs of Syndromes/Diseases (S/D) were: Aplysina fistularis, A. cauliformis, A. archeri, Callyspongia vaginalis, Ircinia campana, I. felix, e I. strobilina, The sponges from Madrisquí were the most affected (5% of the colonies). The sponge species most affected (highest prevalence of some S/D) varied according to the reef localities. I. campana with 75% and A. cauliformis with 33.33% in Madrisqui, A. archeri with 33.33% in La Pelona, I. campana with 100% in Dos Mosquises Sur. Very few diseased sponges and a higher richness of species were found in Boca de Cote, showing the healthiest condition among the four sponge communities studied.

## 18.757

**Quantification of Reef Benthos Communities and Variability Inherent to the Video Transect Method, Todos os Santos Bay, Bahia, Brazil**

**Carla RAMOS*[1]**, Fernanda AMARAL[1], Ruy KIKUCHI[2], Eduardo CHAVES[2], Gabriel RIVAS[3]

[1]Biologia, Universidade Federal Rural de Pernambuco, Recife, Brazil, [2]Geologia, Universidade Federal da Bahia, Salvador, Brazil, [3]Física e Matemática, Universidade Federal Rural de Pernambuco, Recife, Brazil

Changes in abundances and distribution of key reef species can be used as reliable indicators of environmental problems that are detected by long-term monitoring. The video transect technique, created in Australia in 1988 and introduced in Brazil in 2003, has several advantages. However, it is necessary to evaluate the variation in the quantification of reef benthos communities that is inherent to this method. This study was conducted to describe the variation that occurred during the assessment of a reef environment in Todos os Santos Bay (Bahia State) (S 12°59', W 38°11') at a depth of 3 to 5 m. Six 100 m parallel transects (2 m apart) were carried out during January and February 2007. Each transect was subdivided into five 20 m filmings, which, after captured, were once again recorded by a second diver. The images were analyzed by VITRA software – developed specially for this method. The cover percentages studied and the descriptive indexes of the reef community were calculated during the data analyses. The analysis between transects, using the Bray-Curtis Similarity Index and further the Cluster analysis, were carried out using PRIMER Version 5.1.2. The Mantel test was also used (through Spearman's ñ coefficient) to identify the degree of association between transects' similarity and their repetitions. The reef environment showed a high level of homogeneity related to the macrobenthic community, with three areas extremely similar to each other. The Shannon-Wiener Diversity Index (H') was of 1.76. The most frequent functional group was the calcareous articulated algae, followed by the calcareous hydroid *Millepora alcicornis* (the main reef builder of the studied environment), and the zoanthids *Zoanthus* spp. The $\tilde{n} = 0.693$ ($P < 0.001$) confirmed that the method is appropriated to reef communities' monitoring in long-term studies.

## 18.758

**Coral Reef Biodiversity Loss At Mexican Caribbean Due To The Increasing Tourist Development Effects**

**Gilberto ACOSTA GONZÁLEZ*[1]**, Fabián RODRÍGUEZ-ZARAGOZA[2], Carlos GONZÁLEZ SALAS[3], Jesús ARIAS GONZÁLEZ[1]

[1]Recursos del Mar, Centro de Investigación y Estudios Avanzados del I.P.N., Merida, Mexico, [2]Departamento de Ecología, Universidad de Guadalajara, Zapopan, Mexico, [3]Departamento de Biología marina, Universidad Autónoma de Yucatán, Merida, Mexico

The loss of biodiversity in Mahahual fringing reef (Mexican Caribbean) was evaluated. It is a non-protected area and had high biodiversity and well developed reefs in 2000, and since 2001 it has an exponential growth of tourism activity. Two reef zones were assessed: reef slope and reef terrace (~10 to 18m deep) for the years 2000, 2005 and 2006, with 72 reef fish census transects (50 x 2m) and the corresponding benthic videotransects (to estimate percentage cover of biotic components and substratum). Alfa and beta diversity were assessed by zone and the total diversity was compared among years, with the average taxonomic distinctness, rarefactions, additive diversity partitions and multiple linear regressions built by canonical redundancy analysis. Results show that fish species diversity decreased from 54 to 45 in the reef slope and from 70 to 46 in the reef terrace, and from 82 to 58 among years. This decreased the rare species and singletons, meaning a loss in beta diversity, mainly in the reef terrace. Rarefactions and additive partitions show the greatest change form 2000 to 2005. Linear regressions show the loss of beta diversity to be linked to the decrease in the boulder, sub-massive and encrusting-foliose coral morphs: the most important structural elements of the Caribbean reefs. Tourism effects derived from coastal-urban development (piers, marinas, navigation channels), increase in water related leisure activities (SCUBA diving, snorkel, boating), and the increase in pressure to local reef fisheries have degraded this reef.

## 18.759

**The Status Of The Reefs Of Sudan in 2007**

**Rebecca KLAUS*[1]**, Jeremy KEMP[1], Melita SAMOILYS[1,2], Holger ANLAUF[1]

[1]Equipe Cousteau, Paris, France, [2]Cordio, Mombassa, Kenya

The coast of Sudan borders the western shore of the Red Sea which is recognised as an area of global importance for marine biodiversity. The mainland is edged by a near-continuous often steep fringing reef. Offshore is a complex barrier reef system, composed of a diverse range of fully or partially submerged reef formations, and numerous uninhabited islands. While some of the more accessible offshore reefs (e.g. Sanganeb Atoll) have previously been the subject of research, and others are renowned tourism dive sites (e.g. Sha'ab Rumi), much of the coast and more remote reef complexes have never been surveyed. Several recent initiatives, associated with the establishment of two marine protected areas and planning for integrated coastal zone management, through partnerships between various non-governmental organisations and local Government, have provided the opportunity to assess the status of the Sudanese reefs (2002, 2006 and 2007). The diversity of flora and fauna associated with the reefs within Sudanese waters transition from communities that are characteristic of the northern Red Sea to those more representative of the southern Red Sea. Recreational and extractive use of the resources is still moderately low however, the condition of the reefs and the abundance of resources is highly variable. There are low abundances of several key commercial fin fish (particularly groupers and larger snappers) and invertebrate groups (particularly sea cucumbers and larger gastropod molluscs), and an apparent absence of sea-urchins in some parts. The reefs were impacted by the 1998 coral bleaching event, and the extent of mortality and recovery reflected localized differences in community composition and environmental conditions. The bio-geographical trends in diversity within Sudanese waters, the variability in resource abundance and present condition of the reefs all have important implications for the resilience of the system that need to be accounted for in planning for management.

## 18.760

**Status Of Coral Reefs in Iranian Waters Of The Persian Gulf**

**OMID SEDIGHISAVADKOUHI*[1]**, HAMZEH VALAVI[2]

[1]marine Environment Deputy, Echobiology Bureau, Department Of The Environment, Tehran, Iran, [2]marine Environment Deputy, Echobiology Bureau, Department Of The Environment, Shiraz, Ireland

Status of coral reefs of six Islands (Farur, Banifarur, Kish, Hendurabi, Khark and Kharkoo) and Nayban Bay were studied from February to September 2007. MantaTow technique, Line Point Transect (Substrate Line Transect), Fish and Invertebrate belt Transect methods were used for this survey.

A total of 46 hard coral species (27 Genera/12 Families), the highest number of species recorded for Iranian waters, and 25 species of fish were identified. 21 species of reef building corals are reporting from Iranian waters for the first time. Kish (30 species) and Farur (29 species) were most diverse reef area.

Farur and Khark-Kharkoo showing 68% and 64% live coral cover, respectively were found as the best developed and healthy reef areas.

Favidae (17 species), Siderastreidae and Poritidae (each 5 species)were the most diverse coral families in the the region.

Coral cover of studied areas is dominated by poritidae, Acroporidae and Favidae Families.

Highest density of reef fishes such as Dark butterfly fish were recorded in Kharkoo (13/100sqm) and Farur (10.75 /100sqm) and highest density of Arabian butterfly fish were recorded in Kish (5.5/100sqm ) and Farur reefs ( 2.5/100sqm).

In addition to anthropogenic factors, natural stressors particularly elevated sea water temperature has affected coral reefs of Iranian waters dramatically.

In September 2007, a significant increase in water temperature as high as 35.5° to 37° C were recorded in the survey area.

Acroporids corals in Kish Island have been 98% bleached. In Nayband bay, corals of Favids up to 60% and Porites up to 30% were bleached. Coral bleaching in Farur ranged from 25% in deeper waters to 60% in shallow waters.

## 18.761

**Fish Communities And Habitat Interactions At Two Reef Systems Of The Gulf Of Mexico.**

**Gabriela NAVA MARTÍNEZ*[1]**, Ernesto ARIAS[2]

[1]Oceanus, A.C., Chetumal, Quintana Roo, Mexico, [2]CINVESTAV, Merida, Mexico

Information of four reefs of the Sistema Arrecifal Veracruzano (SAV) and two reefs in the Bank of Campeche (SABC) was obtained to describe so much the attributes of the community of fish as well as of the benthic community of both reef systems. The results were analyzed to describe the interactions among the distribution and abundance of the species of fish in different environments in the reefs of the Gulf of Mexico. For the attribute of abundance significant differences were observed between systems, reefs and reef zones being in general the leeward zones significantly more abundant than those of windward, different to those typical distributions. For the trophic structure, the abundance of herbivores was significantly different form the carnivorous, which were distributed in environments of higher complexity. The sites could cluster in typical habitats regarding the benthic community. The results showed that the reefs of the Gulf of Mexico had an environment highly dominated by algae specially incrusting algae. The coverage of stony coral was higher in the SAV, whereas in the SABC octocorals predominated. The species of predominant fish in the SABC were herbivores belonging to the family Scaridae and Pomacentridae, whereas in an environment with major structural complexity and diversity of organisms as some sites of the SAV where octocorals and coverage of live coral are predominant the major fish species were mainly Chaetodontidae, Pomacanthidae, Acathuridae and Haemulidae. This distribution seems to have a trend depending of the environment but affected locally by wave exposure and effects of the local impacts as fishing pressure reflected in the abundances of fish and the reduction of herbivores or carnivorous and/or extractives activities that are reflected in the loss of coverage and structural complexity.

## 18.762

**Marine Debris Density On Coral Reefs Around U.s.-Affiliated Pacific Islands**

**Sarah MYHRE*[1,2]**

[1]Joint Institute of Marine and Atmospheric Research, Honolulu, HI, [2]Coral Reef Ecosystem Division, NOAA Pacific Islands Fisheries Science Center, Honolulu

Observations by towed divers of marine debris were recorded in 2006 and 2007 in seven U.S.-affiliated Pacific Island regions: the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), the Commonwealth of the Northern Marianas Islands (CNMI), American Samoa, the U.S. Lines Islands and the Phoenix Islands. The regional density of debris observations (ob/km²) was calculated from a Pacific-wide total of 431 surveys, covering an estimated 10,210 km². Debris density was described for four categories: nets/lines, munitions, shipwrecks, and other manmade objects. Observation density of nets/lines was highest in the MHI (0.034 ob/km²) and Wake Island (0.029 ob/km²), but was absent from American Samoa and the U.S. Line Islands. Observation density of munitions (i.e., unexploded ordinance) was highest again in the Main Hawaiian Islands (0.017 ob/km²) followed by CNMI (0.007 ob/km²) and Wake Island (0.005 net/line ob/km²), but was absent from all other regions. Observation density of shipwrecks around Wake Island (0.011 ob/km²) was tenfold greater than in the NWHI, MHI, CNMI and American Samoa. Observation density of other manmade objects was greatest around Wake Island (0.037 ob/km²) and the MHI (0.022 ob/km²), but was absent from the U.S. Line Islands. These trends indicate regional differences in the magnitude and type of human use and impacts to coral reef ecosystems.

## 18.763

**Changes in Coral Reef Ecosystem Structure Across Environmental And Human Impact Gradients**

**Sheila WALSH*[1]**, Elizabeth DINSDALE[2], Mary DONOVAN[3], Robert EDWARDS[4], Tracey MCDOLE[2]

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, [2]San Diego State University, San Diego, CA, [3]Marine Science Institute, University of California, Santa Barbara, Santa Barbara, CA, [4]Computer Science, San Diego State University, San Diego, CA

The relative importance of environmental versus human causes for global change is strongly debated. Coral reef ecosystems have been shown to respond and adapt to environmental conditions over time and space. However, humans have been dramatically changing this adaptive landscape in recent history. We test the relative importance of and interactions between decreased sea surface temperature and enhanced productivity due to local upwelling and fishing pressure and human population density (a proxy for anthropogenic nutrients) on coral reef ecosystem structure. Dramatic decreases in coral cover concurrent with a decrease in biomass of the upper trophic levels of the fish community were found. Population density and fish catch were the best explanatory variables for this pattern in ecosystem structure. Sea surface temperature was not significant, but chlorophyll levels were marginally significant suggesting that increased productivity associated with human sewage rather than cold upwelling water is important in structuring the ecosystem. At areas of intermediate human disturbance, the fish community showed much greater changes than the benthic community, which may be due to the different time scales of response in the communities and the lack of significant change in abundance of herbivorous fish. This pattern in the herbivorous fish is not evidence for a trophic cascade as a result of the dramatic decline in predatory fish. Our results show strong effects on ecosystem structure due to moderate human impacts. Human induced changes in environmental conditions of similar magnitude to natural conditions elsewhere may have important impacts due to a lack of adaptation or synergistic effects with other human impacts, such as fishing.

## 18.764

**A Coral Reef Monitoring Experience: Joining Community And Scientific Participation.**

**Ana Lidia GASPAR*[1]**, Beatrice FERREIRA[2], Mauro MAIDA[2], Caroline FEITOSA[2], Sergio REZENDE[2], Eduardo MACEDO[2], Fabio NEGRAO[3], Ana Paula PRATES[4], Andreza PACHECO[2], Iara SOMMER[5], Liana MENDES[6], Joao Marcello CAMARGO[1], Bernadete BARBOSA[7], Danilo MARX[8]

[1]Instituto Recifes Costeiros, Tamandare, Brazil, [2]Oceanography Department, Federal University of Pernambuco, Recife, Brazil, [3]Instituto Recifes Costeiros, Caravelas, Brazil, [4]NZCM, Ministry of Environment, Brazilia, Brazil, [5]APA Guadalupe, Tamandare, Brazil, [6]UFRN, Natal, Brazil, [7]Ibama, Tamandare, Brazil, [8]Pró-mar, Tamandare, Brazil

The Brazilian National Coral Reef Monitoring Program is under way since 2002, funded by the Ministry of Environment, and has covered eight reef areas located in the five major reef regions from north to south: Maracajau in the Touros-Natal region; Tamandare and Maragogi in the Pirangi-Maceió region; Itaparica in the Bahia de Todos os Santos-Camamu region; Recife de Fora in the Porto Seguro-Cabrália region and Abrolhos reef in the Abrolhos Region, plus oceanic areas of Fernando de Noronha and Atol das Rocas. As recommend by the GRCMN, long-term monitoring programs should include community monitoring as well as more detailed surveys. The Brazilian program is a low budget initiative and thus the global protocol Reef Check was adopted as a first step basis. Since trained scientists, University students, park managers, NGO personnel and diver volunteers form the Brazilian Monitoring Program team, it was possible to incorporated gathering of more detailed data while still keeping the results compatible with the Reef Check protocol. New indicators were added to the standard Reef Check categories, and fish, invertebrates and corals were recorded to the species level. These detailed data allowed to obtain results on diversity of coral and fish species by region, latitudinal differences in species abundances, and to detect effects of different management strategies along 2,000km of the coast. During 5 years, surveys were conducted in 90 sites, distributed among the regions according to local support and field facilities, from a minimum of four and a maximum of 17 sites per reef area. Monitoring effort was possible with the support of several institutions and participation of volunteers who conducted surveys and participated from field trip organization to data entering. The efforts were aligned with other initiatives such as the Campaign for Conscious Conduct at Reef Environments, local research and conservation projects.

## 18.765

**Differential recovery rates of selected Philippine reefs from impacts of the 1997-1998 ENSO event: A decade after**

**Miledel Christine QUIBILAN*[1]**, Karen Lou FRANCISCO[2], Rollan GERONIMO[2], Porfirio ALINO[3]

[1]Conservation International Philippines, Quezon City, Philippines, [2]Marine Science Institute, University of the Philippines Diliman, Quezon City, Philippines, [3]Marine Science Institute, University of the Philippines Diliman, Quezon City, Panama

The 1997-1998 ENSO event leading up to a massive coral bleaching event, remains to this day, as one of the most significant disturbance that has contributed greatly to demise of coral reefs worldwide. In the Philippines, as much as 20% coral mortality was observed 6 months to a year after the event. From 1997-1999, the subsequent changes in the coral community structure was compared at the level of individual frames within transects, among transects within reefs northwest of Luzon, Palawan and offshore reefs in South China Sea and Sulu Sea. We observed significant reductions in hard coral cover and consequent increases in dead coral and algal cover as well as in the overall spatial distributions of major benthic community attributes. The observed differential responses of the reefs were attributed mainly to their relative exposure (i.e. extent and duration) to the prevailing anomalous sea surface temperatures (SSTs) and to the degree of susceptibility of coral species to thermal stress and high light conditions. A decade after the event, follow-up surveys were done from 2000-2007 to determine if reefs have indeed recovered or not. While impacts from other natural (e.g. COTS infestation, storm impacts) and human-induced (e.g. siltation and overfishing) stressors have delayed reef recovery to different degrees, the establishment and effective management of no-take areas and the successful implementation of municipal fisheries regulations outside these areas indicate a reversal of degradation trends.

## 18.766

**Damage And Short-Term Recovery Of Coral Reefs After Consecutive Hurricanes in A Caribbean Island**

**Marinés MILLET-ENCALADA*[1,2]**, Lorenzo ALVAREZ-FILIP[3], Roberto HERNÁNDEZ-LANDA[1], Héctor REYES-BONILLA[2]

[1]Scientific monitoring and academic vinculation, Parque Nacional Arrecifes de Cozumel, Cozumel, Mexico, [2]Marine Biology, Universidad Autónoma de Baja California Sur, Baja California Sur, Mexico, [3]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom

In tropical ecosystems hurricanes are important factors that shape their structure and functioning. During 2005, Cozumel Island suffered the impact of two strong hurricanes. We took this opportunity to study the immediate damage and short term (2 yr) recovery of the coral reefs affected by these consecutive disturbances in the Cozumel Reefs National Park. From 2004 to 2007 we surveyed six reefs twice a year (spring and fall) performing 36 point intercept transects in a 30 m long transect for benthic components and 48 transect band (30 m long 2 m wide) for fish. Our results show that the amount of bare rock on reefs increased greatly post-impact, as a result of the loss of benthic organisms. In terms of the biotic communities, the total algae cover decreased by 28 % while the coral cover declined 55 % after the hurricanes. Physical damage to corals was patchy and most of the damage occurred to fragile species. The recovery trends indicate that the macroalgae were the benthic component with the most rapid colonization rates. Coral and massive sponges showed slow rates of recovery, while encrusting sponges exhibited a slight decrease in the last year. The abundance of grazing fishes (Acanthuridae and Scaridae) increased after the impacts suggesting that this group maintained low levels of filamentous algae in the reefs. In conclusion, after two years we found evidence of recovery and an increase in live coral tissue. The Marine Park protection and the decrease in tourist pressure may have facilitated this recovery, however it is important to notice that if the high growth rates of macroalgae continue, as they have up to now, coral recuperation might be compromised in the future.

## 18.767

**Characterization Of A Terrigenous Reef At Southwestern Gulf Of Mexico**

**Horacio PÉREZ-ESPAÑA*[1]**, Jacobo SANTANDER MONSALVO[1], Sarahi GÓMEZ VILLADA[2], Miguel Ángel LOZANO ABURTO[1], Jezahel Virgilio MIRANDA ZACARÍAS[3], Juan Manuel VARGAS HERNÁNDEZ[4], Maribel DAMIÁN VELÁZQUEZ[4], Sachiko HAYASAKA RAMÍREZ[1]

[1]Centro de Ecología y Pesquerías, Universidad Veracruzana, Boca del Río, Mexico, [2]Universidad Nacional Autonoma de Mexico, México, Mexico, [3]Centro de Ecología y Pesquerías, Universidad Veracruzana, Boca del Rio, Mexico, [4]Facultad de Biología, Universidad Veracruzana, Xalapa, Mexico

The Veracruz Reef System (VRS) is a Marine Protected Area (MPA) experiencing high sedimentation rates and high human impacts, including strong fishing activity, high vessel traffic from the largest harbor on the Mexican Gulf coast which is located within this MPA, and the waste water of the city (around one million habitants), which final destination is the area adjacent to the reefs. Reefs were characterized using video transects for the reef coverage, visual censuses for adults and juveniles fish abundance as well as size, quadrants for coral recruitment, transects for coral diseases and echinoderms, and tube traps for sedimentation rates. Eight reefs from the VRS where studied at two different depths. Coral coverage was 20% average; this value showed differences among reefs and depths. Turf was the most abundant component (26%). A total a 109 fish species where found, with a high dominance of *Coryphopterus personatus* which represent 49% of abundance. Deep zones have a higher abundance and density. No clear pattern of sizes per reef or depth was found. Recently three new fish species have been described. Twenty-six juvenile fish species were found, with a higher abundance and richness during the warm season. Fourteen coral species were recorded during the recruitment study, with *Agaricia* and *Siderastrea* being the most abundant genus. Eight diseases were identified, and contrary to the expected, the reef with the higher number of diseases was not the closer to the city or the river. Twelve echinoderm species were found, with a high dominance of the sea urchin *Echinometra viridis* which represent 75% of the total abundance. Sedimentation rates were really high, with values higher than 2000 gr/m2/day. The highest rates of sedimentation were during winter. It is significant because there are plans to build a larger harbor within the reef zones.

## 18.768

**The Presence Of Deep-Coral Reefs (40 – 120 M) in Hawaii**

**Anthony MONTGOMERY*[1]**, John ROONEY[2], Richard PYLE[3], Raymond BOLAND[2], Frank PARRISH[2], Heather SPALDING[4], Ken LONGNECKER[3], Brian POPP[5]

[1]Hawaii Deaprtment of Land and Natural Resources, Hawaii Division of Aquatic Resources, Honolulu, HI, [2]NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, [3]Bishop Museum, Honolulu, HI, [4]Botany, University of Hawaii at Manoa, Honolulu, HI, [5]Geology and Geophysics, University of Hawaii at Manoa, Honolulu, HI

Limited understanding exists of Hawaii's deep-coral reef communities through studies of black coral, fish biodiversity surveys, and ongoing mapping efforts. However, many researchers are unaware of the existence of deep-coral reefs, so they are typically not included in reef assessment and monitoring programs. They are likewise not usually included in management related reports on the status and health of coral reefs or general overviews of coral reef science. Most studies of coral reef development and coral reef ecology do not include deep-coral reefs. Although limited, previous work has opened a window into this understudied environment and may change the way scientists view coral reefs in general. The true extent and distribution of deep-coral reef habitats in the Hawaiian Islands is still largely unknown.

In 2004, a deep-coral reef in the southern Auau Channel, Maui was discovered at 75 meters. Although previous research has shown the presence of deep scleractinian corals in the channel, the distribution was unknown. In 2005, intermediate deep reefs (~40 m) on Niihau, Kauai, and Oahu were also discovered. In addition, deep-water algae surveys revealed large numbers and diversity of scleractinian corals as well as a high biodiversity and role of algae in the same areas. Most recently in December 2007, researchers were able to begin mapping and studying the presence of deep-coral reefs in the Auau Channel, but also surprisingly found large areas of deep-coral reefs (50- 80 m) off Kauai. As more information becomes available, researchers are realizing the spatial extent of deep-coral reefs is wider then previously thought. A wider presence of deep-coral reefs in Hawaii may suggest even a larger, more important role of deep-coral reefs to the broader coral reef ecosystem. This paper will summarize previous and new information on the existence of these unique, understudied habitats.

## 18.769

**Differential Susceptibilities Among Coral Species To Recurrent (1998, 2002, 2005 And 2006) Coral Bleaching Phenomenon in The Gulf Of Mannar And Palk Bay, Southeast Coast Of India.**

**Kannan JAYAKUMAR*[1]**, Arumugam Kuppusamy KUMARAGURU[2]

[1]Centre for Marine and Coastal Studies, School of Energy, Environment and Natural Resources, Madurai Kamaraj University, Madurai, India, [2]Centre for Marine and Coastal Studies, Madurai Kamaraj University, Madurai, India

Coral bleaching is a stress condition in reef corals that involves a breakdown of the symbiotic relationship between the corals and the unicellular algae (zooxanthellae). The symptoms of bleaching include a gradual loss of color when zooxanthellae are expelled from the coral tissue, leaving coral skeleton turn to white in colour. Corals can be affected in large scale during mass bleaching events such as the one that occurred in 1998. The mass bleaching events recorded during 1998, 2002, 2005 and 2006 in the reefs of the Gulf of Mannar and Palk Bay have been triggered primarily by anomaly in water temperature. The extent of the impact of coral bleaching and their recovery during the subsequent periods were studied using Permanent Line Intercept transects in the 21 islands of the Gulf of Mannar and the adjacent Palk Bay. Differences among the species in their suceptibility to disturbance like coral bleaching is critical aspect of community dynamics since it has a significant effect on the community strucuture and species diversity. Studies on the susceptibility of coral species to the the bleaching phenomenon were carried out during the four incidences of bleaching around the 21 islands of the Gulf of Mannar and the adjacent Palk Bay. The study concluded that corals which belong to the families Acroporidae, Poritidae, Faviidae and Pocilloporidae showed different levels of responses during the four bleaching events in both the Gulf of Mannar and Palk Bay.

## 18.770

**The Corals Of Akumal, Riviera Maya, Mexico.**

**Daniel TORRUCO*[1]**, Alicia GONZÁLEZ[2]

[1]Recursos del Mar, Centro de Investigaciòn y Estudios Avanzados del Instituto Politécnico Nacional, Mérida, Mexico, [2]Recursos del Mar, Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional, Mérida, Mexico

Corals data in the reef of Akumal, Quintana Roo in 11 depths from 1 as 50 m were quantitatively surveyed in june 2007. A total of 38 species, with a density of 7.02 org/m2 were identified . The greater species richness was presented in the depth of 35 m (13 species). The Shannon-Wiener's index diversity value show a pick at 31 m. The similarity analysis was formed 4 groups of similar depths; and their species form a assemblaje of three groups. In relationship to the ordination by the biplot analysis, the corals species show relationships with bigger than 15 m. Neither pattern is related directly with the gradient of depth and it is probable that the components that originate the presented patterns are the own characteristics of the substrate.

## 18.771

**Bathymetric Distribution Of The Benthic Marine Flora In Chemuyil, Mexico.**

**Alicia GONZÁLEZ*[1]**, Daniel TORRUCO[1]

[1]Recursos del Mar, Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional, Mèrida, Mexico

We determined 39 species of benthic marine flora between 0.5 m and 115´. Enteromorpha flexuosa, Halimeda incrassata, Coralline articulate, Lobophora variegata and Galaxaura oblongata was dominant and E. Flexuosa was very comon. The sampling methodology this based essentialy on 117 coral reef phoptotransects to several dephts in each location. The diversity indices and density tend to be higher at greater depths. Most frequent species, with relative numerical abundance higher than 10%, were: El flexuosa and H. Incrassata. In this work, they are analyzed the importance of some ecological attributes in the regional distribution of this group. The most diverse location was between 22 to 27 m. The similarity analysis it give one high definition between the locations, from they here are argued the importance of the factors like: substrata availability, wave protection and environmental conditions.

Keywords: Algae, Yucatan, Biodiversiversity.

## 18.772

**Two Centuries Of Structuration Of Tropical Benthic Comunities On The Lava Flows Of Piton De La Fournaise (Reunion Island)**

**J. Henrich BRUGGEMANN*[1]**, Mireille M.M. GUILLAUME[1,2]

[1]ECOMAR, Université de la Réunion, Saint-Denis, Reunion, [2]Milieux et Peuplements Aquatiques, UMR 5178 CNRS-UPMC-MNHN, Muséum National d'Histoire Naturelle, Paris, France

Two centuries of structuration of tropical benthic comunities on the lava flows of Piton de la Fournaise (Reunion Island)

## 18.773

**Florida Keys Coral Reef Evaluation And Monitoring Project: Patch Reefs**

**Michael COLELLA*[1]**

[1]Florida Fish and Wildlife Research Institute, St. Petersburg, FL

The Coral Reef Evaluation and Monitoring Project (CREMP) has assessed the condition of 10 patch reefs in the Upper, Middle and Lower Florida Keys for the past 11 years using video transects, species richness, and, for the past 6 years, clionid sponge data. While each patch reef site has unique characteristics, regional differences in patch reef data are observed. For the Upper Keys patch reef stations: 1) coral cover and species richness is the lowest of the three regions and has shown some decline through time, 2) there is little or no area affected by clionid sponges. For the Middle Keys patch reef stations: 1) coral cover and species richness is the intermediate of the three regions and has shown no decline through time, 2) the area affected by clionid sponges is slightly higher than the Upper Keys and is consistent through time. For the Lower Keys patch reef stations: 1) coral cover and species richness is the highest of the three regions and has shown some decline through time, 2) the area affected by clionid sponges is by far the highest of the three regions, but has shown some decrease through time. While coral reefs typically exist in clear, low nutrient waters these locations are found in areas that would be considered detrimental to coral growth. Despite adverse environmental conditions, the 10 patch reef sites monitored by the CREMP have not exhibited the same decline in coral reef condition (i.e. coral cover) through the years that have been observed at many of the reefs in the Florida Keys. Several possible explanations for this exist. The coral species and individual colonies found here may be better adapted to surviving these marginal environmental conditions. Alternatively, while the environmental conditions are not ideal, they may have protected these reefs from some of the impacts observed in other habitat types.

## 19.774

**Spatial Differences Of The Linear Extension Of Pocillopora Damicornis In Polhena Reef Of Southern Sri Lanka**

Wickrama Arachchige UPASANTA KUMARA[1], **Wickrama Arachchige UPASANTA KUMARA*[1]**

[1]Oceanography and Marine Geology, University of Ruhuna, Matara, Sri Lanka

A total of 65 approximately same sized colonies of *P. damicornis* situated in inshore patchy reefs located at the leeward side of the fringing reef in Polhena in Southern coastal belt of Sri Lanka were surveyed. All the measurements were taken every fortnight.

This study took place on three slopes of the reef front, side and back and identified as sites. Three locations were selected in each site as surface, bottom and middle considering the depth.

Mean, standard deviation and one–way ANOVA was used during the statistical analysis. Multiple comparisons were done using least significant different (LSD) for light intensity and sediment volume. The water parameters observed were 28.06±1.14$^0$C, 8.78 ±0.40mgL$^{-1}$, 1.40±0.32 mgL$^{-1}$, 31.91±3.49 ppt, 8.12±0.04*10$^3$, 1.01±0.61 mgL$^{-1}$, 5.78±2.37NTU, 49.17±1.89Lux and 90.08±39.65mL respectively. It was observed that the mean difference of light intensity and sediment volume between each location was significantly different. Higher sediment volume and lowest diameter extension were observed at back bottom (0.055±0.01mm day$^{-1}$). The highest value was observed at front surface (0.22±0.01mm day$^{-1}$). ANOVA showed a significant difference of the diameter extension of *P. damicornis* between locations and sites. Diameter extension was significantly low at back showing a significant negative correlation with increased sedimentation rate (7897.26gm$^{-2}$ day$^{-1}$).

## 19.775

**The Role Of Oceanographic Processes in The Trophic Ecology Of Coral Reefs: Linking Reef Biodiversity And Biogeochemistry**

**Alex WYATT*[1]**, Stuart HUMPHRIES[2], Anya WAITE[1], Ryan LOWE[1], Russ BABCOCK[3]

[1]School of Environmental Systems Engineering, The University of Western Australia, Crawley, Australia, [2]Department of Animal & Plant Sciences, University of Sheffield, Sheffield, United Kingdom, [3]Marine and Atmospheric Research, CSIRO, Wembley, Australia

Rapid recycling of sparse nutrients as a means of sustaining productivity is a paradigm that suggests that reefs are largely independent of the surrounding ocean, being neither a net source nor sink of nutrients. Recently studies have begun to suggest that reefs may be closely linked to the ocean, and perhaps more dependent on its variability, than previously considered. Our recent work at Ningaloo Reef, Western Australia demonstrates considerable depletion of phytoplankton (measured via chlorophyll *a*) in oceanic water pumped over the reef by wave action. Based on this depletion, we postulate the idea of an oceanic reef "catchment": the area of ocean which sustains reef productivity. By linking depletion rates across the reef to local and regional oceanography, we estimate the size of this catchment to be on the order of 10,000 km2 for the 290 km stretch of Ningaloo. Uptake of phytoplankton alone represents a nitrogen flux to the reef that may be up to an order of magnitude higher than typically reported for dissolved nitrogen, confirming that particulate feeding may be a missing link in reef nitrogen budgets. We used stable isotope biomarkers to determine which components of the reef biotope regularly utilise ocean-derived particles and are therefore closely coupled to offshore oceanographic processes. Our work consequently has significant implications for the impact that human- and climatically-induced changes in the surrounding ocean may have on coral reefs, particularly for those organisms most dependent on oceanic supply.

## 19.776

**Metabolic Responses And Defense Mechanism By Coral *galaxea Fascicularis* Against Increased Hydrogen Peroxide in Seawater**

**Tomihiko HIGUCHI*[1]**, Hiroyuki FUJIMURA[1], Takemitsu ARAKAKI[1], Tamotsu OOMORI[1]

[1]University of the Ryukyus, Nishihara, Japan

Coral reef decline has recently been observed around the world, caused by changes in the environment following natural and anthropogenic activities. Hydrogen peroxide (H2O2), a strong active oxygen species, is one of the photochemically formed chemicals in both seawater and atmosphere. Because of its strong oxidizing power, H2O2 affects plants and marine organisms. Increases in seawater temperature, irradiance, UV radiation can result in the formation of harmful, reactive oxygen species within zooxanthellae and coral hosts. The cellular response to the formation of oxygen radicals has many defense mechanisms that include the increased activity of free radical scavenger enzymes such as superoxide dismutase (SOD) and catalase (CAT). SOD catalyzes the dismutation of superoxide into oxygen and H2O2, and CAT is responsible for degrading H2O2 into water and oxygen. Our study tried 1) to obtain quantitative information on coral's metabolic changes with increased H2O2 and 2) to investigate defense mechanisms by zooxanthellae and host corals against increased H2O2 in seawater. The corals, *Galaxea fascicularis*, were exposed to various concentrations of $H_2O_2$ (0, 0.3, 3 μM). When $H_2O_2$ was added to the seawater, we observed clear changes in the coral metabolisms. Higher concentrations posed more stress to the coral colonies. Within 3 days, photosynthesis and calcification were decreased by the increased $H_2O_2$, but respiration was not affected. In the exposure experiments, CAT activities of both zooxanthellae and host corals were increased, but SOD activities were un-changed. It was suggested that coral have a defense mechanism against increased $H_2O_2$ in seawater. However, coral photosynthesis and calcification system received damages by the increased $H_2O_2$. Thus, though CAT activities were increased, they were not sufficient to scavenge all of the $H_2O_2$. The hydroxyl radical generated by the remaining $H_2O_2$ could have caused damages to the coral metabolic systems.

## 19.777

**Pumping Of Pore Water Nutrients By The Upside-Down-Jellyfish Cassiopeia Sp. in Coral Reefs**

**Carin JANTZEN*[1]**, Christian WILD[2], Mohammed RASHEED[3], Claudio RICHTER[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [2]Coral Reef Ecology Work Group (CORE), Center of Geobiology and Biodiversity Research, MÃ¼nchen, Germany, [3]Marine Science Station Aqaba, Aqaba, Jordan

The jelly fish *Cassiopeia* sp. is common in coral reefs, seagrass beds and mangrove ecosystems. As opposed to the fully pelagic other members of the Rhizostomidae, this unusual medusa leads a quasi benthic phototrophic life, where its peculiar swimming orientation, upside-down against the substrate, is believed to be associated with exposing its zooxanthellae-laden mouth arms to suitable levels of light. Here we show that the concave bell of *Cassiopeia* sp. also acts as a suction pump, effectively drawing nutrient-rich pore waters from permeable coral reef sediments, thereby enhancing photosynthesis of the zooxanthellae. Chamber incubations with fluorescein-labelled pore water revealed two orders of magnitude increased pore water fluxes across the sediment-water interface in the presence of *Cassiopeia* sp., with an exchange of at least 1 cm deep pore water within one hour. Accompanying nutrient uptake experiments revealed effective assimilation of ammonia and phosphate by the jellyfish. As natural abundances of *Cassiopeia* sp. in coral reefs may exceed 10 individuals m$^{-2}$, this previously overlooked ecosystem engineer may harness a significant fraction of sediment-locked regenerated nutrients, thereby facilitating pelagic-benthic coupling and primary production in coral reefs.

## 19.778

**Natural Organic Matter Release by Hermatypic Corals of the Northern Red Sea**

**Malik NAUMANN*[1]**, Andreas HAAS[1], Florian MAYER[1], Christoph MAYR[2], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]GeoBio-Center & Department of Earth and Environmental Science, Ludwig-Maximilians-Universität München, München, Germany

Quantification of organic matter (OM) release by corals represents the essential basis of studies investigating the ecological role and fate of coral-derived OM. However, there is very few information available on OM release rates by corals, especially in respect of genus specificity, vertical variability and seasonality. This study presents the first results of extensive quantification experiments conducted in high spatial and temporal resolution with all dominant hermatypic coral genera from Northern Red Sea fringing reefs, the globally most common type of warm water coral reefs. Results were related to benthic coverage by the respective corals as determined from parallel reef transect surveys covering reef areas shallower than 20 m water depth. Particulate organic matter (POM) and dissolved organic carbon (DOC) release of *Acropora*, *Favites*, *Fungia*, *Millepora*, *Pocillopora* and *Stylophora* colonies were quantified using beaker incubations during several expeditions at different seasons to Aqaba, Jordan. Particulate organic carbon (POC) and particulate nitrogen (PN) release rates were highly variable between coral genera with maximum values of 7.8 mg C and 0.5 mg N m-2 coral area h-1 observed for the genus *Stylophora* (5 % benthic coverage). Quantification of DOC release was affected by simultaneous uptake during beaker incubations. However, net DOC release was measured for the genera *Acropora*, *Favites*, *Fungia* and *Millepora*. This stimulated planktonic microbial oxygen consumption (up to 6-fold) and DOC turnover (up to 17-fold), thereby indicating fast degradation of coral-derived OM in reef waters. Calculated daily POC and PN release by dominant corals in the investigated reef accounted for 16.1 mg C and 1.2 mg N m-2 reef area or 430 ml of mucus m-2 d-1. These data from fringing reefs are in the same range as release rates measured for platform reef systems, thus implying a general and established ecological function of OM release by reef building corals.

## 19.779

**Picoplankton Enrichment in Coral Mucus Aggregates: Enhanced Access Of Planktonic Biomass To Reef Benthos**

**Malik NAUMANN*[1]**, Claudio RICHTER[2], Mohammad AL-ZIBDAH[3], Christian WILD[1]

[1]Coral Reef Ecology Work Group (CORE), GeoBio-Center, Ludwig-Maximilians-Universität München, München, Germany, [2]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [3]Marine Science Station, Yarmouk University, Aqaba, Jordan

The planktonic community of coral reef waters is dominated by phototrophic picoplankton organisms (e.g. the cyanobacterium *Synechococcus*), which often account for half of the total planktonic biomass. Their extremely small size prevents fast sedimentation to the seafloor and consumption by most filter-feeding benthic reef organisms, thereby implying rather weak contribution of picoplankton to benthic metabolism and material cycling in coral reefs. Here, we investigate if picoplankton entanglement in coral mucus may enhance picoplankton flux to the benthos. Retention of picoplanktonic cyanobacteria in mucus from scleractinian corals was quantified in the laboratory and in the field. Freshly collected mucus from the mushroom coral *Fungia* already contained substantial background levels of cyanobacteria (1.0 ± 0.2 x 104 cells ml-1) of pelagic and/or symbiotic origin. Laboratory experiments with rotating chambers showed that 15 to 43 % of the initial *Synechococcus* population was cleared within 1 h when mucus was present, while mucus-free controls revealed that clearance due to cell clumping accounted for only 3 - 8 %. Additional incubation experiments in flow-through tanks displayed 15-fold picoplankton enrichment in aged mucus aggregates. Aged mucus aggregates collected in-situ from branching colonies of the staghorn coral *Acropora* spp. exhibited high cyanobacteria concentrations of up to 4.6 x $10^6$ cells $ml^{-1}$ compared to 1.6 ± 0.9 x $10^4$ cells $ml^{-1}$ in the surrounding water. The ensuing rapid sedimentation (mean: 0.5 cm $s^{-1}$) of the enriched aggregates hints to coral mucus as a so far overlooked vector for picoplankton, thereby enhancing pelagic-benthic coupling near coral reefs.

## 19.780

**Trophic Analysis Of The Papahanaumokuakea Marine National Monument Coral Reef Ecosystem Using Stable Isotopes**

**Anna HILTING*[1]**, Carolyn CURRIN[1], Randy KOSAKI[2]

[1]NOS/CCFHR, NOAA, Beaufort, NC, [2]NOS/OOCRM, NOAA, Honolulu, HI

Papahanaumokuakea Marine National Monument in the Northwestern Hawaiian Islands, a unique coral reef ecosystem dominated by apex predators with few local anthropogenic stressors, provides a relatively pristine model to which disturbed coral reef ecosystems may be compared. Stable isotope analysis of atoll and seamount communities in the Monument provided evidence for interactions among trophic levels and for the ratio of benthic algal/phytoplankton productivity supporting fish production. The average □13C value of benthic algal producers (-9.43‰) was enriched by 14‰ compared to the average phytoplankton value (-23.4‰). The □13C averages of all consumer taxa are at least 4.5‰ more enriched in □13C than phytoplankton and at least 2.5‰ more depleted in □13C than benthic algae. The average apex predator □13C value was -14.55‰, only 5‰ less than the average value of benthic algal producers, suggesting that benthic algae are an important contributor to the Northwestern Hawaiian Islands food chain. Average □13C values of the apex predator taxa (sharks, jacks and the snapper, *Aprion virescens)* varied by about 1‰, while mean □15N values varied by about 3‰. Results of □15N analysis for the tiger shark, *Galeocerdo cuvier* (12.09‰) were distinct from those of other apex predators: *Caranx ignobilis* (10.53‰), *Carcharhinus galapagensis (*10.27‰), *Carcharhinus amblyrhynchos* (10.03‰), *Caranx melampygus (*9.93‰), and *Aprion virescens* (9.35‰). The average □15N value of herbivorous fish was 6.30‰, 4.1‰ enriched compared to the average value (2.2‰) of the measured primary producers. Presuming an average enrichment of 3‰ per trophic level, apex predators were feeding near the second and third trophic levels.

## 19.781

**Hemichordata: Enteropneusta (Acorn Worm) Bioturbation: Maintaining And Facilitating The Balance Of Coral Reef Biogeochemical Cycles**

**Kimberly TAKAGI*[1]**, Makoto TSUCHIYA[2]

[1]Chemistry, Biology and Marine Science, University of the Ryukyus, Nakagusuku-son, Okinawa, Japan, [2]Chemistry, Biology and Marine Science, University of the Ryukyus, Nishihara, Okinawa, Japan

Bioturbation is often associated with soil enrichment as a result of incresases in elemental turnover, organic matter (OM) degradation and content. However, if a bio-turbating organism can also "impoverish" OM rich environments, then it can aid in maintaining the biogeochemical balance within a system. In Bise, Okinawa, Japan, Hemichordata: Enteropneusta (acorn worms) are found at densities up to 24 individuals $m^{-2}$. In addition, it inhabits the sandy beach, seagrass and coral and seagrass environments. As such, we assert that the acorn worm acts as a "biopurifier," and impoverishes the coral reef ecosystem of excess nutrients and organic matter.

Through the use of fatty acid (FA) biomarkers, C:N, and nutrient analysis, we conducted in situ studies and ex situ experiments. We analyzed sediments from areas inhabited by, not inhabited by, and fecal casts of the acorn worm. In addition, seawater samples from inhabited and not inhabited areas were analyzed for total nitrates and ammonium concentrations. Field-based results confirm that acorn worms assimilate 'reactive' organic matter and subsequently biopurify its surrounding sediments in the beach habitat. Total nitrates also show acorn worm presence mitigates the release of nitrates into the water column and sediments. However, as the overall FA contribution, total organic carbon and total organic matter contents changed little in the seagrass and coral/ seagrass environments, rather than biopurify, acorn worm bioturbation aids in facilitating the maintenance of the biogeochemical balance within the coral reef ecosystem.

## 19.782

**Exposure To Nutrient-Enriched Sediments Mitigates The Negative Impacts Of Sedimentation On Coral Growth in The Caribbean Corals Porites Astreoides And Siderastrea Siderea**

Diego LIRMAN[1], **James HERLAN*[1]**, Chis LANGDON[1], Tom CAPO[1]

[1]Marine Biology and Fisheries, University of Miami, Miami, FL

Sedimentation is one of the main sources of disturbance to coral reefs worldwide. However, the recent documentation of healthy coral communities in areas with high sediment and nutrient inputs suggests that an enhanced heterotrophic environment may allow corals to thrive under conditions often considered as marginal. In this study, we document the effects of sedimentation on the growth of *Porites astreoides* and *Siderastrea siderea* to evaluate whether the higher nutrient content of enriched sediments can be utilized by corals to offset the negative impacts of sedimentation.

Both *P. astreoides* and *S. siderea* showed a high tolerance to chronic, high sedimentation levels that reduced light levels and covered corals daily for three weeks. Limited tissue losses were observed, but none of the coral fragments (2-3 cm in diameter) exhibited total mortality. The growth of *P. astreoides* and *P. siderea* was significantly influenced by the addition of sediments. For *P. astreoides*, control corals had the fastest growth rates, followed by corals from the enriched nutrient treatment, non-enriched sediment treatment, and finally, the shading treatment. No significant difference in growth rates were documented between control corals and corals exposed to enriched sediments, but these two groups grew significantly faster than shaded corals and corals exposed to non-enriched sediments. For *S. siderea*, growth rates were highest for control corals, followed by corals in the enriched sediments treatment, the shading treatment, and the non-enriched sediment treatment. Significant differences were only documented between controls and corals exposed to non-enriched sediments. The enhanced growth of *Porites astreoides* and *Siderastrea siderea* exposed to nutrient-enriched sediments shows that corals are able, at least in part, to offset the negative impacts of sedimentation by assimilating sediment nutrients.

## 19.783

**Clipperton Lagoon: A Possible Future For An Atoll Lagoon**

**Charpy LOIC*[1]**, Rodier MARTINE[1]

[1]UR167, IRD, Marseille, France, Metropolitan

Clipperton Island, which is sometimes referred as Ile de la Passion (10°17' N 109°13' W) is the unique coral atoll, in the eastern Pacific. During 2005, we participated to the Jean-Louis Etienne expedition to investigate the lagoon and the surrounding oceanic waters of Clipperton. Our results confirm the meromictic character of the deep basins due to the last closure of the lagoon around 1849. We found a system with three layers of water which did not intermix and the deepest layer did not contain any dissolved oxygen. The transition layer between brackish and salted waters is characterized by a temperature inversion of 1.6°C. The origin of this increase is probably due to the microbial activity. Taking into account the methodological problems of previous measurements, the physical characteristics of the lagoon do not seem to have changed significantly since the last expeditions. The low DIN and SRP concentrations observed in the upper layer reflects the important nutrient uptake by primary producers of the lagoon as attested by the elevated gross primary production (3.8 g C m-2 day-1) estimated by O2 method. Phytoplankton production integrated in the upper 3 m represents 21 % of the total primary production (benthos + plankton). This comparison confirms the dominant role of benthic plants (macrophytes or epiphytes) in lagoon global metabolism.

## 19.784

**Variability Of Uvr Penetration And Its Biogeochemical Implications For Coral Reef Ecosystems in Malaysia**

**Victor KUWAHARA*[1]**, Taeko FURUKAWA[1], Asami NAKAYAMA[2], Ryota NAKAJIMA[2], B. H. Ross OTHMAN[3], Tatsuki TODA[2]

[1]Faculty of Education, Soka University, Tokyo, Japan, [2]Faculty of Engineering, Soka University, Tokyo, Japan, [3]School of Environmental & Natural Resources Science, Universiti Kebangsaan Malaysia, Bangi Selangor, Malaysia

Biologically diverse coral reef ecosystems, which are symbiotically dependent on photosynthesizing zooxanthellae, are indirectly susceptible to small increases or changes to the spectral UVR distribution. Prior studies have described that the photobiological effects of UVR are largely determined by the underwater spectral UVR:PAR ratio that is directly controlled by the absorption and scattering of biogeochemical material within the water column, i.e. particulate organic matter (POM), dissolved organic matter (DOM), etc. The purpose of this survey was to, 1) establish the current variability of UVR and PAR penetration above coral reefs around the Malaysian peninsula, 2) measure the variability and distribution of UVR specific biogeochemical factors and 3) determine the impact of biogeochemical variability as it affects the UVR:PAR ratio. Downwelling UVR and PAR irradiance and bio-optically derived biogeochemical factors were collected at 14 different coral biodiversity survey stations around the entire Malaysian peninsula from August 10 – 29, 2007. The results show mean penetration of the 1% surface UV-B radiation (320 nm) is generally deeper above reefs on the East coast (16±7 m) relative to the West coast (5±3 m) around the Malaysian peninsula. The UVR:PAR ratio was also generally higher on the East coast relative to the West coast reefs suggesting variable concentrations of UVR-specific absorption. UVR attenuation at all biodiversity stations showed significant relationships ($P<0.01$) with bio-optically derived chlorophyll, CDOM, and POM concentrations, but not with DOC. The results suggest that coral reef communities with higher concentrations of POM and CDOM on the West coast of the peninsula are less susceptible to harmful UV-B radiation. Further, the results support prior studies that show chromophorically active concentrations of DOM and POM are significantly altering the amount of UVR penetration above coral reefs and may be ephemeral factors in regulating intricate biogeochemical cycles around benthic coral communities in Malaysia.

## 19.785

**The Nitrogen Isotopic Dynamics Of The Florida Reef Tract**

**Kathyrn LAMB*[1]**, **Peter SWART*[1]**, Mark ALTABET[2], Samantha EVANS[1], Courtney DRAYER[1]

[1]MGG, University of Miami, Miami, FL, [2]School of Marine Sciences, Univeristy of Massachusetts, Dartmouth, MA

We have conducted a thorough spatial and temporal analysis of the nitrogen isotopic systematics of the Florida reef system. This study included analyses of the δ15N and δ18O of nitrate, the δ15N and δ13C of particulate organic material (POM), benthic algae, corals and various fish over a two year period. These data show that there are no unusually positive δ15N values which might be attributable to the influence of anthropogenic nitrogen in the Florida Keys. In fact shoreward to offshore transects indicate that the most positive δ13C values in the POM are present closest to shore indicating that the source of the organic material is not anthropogenic in origin, but rather is derived largely from the breakdown of seagrasses. The mean δ15N of coral tissues is +6.6‰, approximately 2‰ more positive than the zooxanthellae, which is in turn similar to the δ15N of the nitrate. The elevated δ15N of the coral tissue as well as herbivorous fish, reflect trophic effects. Overall our data suggest that variations in the $\delta^{15}N$ of the primary producers reflect fractionation during assimilation of nitrate and ammonium as these nutrients are utilized by the reef communities. Enrichments in the higher trophic levels occur as a result of natural processes.

## 19.786

**Using Fatty Acid Biomarkers And Nutrients in Sediments To Detect Seasonal Changes in Organic Matter And Nutrient Sources Within A Mixed Coral And Seagrass Community, Bise, Okinawa, Japan**

**Preetika SINGH*[1]**, Makoto TSUCHIYA[1], Nakano YOSHIKATSU[1], Ninomiya SAYUKO[2]

[1]University of the Ryukyus, Okinawa, Japan, [2]Tokyo Kyuei Co., Ltd, Kawaguchi, Japan

Changes in fatty acid biomarkers and nutrients in sediments from various areas of a coral and seagrass moat were analyzed. Sediments near the wastewater pipes leading into the moat were compared with sediments from the subtidal region, which comprised of a seagrass bed, and a mixed coral and seagrass community.

The high amount of nitrites (0.7 µMol/g ) from autumn 2006 until spring 2007, and ammonium (21.6 µMol/g) during the spring season in 2007 observed in sediments near the wastewater pipes indicates that there is a significant input of nutrients from the terrestrial sources. The fatty acid results show that the sediments near the wastewater pipes had a significantly high amount of essential fatty acids (ω3 and ω6 polyunsaturated fatty acids) in autumn of 2006 and macroalgal fatty acids in winter.

In the subtidal regions, the seagrass bed sediments had the highest amounts of ammonium (24.4 µMol/g) during the summer season and this was followed by ammonium levels in the sediments from the mixed coral and seagrass community (17.7 µMol/g). The sediments also had the highest essential fatty acids and microalgal biomarkers concentrations during the summer season.

The fatty acids results thus indicate that while the sediments near the wastewater pipe are contributing a significant amount of organic matter during autumn and winter, the diatoms and dinoflagellates may be contributing to organic matter within the subtidal sediments during the summer season.

## 19.787

**Nutrient Enrichment Of A Marine Cage Culture And Its Impact On The Composition Of Coral Species in The Subtropical Coral Community**

**Yuan Chao Angelo HUANG*[1]**, Pei-Jie MENG[2], Yung- Song CHEN[3], Shou Chong HUANG[4], Chaolun Allen CHEN[5]

[1]Institute of Oceanography, National Taiwan university, Taipei, Taiwan, [2]National Museum of Marine Biology and Aquarium, Pintung, Taiwan, [3]Department of Animal Science, National IlanUniversity, Ilan, Taiwan, [4]Researcg Center for Biodiversity, Academia Sinica, Taipei, Taiwan, [5]Research Centre for Biodiversity, Academia Sinica, Taipei, Taiwan

Offshore cage culture has been demanded increasingly in the oligotrophic water around coral reefs, particularly in those reefs of developing countries. However, the nutrient enrichment and its impact on the adjacent coral community remain unexplored. In this study, the nutrient gradient and the coral species composition in a subtropical coral community were investigated from 2006 to 2007 in the Makong inner Bay (23¢X32.471'N; 119¢X35.320'E), Penghu Islands, Taiwan. Three zones, cage, middle, and none-cage, were divided according to the GPS of cages and coral community. The results indicated that nutrient enrichment in cage zone was significantly higher, especially the nitrogenous components (Ammonia) from the metabolized waste of the cultivated fishes. The other environmental factors presumably affected by cage cultures, including sedimentation rate, organic matter content, and total suspend solids, were not significantly different between cage zone and these other two zones. The highest coral species richness was observed in the middle zone (29 species). In the cage zone coral species richness was slightly decreased to 20 species, and in the non-cage zone it sharply decreased to between 4 and14 species. This tendency is also reflected by the variability of Shannon-Weaver species diversity index. In conclusion, there was a distinct within-reef zonation in coral distribution. Furthermore, nutrient enrichment caused by effluent from the cage did not reduce the coral diversity, but changed the species composition of reef-building corals.

## 19.788

**Submarine Groundwater Discharge And Its Role in Structuring Coral Reef Communities Along The Arid Kona Coast Of Hawaii, Usa**

**Eric GROSSMAN*[1]**, Karen LISA-KNEE[2], Adina PAYTAN[3], Ann GIBBS[1], Josh LOGAN[1], Kathy PRESTO[1], Curt STORLAZZI[1], Sallie BEAVERS[4], Lisa MARRACK[4], Rebecca MOST[4]

[1]Coastal and Marine Geology Program, US Geological Survey, Santa Cruz, CA, [2]Stanford University, Palo Alto, CA, [3]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, [4]National Park Service, Kailua-Kona, HI

Coral reef mapping and measurements of nearshore water temperature (T), salinity (S), Radium (Ra) isotope quartets, nutrients, waves, and tidal currents suggest that submarine groundwater discharge (SGD) may play an important role in shaping coral reef communities along the arid Kona coast of the island of Hawaii. Seasonal and tidal surveys across the reef complex of Kaloko-Honokohau National Historical Park (KAHO) between Dec 2003 and April 2006 show persistent discharge of cool, fresh surface water into the nearshore and patterns of transport and mixing with marine waters. In the absence of stream flow, these data reveal that the source of this fresh to brackish water is SGD. Fluxes to the park's coastal waters ranged between 9.4 and 47.0 m3/d/m of coast and are adequate to maintain a buoyant fresh to brackish surface lens across extensive areas of the reef complex. Nutrient concentrations in groundwater were an order of magnitude higher than surrounding coastal waters of the park. Northerly, alongshore currents generally transported this nutrient-rich water through the park from a dominant source (Honokohau Small Boat Harbor), while large waves mixed the water column to ~10-15 m depths. Coral zonation largely reflects wave exposure along KAHO, however, the octocoral *Sarcothelia edmonsoni* and various green and brown algae were most dense in areas of high SGD. It is likely that recent increases in municipal groundwater withdrawals and nutrient (urban chemical) loadings translate to elevated SGD-derived nutrient and contaminant discharges. Such data provide important near-baseline information for assessing and predicting climate, land use, and SGD impacts to the area's fragile ecosystems.

## 19.789

**Detrital Resources in An Undisturbed Coral Reef Food Web: Preliminary Findings From Palmyra Atoll's Coral Reefs**

**Lisa MAX*[1]**

[1]Ecology Evolution and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA

Coral reef food web studies have traditionally focused on the competitive and predator-prey relationships between reef organisms. These studies often discount the driving roles that ecosystem processes, such as detritus-cycling, play in maintaining energetic and nutritional pathways on coral reefs. Detritus, the pool of non-living organic material that organisms contribute to via metabolic by-products and eventual death, is an important conduit of energy and nutrients to all trophic levels within ecological communities, yet it receives scant attention in coral reef food web literature. My preliminary studies on the role of detritus at Palmyra Atoll National Wildlife Refuge, demonstrate that detrital material is of high nutritional quality, and is a likely food source for a wide variety of reef organisms in this undisturbed coral reef system. Stable isotope analyses performed on detrital samples demonstrate that its isotopic signature varies among Palmyra's backreef and forereef habitats. Detrital material used in this study was collected via suction sampling from reef substrates and via sediment traps fixed to the benthos. In order to characterize the biological community in each sampling area, still photo-quadrats and fish and invertebrate surveys were carried out. Overall, this study's findings suggest that detritus may be an important link in Palmyra Atoll's coral reef food webs, opening avenues for further research on Palmyra and other coral reefs systems.

## 19.790

**Carbonate Gain And Loss: Comparing Carbonate Production With Parrotfish And Urchin Bioerosion On A Protected Reef In Hawaii**

**Ling ONG*[1]**, Kim HOLLAND[2,3]

[1]University of Hawaii at Manoa, Honolulu, HI, [2]Hawaii Institute of Marine Biology, Kaneohe, HI, [3]Hawaii Institute of Marine Biology, Kaneohe

Parrotfishes and urchins can be significant bioeroders and sediment producers on coral reefs but little has been done to quantify this in Hawaii. Parrotfish and urchins bioerode the carbonate structure of the reef while grazing, and the ingested carbonate is defecated as sediment. The 41 ha study site, Hanauma Bay, Oahu, Hawaii is a marine protected area where harvesting has been prohibited since 1967. The parrotfish and urchin sizes and densities present are assumed to be natural. Bioerosion rates between parrotfishes and urchins are compared and the overall grazer (parrotfish and urchins) bioerosion rate is also examined relative to the gross carbonate production rate for the different reef zones. Overall, parrotfish bioerosion rates in Hanauma Bay are 4 - 9 times urchin bioerosion rates in all the examined reef zones. Grazer bioerosion exceeds gross carbonate production on the reef flat, is nearly equal on the fore reef and significant positive carbonate accretion only occurs on the reef shelf. Of the four bioeroding parrotfish species present, over 70% of parrotfish bioerosion is by large individuals (> 45 cm FL) of just one species, S. rubroviolaceus. The overall parrotfish sediment production rate in Hanauma Bay (1.36 kg.m-2.yr-1) exceeds the total sediment production rate in neighboring Kailua Bay (0.9 kg.m-2.yr-1) where parrotfishes are reportedly absent. Thus, large parrotfish species are potentially ecologically important as bioeroders and sediment producers on reefs in Hawaii. A slot limit, where parrotfish smaller than the size at first reproduction and those larger than 45 cm are protected, is suggested as a fisheries management strategy to preserve biomass and maintain ecological function.

## 19.791

**Macroalgal Tissue Nutrients As Indicators Of Nitrogen And Phosphorus Status in The Florida Keys**

**Dennis HANISAK*[1]**

[1]Harbor Branch Oceanographic Institute, Fort Pierce, FL

This study used the tremendous biochemical and ecological diversity of macroalgae to assess nitrogen and phosphorus availability at a broad, ecosystem-level scale in the Florida Keys and nearby waters. Spatial variation in tissue nutrients (carbon = C, nitrogen = N, phosphorus = P) of dominant macroalgae were assessed, both as ratios and absolute values, along 12 inshore-offshore transects in the Florida Keys and at 10 stations in nearby Florida Bay. The resulting detailed analysis demonstrated spatial and temporal patterns in macroalgal tissue nutrients. The transect data revealed no universal inshore-offshore patterns in tissue nutrients and no obvious "hotspots" of nutrient enrichment. Similarly, when data were compared among segments, there was no universal geographical pattern in tissue nutrients for all species. The most striking result was that the N and P status of macroalgae in Florida Bay was significantly different than other locations. Macroalgae collected from Florida Bay generally had higher N and lower P levels than algae collected elsewhere. The most common inshore-offshore pattern was higher %N and lower %P availability inshore; however, limited inshore-offshore differences in N:P ratio suggests that both nutrients were generally readily available in proportional amounts required by the various species. Most species in this study had higher %N, and to a lesser extent, higher %P and %C in March than in July. Based on the published literature on other species of macroalgae, it appears that N and P are generally available in sufficient quantities that most macroalgal growth is not limited by either nutrient.

## 19.792

**Diel Nitrogen Dynamics On A Florida Keys Coral Reef: Temporal Variability in Din Transformations By The Barrel Sponge *xestospongia Muta.***

**Patrick GIBSON*[1]**, Christopher MARTENS[1], Niels LINDQUIST[2], James HENCH[3], Howard MENDLOVITZ[1], Brian POPP[4], Joseph BOYER[5]

[1]Department of Marine Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, NC, [3]Environmental Fluid Mechanics Laboratory, Stanford University, Stanford, CA, [4]Department of Geology and Geophysics, University of Hawaii, Honolulu, HI, [5]Southeast Environmental Research Center, Florida International University, Miami, FL

The common barrel sponge, *Xestospongia muta*, is a dominant animal on Florida Keys reefs. *X. muta* hosts biogeochemical processes that can drive or mediate changes in ecosystem structure and function. Fluxes of dissolved inorganic nitrogen (DIN) resulting from *X. muta* pumping and respiration were examined with high temporal resolution utilizing the *Aquarius* underwater research habitat at Conch Reef off Key Largo during two missions in September and October 2007. Hourly samples of ambient and sponge excurrent water were simultaneously collected by automated underwater sampling units. Over 300 paired samples were analyzed in order to quantify the net fluxes of nitrate, nitrite, ammonium, and total DIN. This approach generated information about the inherent fine scale variability of ambient DIN concentration and speciation in the surrounding reef environment as well as the effect of sponge biogeochemical transformations on the nitrogen pool. Initial results suggest the occurrence of significant temporal variability in net DIN fluxes to the reef water column. Ambient DIN concentrations increased by an average of ~50% after being pumped through the sponge, however diel excurrent water DIN concentrations varied by at least five fold. The DIN flux is principally nitrate as a result of microbial nitrification occurring within *X. muta* tissues. Variability in the diel respiration cycle of the barrel sponges could impact the rates and/or mechanisms of N transformations. Considering the impressive pumping capacity of *X. muta* and other reef sponges, temporal changes in the flux of DIN from sponge processing could have important implications for the nutrient budgets and ecosystem dynamics coral reef ecosystems wherever sponges are abundant.

## 19.793

**Effect Of Coastal Water Nutrient Enrichment On Macroalgal Communities Over The Southern Martinique Reef**

**Helene LEGRAND*[1]**, Yann ROUSSEAU[2], Brian LAPOINTE[3], Philippe LENFANT[4], René GALZIN[4], Jean-Philippe MARECHAL[2]

[1]Observatoire du Milieu Marin Martiniquais, FORT DE FRANCE, Martinique, [2]Observatoire du Milieu Marin Martiniquais, Fort de France, Martinique, [3]Harbor Branch Oceanographic Institution, Ft Pierce, FL, [4]EPHE - Université Perpignan, Perpignan, France

Coral reefs of Martinique have undergone an excessive growth of macroalgae over the past two decades, leading to a decrease in coral cover and health status. Increasing urbanization, agricultural and industrial activities over the South coast of Martinique have raised land-based nutrients discharges.

In this study we used macrophytes ä15N signatures to point out the influence of anthropogenic nutrient enrichment on macroalgal communities' development.

Field experiments were conducted at 10 stations located along the Southern reef of Martinique. Seven sites were chosen close to anthropogenic nutrient discharges and 3 offshore sites were selected as reference sites.

Three macroalgae indicator species were collected at each site and two depths to assess spatial variability among shallow subtidal (5m) and mid-depht (25-30m) waters. Dried tissues were used for stable nitrogen isotope (ä15N) analysis. Water-column dissolved inorganic nitrogen (DIN), soluble reactive phosphorus (SRP) and chlorophyll a were measured. The sampling was performed during the wet and dry season for seasonality changes in N source availability.

We expect that concentrations of dissolved inorganic nitrogen, soluble reactive phosphorus, and chlorophyll a increase at sites directly impacted by sewage discharges (outfalls, rivers, bays…). The offshore reference sites should be more nutrient limited than the nearshore ones. We assume that macroalgae in nearshore waters have elevated ä15N values characteristic of sewage enrichment and agriculture fertilizers. Furthermore ä15N values are presumed to be significantly highest over shallow reefs compare to deep water.

These results will suggest that regional-scale agricultural runoff from the mainland as well as local sewage discharges from urbanization and economic activities are both significant nitrogen sources supporting eutrophication and macroalgal invasion in coral reef communities.

## 19.794

**Seasonal Variation Of $\delta^{15}$n in Coral Skeletons**

**Atsuko YAMAZAKI*[1]**, Tsuyoshi WATANABE[1], Tatsunori KAWASHIMA[1], Naohiko OHKOUCHI[2], Nanako OGAWA[2], Mitsuo UEMATSU[3]

[1]Graduate School of Science, Hokkaido Univercity, Sapporo, Japan, [2]Institute for Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, [3]Ocean Research Institute, The University of Tokyo, Tokyo, Japan

The skeletons of scleractinian corals are composed of aragonitic skeletons and a few amount of organic matrix containing nitrogen. In this study, we estimated the origin of $\delta^{15}N$ changes in coral skeletons and demonstrate the possibility that coral $\delta^{15}N$ could be a powerful tool of reconstructing paleoenvironments.

We collected two corals from the mouth of Todoroki River in Ishigaki Island, and Okinotori Island, Japan. Ishigaki coral had grown under strong influence of terrestrial input such as the fertilizer from cane fields thorough the Todoroki River. In contrast, Okinotori Island is isolated in open ocean and very apart from any terrestrial sources (900 km). Typhoons come across Okinotori Island very frequently and cause upwelling which brings nutrient rich water from deeper layer. We analyzed their δ18O and δ13C with 200 µm intervals using Finnigan Mat 251 in Hokkaido University, and δ15N with 800 µm intervals using Finnigan Delta plus XP in JAMSTEC, respectively.

The average δ15N and total nitrogen (TN) of Ishigaki coral are 1.5 ‰ and 0.01% larger than those of Okinotori coral, respectively. This is probably due to the difference of nutrient sources. Furthermore, constant nutrient supply in Ishigaki Island, bring enough primary production to coral reef. Consequently, δ15N is different between two sites. $\delta^{15}N$ in Okinotori coral correlates with TN. $\delta^{15}N$ and TN have positive peaks in low SST season, when vertical mixing brings nutrients to sea surface. These positive peaks are also found after typhoon events. A supply of nutrients promotes activity of zooxanthellae, which makes $\delta^{15}N$ in coral large.

The results suggest that $\delta^{15}N$ in coral could record the changes of symbiotic algae activity and it can be expected to use as a new marker for reconstructing past environmental and physiological changes.

## 19.795

**Evaluation Of Stable Isotope Analysis As A Tool For Monitoring Impacts Of Anthropogenic Nutrient Inputs On Coral Reefs**

**James FOLEY*[1]**

[1]School of Marine Science & Technology, Newcastle University, Newcastle, United Kingdom

Sewage can have severe implications for animal trophodynamics over coral reefs. Tobago reef algae have previously been identified as sewage impacted with impacts reducing with distance from source. Here the impact is assessed of sewage from two known point source sewage outfalls on Tobago's coral reefs over multiple trophic levels to assess the degree to which these impacts extend up the reef food chain. Stable isotope analysis (SIA) measured spatial and trophic variation of nitrogen and carbon stable isotope ratios ($\delta^{15}N$ and $\delta^{13}C$) in tissues from four coral reef organisms at different trophic levels, and from particulate organic matter (POM) from two sewage/domestic waste outfalls. Organisms progressively distant from effluent outfalls showed no significant differences in $\delta^{15}N$ or $\delta^{13}C$ between sites, apart from at the highest trophic level. $\delta^{15}N$ and $\delta^{13}C$ of POM from one outfall were similar to $\delta^{15}N$ and $\delta^{13}C$ of estimated natural marine primary production sources, although POM from a second outfall differed from this. However, discharge from the second was too low at this time of year to reach the sea, rendering it unable to contribute to coral reef production sources. Data correlates with another study, showed significant temporal variability in primary production sources. Together, these data indicate either no significant effect of anthropogenic nutrients from these two point sources on Tobago's coral reefs during the dry season, or that SIA is unable to detect effects due to sewage signals not differing from signals of natural production sources e.g. phytoplankton. With increasing use of SIA in ecological studies, this demonstrates importance of appropriate use of monitoring tools, improved understanding of limitations, and caution in their use to avoid misinterpretation and consequent expenditure on ineffective mitigation strategies.

## 19.796

**Diel Patterns of Abundance and Vertical Distribution of Zooplankton over a Florida Coral Reef**

**Keri O'NEIL*[1]**, Karla HEIDELBERG[2], Kenneth SEBENS[3]

[1]National Aquarium in Baltimore, Baltimore, MD, [2]Department of Biological Sciences and Wrigley Institute of Marine Science, University of Southern California, Avalon, CA, [3]Friday Harbor Laboratories and Department of Biology, University of Washington, Friday Harbor, WA

Zooplankton on corals reefs comprise reef resident species, demersal migrating species, open ocean holoplankton advected onto reefs, and meroplankton from both open ocean and reef sources. This diverse zooplankton resource provides substantial nutrient input to the reef ecosystem via reef fish, corals and other predators. We examined vertical and temporal patterns of zooplankton associated with Conch Reef in the Florida Keys. Intensive diel sampling was accomplished via saturation diving (*Aquarius* underwater laboratory), allowing samples to be collected both at the surface and at depth six times daily for seven consecutive days. Samples were pumped at four heights above the substrate, including just above coral tentacles. *Oithona* spp. were the most abundant copepods and this species was evenly distributed with depth. *Acartia* spp. comprised the second most abundant copepod genus and had significant differences with both time and depth. Several taxa were homogeneous throughout the water column, while others were generally more surface or substrate associated. The behavior of certain holoplankton associating with reefs may explain some of the patterns found here. This spatially and temporally stratified sampling regime allows an accurate description of zooplankton taxa available as prey for benthic suspension feeders, such as anemones and corals, and for fish and other zooplanktivores on and at discrete heights above reef surfaces.

## 19.797

**Physiological Effects Of Submarine Groundwater Discharge On The Hawaiian Marine Alga *gracilaria Coronopifolia***

**Daniel AMATO*[1]**

[1]Botany, University of Hawaii Manoa, Honolulu, HI

Submarine groundwater discharge (SGD) is thought to be a significant source of nutrients to many coastal ecosystems. To date, a causal relationship between SGD and primary productivity has not been described. In order to determine the physiological effects of this process on coastal macroalgae, the Hawaiian endemic edible red alga *Gracilaria coronopifolia* J. Agardh was collected and grown in a highly controlled flow-through digital mesocosm. To simulate increasing levels of SGD, treatments ranged from an ambient oceanic control of high salinity/low nutrients to low salinity/high nutrients. Empirical relationships among salinity, nitrate, and phosphate from known sites of SGD in Hawaii were used to determine the chemical composition of four treatments with six replicates per treatment. After 16 days, the mean specific growth rate and apical tip development of the 27‰ salinity treatment was at least two times greater than controls ($p=0.003$, $p=0.000$). The 11‰ salinity treatment was found to be close to *G. coronopifolia's* subsistence threshold. Pulse amplitude modulated chlorophyll fluorometry (PAM), in vivo pigment absorbance, and chlorophyll *a* measurements indicate the photosynthetic efficiency of treatments 19‰, 27‰ and 35‰ is not significantly different. The results of this study demonstrate that water chemistry parameters which simulate moderate amounts of SGD in a tropical oligotrophic environment more than double the growth rate and development of new apical tips in *G. coronopifolia* when compared to ambient oceanic controls. This conclusion has important implications for management of native and invasive species, coastal primary productivity, and groundwater conservation. The parameters "Tip Score" and "New Tip Index" developed during this study are novel and effective techniques for the quantification of algal apical tip development.

## 19.798

**Planktonic Carbon Balance Over A Coral Reef System**

**Paula SPINIELLO*[1]**

[1]Instituto de Zoologia Tropical, Universidad Central de Venezuela, Caracas, Venezuela

The following investigation was conducted to evaluate the temporal dynamic of carbon supply and demand in the planktonic compartment on a coral reef based system. Phytoplankton carbon supply was estimated through measurements of primary productivity and express as mg C/m/day. Zooplankton secondary production, and ingestion and assimilation efficiencies were used to estimate the carbon demand. Primary net productivity didn't show significant variations throughout the study, with values ranging from 205,02 to 265,22 mgC/m3/day. These values are high compared to other reefs systems in the Caribbean, which is mainly a consequence of the nutrients input from the adjacent mangrove system as well as the urban development. Carbon demand by the zooplankton showed a significant seasonal variation with values ranging from 26 mgC/m3/day at the beginning of the dry season to 209 mgC/m3/day at the end of the rainy season. The carbon supply throughout the study was higher than the demand, indicating that the production of autotrophic carbon in the pelagic zone is sufficient to cover the requirements of the zooplankton community.

## 19.799

**Temporal And Spatial Variability Of Sediment Productivity On A Fringing Reef (Reunion Island, Western Indian Ocean)**

**Dorothée TADDEI*[1]**, Pascale CUET[1], Jacques CLAVIER[2], Patrick FROUIN[1]

[1]Biology, ECOMAR Lab, University of Reunion Island, Saint Denis cedex 9, Reunion, [2]University of Bretagne, UMR CNRS IUEM, Plouzané, France, Metropolitan

The aim of this study was to assess the contribution of sediments to the carbon cycle in coral reefs. Productivity was measured at 8 stations (200 m apart) of La Saline fringing reef (Reunion Island), in winter and summer. Changes in pH, total alkalinity, temperature, salinity and light intensity (photosynthetically active radiation) at the water-sediment interface were measured in benthic chambers. Community net ($CP_{net}$) and gross ($CP_{gross}$) productions, and community respiration (CR) were estimated at different times of the day (and, hence different light intensities). Light response curves were plotted for productivity using the exponential model. At the whole reef scale, sediments were heterotrophic with a $CP_{gross}$/CR being 0.8 ± 0.1. Carbon consumption exceeded production; sediments were therefore a sink for POC. The reef flat productivity was steady for the different sites without any seasonal trend ($CP_{net}$ = 14 ± 12, $CP_{gross}$ = -87 ± 17, CR = 101 ± 11 mmolC $m^{-2}$ $d^{-1}$). Conversely, back reefs showed a specific pattern of spatial variations with the highest values recorded in summer. In summer, CR varied from 88 to 264 mmolC $m^{-2}$ $d^{-1}$ and $CP_{gross}$ from -86 to -212 mmolC $m^{-2}$ $d^{-1}$. This pattern reflected the combined effects of reef currents and groundwater discharge that brings DIN from land-based human activities. This study 1) confirms the heterotrophic status of sediments whose communities depend on exogenous organic matter probably originated from coral/macroalgae communities and 2) highlights a seasonal trend for production in back reef and as well as a small scale spatial variability which is rarely taken into account in such reef studies. Finally this work highlights the importance to sample at small spatial scale in fringing reef to avoid errors in budget calculation.

## 19.800

**Recycling-Oriented Aquaculture System Utilizing Natural Ecological Functions Of Mangrove Organisms**

**Yoshimi FUJIOKA*[1]**, Chumpol SRITHONG[2], Ryuichi TABUCHI[3], Toru SHIMODA[4], Takuro SHIBUNO[4], **Hideo OHBA*[5]**

[1]National Research Institute of Aquaculture, Minami-ise, Japan, [2]Kasetsart University, Bangkok, Thailand, [3]Forestry and Forest Products Research Institute, Tsukuba, Japan, [4]Seikai National Fisheries Research Institute, Okinawa, Japan, [5]Tokyo University of Marine Science and Technology, Tokyo, Japan

Model experiments of a recycling-oriented prawn aquaculture using natural ecological function of mangrove ecosystem to protect coastal environments including coral reefs were carried out in Samut Songkhram, the Gulf of Thailand. The survival rate and average weight of prawns, Penaeus monodon, in the water-circulated culture systems were higher than those in the closed culture system. When prawns were cultured under semi-intensive conditions in mangrove planted ponds, their average size increased about by 25%, and artificial feed could be reduced about by 19% compared to the intensive culture system. Diversity and biomass of the macrobenthos decreased during the culture experiments in the prawn culture ponds, while they increased in the mangrove ponds, indicating the possibility that the prawns fed on the small macrobenthos such as polychaetes and juvenile gastropods as a natural food source. Benthic and planktonic organisms found in the system were investigated quantitatively and 29 macrobenthos, 22 phytoplankton, 19 zooplankton, 17 algae/seagrass and 2 mangroves were identified. The results of feed preference experiments and analysis of digested materials demonstrated that prawns significantly selected polychaetes and crustaceans over commercially sold pellet feed. On the basis of a serious of study, we constructed a model of a recycling-oriented aquaculture system by utilizing the natural ecological functions of benthic and planktonic organisms, mangrove stands and seaweeds.

## 19.801

**Natural Feeding Of Coral Reef Holothurian, Holothuria Atra On Microalgae And Meiofauna From Seagrass Beds in Chuuk, Fsm**

**Do-Hyung KANG*[1]**, MD Abu AFFAN[1], Hyun Soo RHO[1], Sang-Gyu PAIK[1], Heung-Sik PARK[1]

[1]Korea Ocean Research and Development Institute, Seoul, Korea, Republic of

Ansan P.O. Box 29, Seoul 426–744, Republic of Korea

The coral reef holothurian, *Holothuria atra* (Jäger, 1833) has an important role in nutrient recycling as a sediment-feeder in coral reef ecosystems. This recycling of nutrients contributes to the high productivity in coral reefs. Limited information is available on the main food sources of *H. atra*, despite their importance on the reefs. This study investigates the food items (i.e. microalgae and meiofauna) consumed by the sediment feeding holothurian, *H. atra.* Sediment samples in front of the mouth, faeces at the posterior and the intestines of the sea cucumbers were taken from each individual. The different sediment samples were fixed in 10% formalin for later qualitative and quantitative analysis of microalgae and meiofauna. Taxonomical determination of microalgae was performed with an inverted microscope. Extraction of the meiofauna was performed using Ludox HS 40 and the species were identified to the class level. Total number of microalgae and meiofauna was identified to 25 species and 10 classes in three different samples, respectively. Microalgae and meiofauna in before feeding sediment were recorded 349 ind. ml–1 and 12.2 ind. ml–1 with the major groups of Bacillariophyceae and Polychaeta, respectively. After feeding, the microalgae and meiofauna were ingested up to 85.6% and 79.1% by the holothurians. In the intestine contents, the abundance of Bacillariophyceae without chlorophyll was higher than other groups while the abundance of Polychaeta was lower than other groups. This data demonstrated that Bacillariophyceae and Polychaeta were main ingested food items of *H. atra*.

## 20.802

**Conceptual Models For Tropical Atoll And Cold Coral Lophelia Pertusa Reefs**

**Robert GEORGE*[1]**

[1]George Institute, Wilmington, NC

Odum's models of food chain revealed trophiclinks in marine communities.However,the interconnection between primary production, primary, secondary and tertiary consumers remained complex. These models did not incorporate the human dimensions or biophysical interactions. This author in collaboration developed a simpler conceptual model with colleagues for the cold coral Oculina varicosa ecosystem, using rainbow colors depicting trophic levels. This conceptual model focused on 'Ecosystem-based Management'(EbM.)

This paper extends this simple conceptual model approach to coral reef ecosystems: (1)Tropical Acropora spp. ecosystem in the Maldives atolls in the Indian Ocean and (2) The deep-sea coral Lophelia pertusa (Linneus) bioherm, located at the northern tip of the Blake Plateau (400 - 650 m) in the Northwestern Atlantic Ocean.The Maldives reefs were severely impacted by bleaching events during the 1998 El Nino.On the contrary, the azooxanthellate Lophelia pertusa bioherms off North Carolina, adjacent to the Agassiz Coral Mounds(ACM)off cape Fear, are influenced by the Gulf Stream and the Western Boundary Under Current, the former dominated by a single scleractinian coral Lophelia pertusa and the latter dominated by the coral Bathypssamia tintinnabulum. Several species of bathyal crustacean and fish are abundant in this ecosystem.

Two hypotheses are presented in this paper: (A) Acidification stress can impose reduction in calcification rate and weaken coral skeletons and (B) Development of this conceptual models will enable managers to recommend endangered species status to coral and fish species and decision-makers to designate EFH-HAPC status that will assure better protection of these vulnerable ecosystems and pave the way for developing precautionary models.

## 20.803

**A Trophic Model Of Overfished Fringing Coral Reefs in Nanwan Bay, Southern Taiwan**

Pi-Jen LIU[1], **Hsing-Juh LIN*[1]**, Kwang-Tsao SHAO[2]

[1]Department of Life Sciences, National Chung Hsing University, Taichung, Taiwan, [2]Research Center for Biodiversity, Academia Sinica, Taipei, Taiwan

Nanwan Bay, on the southern tip of Taiwan, is surrounded by well-developed fringing reefs and attracts millions of tourists annually. In the past decade, some coral reefs in Nanwan Bay have undergone rapid shifts to macroalgal dominance or to sea anemone dominance. Using the Ecopath approach and network analysis, a mass-balanced trophic model was constructed to analyze the structure and matter flows within the food web. The fringing reef model was comprised of 18 compartments containing five integrated trophic levels, with the highest trophic level of 3.45 for piscivorous fish. The mixed trophic impacts revealed that macroalgae, benthic omnivorous invertebrates, and piscivorous fish were the most-influential compartments in the reefs. Comparative analyses with other fringing reefs demonstrated that total consumption and respiration in Nanwan Bay were lower than those of other reefs. Fishery¡¦s mean trophic level, Finn¡¦s cycling index, and mean trophic transfer efficiency of Nanwan Bay were also lower than those of other reefs. However, total catch, net primary production, net system production, and the net primary production: respiration ratio in Nanwan Bay were higher than those of other reefs. The Nanwan Bay model showed an overfished status, in which less organic matter is being conserved. The low abundance of fish might therefore have resulted in a great proportion of flows not being transferred to higher trophic levels but moving to detritus instead. Our results suggest that the authority should prohibit fishing in the coral reefs of Nanwan Bay, or create more marine protection areas (MPA) to restore fish community.

## 20.804

**The Rites Of Passage in The Marine Corridors Of The Sulu Sea**

**Porfirio ALIÑO*[1]**, Wilfredo CAMPOS[2], Karen FRANCISCO[1], Samuel MAMAUAG[1], Rollan GERONIMO[1], Wilfredo LICUANAN[3], Cesar VILLANOY[1], Melchor DEOCADIZ[1], Pacifico BELDIA[2]

[1]University of the Philippines Diliman, Marine Science Institute, Quezon City, Philippines, [2]University of the Philippines Visayas, College of Arts and Sciences, Iloilo City, Philippines, [3]De La Salle University, Brother Shields Marine Station, Manila, Philippines

The Sulu Sea marine corridors are found at the cradle of the highest marine biodiversity areas in the world. Reefs in the Verde Island Passage-Mindoro Strait-Calamianes Islands, The Balabac Straits and the Cagayan Ridge area were investigated. Coral reef benthic assemblages and their associated fish communities were assessed to provide the state of the reefs. Relative degrees of the natural and human induced were evaluated. We looked at how the connectivity information is crucial in the formulation of a strategic conservation agenda for the various governance levels at each reef area. The utilization of no-take marine protected areas (MPA) as an entry point, in conjunction with fisheries management helps to prioritize the conservation strategies at various ecological and management scales.

Cagayancillo is in a better reef state vis-à-vis those in the municipalities Balabac and Mabini, Batangas. On the other hand, most of the reef areas have exceeded its fishing capacity. Our results suggest the expansion of no-take areas in the corridors need to be expanded to help continue to facilitate interconnectedness. Fisheries Information to Sustain Harvests – BioEconomic 2 (FISH BE2) network model simulations implicates the resiliency of these marine corridors. Further increases in fishing capacity will lead to further decline and reflect on the fishers daily catch rates. Marine corridors show the importance in allocating buffer areas for particularly sensitive sea areas (PSSA) in conjunction with expansion of sizes of the existing MPA.

## 20.805

**Quantifying Environmental Influences On Coral Bleaching in The Florida Keys Using Multi-Species Models**

**Susan YEE*[1]**, Deborah SANTAVY[1], Mace BARRON[1]

[1]ORD/NHEERL/Gulf Ecology Division, U.S. E.P.A., Gulf Breeze, FL

Differential susceptibility among reef-building coral species to temperature-induced mass bleaching events can lead to community shifts and loss of diversity. We evaluated environmental influences on coral colony bleaching from 1998-2005 in the Florida Keys, USA. We used clustered binomial regression to develop models incorporating species-specific responses to the environment in order to identify conditions and species for which bleaching is likely to be severe. We evaluated three separate models incorporating environment, species composition, and species-specific responses to environment, and showed observed prevalence of bleaching reflects an interaction between species composition and local environmental conditions. Environmental variables, including elevated sea temperature (Degree Heating Weeks), solar radiation, and reef depth, explained much of the variability in colony bleaching across space and time. The effects of environmental variables could only partially be explained by corresponding differences in species composition. Species-specific models indicated individual coral species responded differently to local environmental conditions and had different sensitivities to temperature-induced bleaching. Acropora palmata experienced the severest response to temperature, whereas for other taxa the response was fairly weak. For many coral species, including Colpophyllia natans, Dichocoenia stokesii, Diploria strigosa, Montastraea annularis, M. cavernosa, and Siderastrea siderea, bleaching was exacerbated by high solar radiation. A reduced probability of bleaching in shallow locations for S. siderea may reflect an ability to acclimatize to local conditions. Model development provides a useful tool for quantifying the influence of the local environment on species-specific bleaching sensitivities, identifying susceptible species, and predicting the likelihood of mass bleaching events with changing environmental conditions.

## 20.806

**An Integrative Interdisciplinary Research Program On Environmental Change At Midway Atoll (Nw Hawaiian Islands)**

**Donald POTTS*[1]**, Wendy COVER[2], Kristin MCCULLY[2], Jennifer O'LEARY[2], Adina PAYTAN[1]

[1]Institute of Marine Sciences, University California, Santa Cruz, Santa Cruz, CA, [2]Ecology and Evolutionary Biology, University California, Santa Cruz, Santa Cruz, CA

A five year research project was initiated in 2006 to explore responses to environmental change in marine habitats of the Midway Atoll National Wildlife Refuge (MANWR); to identify continuing consequences of 60 years as a major naval base; and to provide data and advice relevant to management of the MANWR. The project is a collaboration between USFWS and UCSC scientists and is supported by the Mitsubishi Corporation as part of its Global Coral Reef Conservation Project. Midway Atoll is latitudinally (29°N) and ecologically marginal. It lies in the transition zone between the North Equatorial and the North Pacific gyral systems, where local atmospheric and oceanographic responses to climate change are largely unpredicted, but are likely to be marked. Immediate goals are: to quantify the major organisms and processes contributing to reef growth, reef destruction, sedimentation and erosion, reef circulation and island hydrology. These data are being used to develop habitat-specific models that will be integrated into biogeophysical models of the whole atoll for exploring responses to IPCC and other projections. Current projects concentrate on interactions of scleractinian corals, coralline algae, fleshy algae, cyanobacteria, sea urchins, fishes, sediment production and transport, and framework accretion and erosion, and nutrients and contaminants in island groundwater and reef flats.

## 21.807

**The Recreational Value Of Coral Reef in The Wider Caribbean: A Classical And Bayesian Approach To Meta-Analysis And Benefit Transfer**

**Luz LONDONO_DIAZ*[1]**

[1]Agricultural and Natural Resources Economics, University of Connecticut, Storrs, CT

Meta-analysis and benefit transfer are increasingly being used by researchers and policy makers in seeking the estimation of environmental values, as well as the adjustment of welfare measures for transferring to different policy contexts. The need for transfer values is justified by the absence of valuation studies in specific policy sites, perhaps due to budgetary constrains. The Caribbean features both: the existence of a number of coral reefs valuation studies, and the urgent need for mechanisms to curb the degradation of these ecosystems. Thus, it constitutes a call for a critical statistical synthesis of existing value estimates as well as for testing the validity of value transfer across policy sites. This paper investigates the validity and robustness of value transfer based two methodological approaches: the classical meta-regression analysis and a Bayesian model, applied on the recreational value of coral reef in the wider Caribbean. The results show that transfer techniques are enhanced under the Bayesian approach, offering higher accuracy in the transfer of recreational benefits, even in the presence of a small meta-sample.

## 21.808

**Food Habit in The Coastal Zones Of The Arid Tropics**

**Hiroshi NAWATA*[1]**

[1]Research Institute for Humanity and Nature, Kyoto, Japan

I analyzed resource patch accessibility and availability in the coastal zones of the arid tropics, focusing on human-camel relationships in coral reef and mangrove ecosystems (Nawata, 2006). In this paper, I reveal a general framework of human food habit in the coastal zones of the arid tropics, based on the case study of the Beja on the Sudanese Red Sea coast. Economic production of the Beja depends mainly on their herds of camels, cattle, sheep, and goats. Although many people practice some cultivation of sorghum and pearl millet, some also engage in fishing on the seashore. Their food habit consist of; i) drink, sesoning and spice; ii) pastoral products such as milk, milk products, meats and eggs; iii) agricultural products such as cereals, beans, vegetables and fruits; iv) hunting, gathering and fishing products such as insects, land reptiles, birds, land mammals, sea reptiles, sea mammals, sea fishes and sea shells; v) human flesh referred in oral history. The most interesting aspects of food habit in the coastal zone of the arid tropics are human dependence on sea products of hunting, gathering and fishing. Therefore, in terms of arid land food production, we should reconsider much possibilities of development in sea products as principal element of the diet for the future.

## 21.809

**Marine Resource Dependence, Resource Use Patterns And Identification Of Economic Performance Criteria Within A Small Island Community: Kaledupa, Indonesia**

**Leanne CULLEN*[1,2]**, David SMITH[2], Jules PRETTY[3]

[1]Sustainable Ecosystems, CSIRO, Cairns, Australia, [2]Coral Reef Research Unit, University of Essex, Colchester, United Kingdom, [3]Centre for Environment and Society, University of Essex, Colchester, United Kingdom

Marine resources in the Wakatobi Marine National Park, Indonesia, are heavily relied upon for food, raw materials and income. Most marine ecosystems in the region are regarded healthy, but there is concern over the rapid deterioration of some of the more accessible areas of reef, mangrove and seagrass. Several management initiatives have been attempted, with little success.

A major reason why past conservation management initiatives have failed to reach their goals is lack of compliance of local communities to management rules and regulations. This is due largely to actual, perceived, or expected, economic losses to communities utilising natural resources for their own sustainability. Hence a key role of management should be to maintain or improve the economic status of local people.

The development of a simple series of economic performance criteria, i.e. testable parameters through which changes could be identified would allow economic status to be assessed. If appropriate methods can be developed, values generated could be used to implement economically and ecologically sound management practices with stakeholder support. To work towards this aim we need to understand local resource use patterns and economic importance, quantify local dependence, and describe existing livelihood strategies.

This study used the example of the Kaledupa sub-district, Indonesia, to provide a detailed case study of a small island community with high natural resource dependence. The study details natural resource use patterns and the extensive local complexities that must be understood for any chance of management success, it also highlights the importance of marine resources to the local economy. A series of economic performance criteria were identified which could be used in the development of appropriate management plans that aim to maintain ecological wealth and develop sustainable utilisation, whilst maintaining or improving the economic status of local user groups and maintaining local participation and support.

## 21.810

**An Interdisciplinary Approach To Reef Conservation**

**Philipp TAVAKOLI*[1]**

[1]Interdisciplinary Studies, North Carolina State University, Raleigh, NC

The objective of this paper is to illustrate the importance of extending reef conservation efforts to the adjacent coastal communities, and in particular of including socio-economic factors.

This paper presents the case study of Koh Tao, Thailand. The method is interdisciplinary: reef surveys, using the REEF CHECK method, are linked to environmental issues and socio-economic factors on the island. The study examines the mutual cause-effect relationships among these issues on a local level and ignores global factors, such as climate change.

The island of Koh Tao is a global center of scuba diving; it probably receives more divers annually than any other destination. The island has not yet followed the trend of massive development of other major tourist destinations, and most reefs are still in good condition. However, development has been growing rapidly over the past few years. The sheer amount of divers, the diesel from the dive boats, and the increasing run-off are taking their toll on the reefs. In brief, this study shows how the locals' lack of education and of appreciation for the reef itself, social community issues, and the very limited scope of economic opportunities, prevent sustainable development and result in reef deterioration. These factors are further reinforced by the transient nature of the dive industry. In return, the deterioration of the reefs results in increasing economic hardship, social tensions in the community, and even fewer opportunities for advancement, such as education, for the local people. Reefs as well as people are caught in this downward spiral. Reef ecosystems and human communities are closely intertwined and the well being of one depends on the well being of the other.

The analysis of cause-effect relationships then provides valuable guidance for sustainable development and ecotourism which ultimately foster reef conservation.

## 21.811

**Integrating Ecological And Perceptual Assessments Of Anchor Damage On Coral Reefs**

**Elizabeth DINSDALE*[1]**

[1]Biology Department, San Diego State University, San Diego, CA

Community participation in ecological management increases the success of the strategies. However, integrating information provided by community members is problematic. Therefore, anchor damage of coral reefs was used as a model to understand how people with different backgrounds described coral reefs and whether these descriptions would be useful for managers. To identify relationships between environmental interpretations, three epistemologically distinct measures; objective ecological measures, perceptual meanings, and subjective health judgments were compared. The ecological measures identified an increase in the number of overturned corals and a reduction in coral cover: the perceptual meanings identified a loss of visual quality; and the health judgments identified a reduction in perceived health of the coral reef sites associated with high levels of anchoring. Combining the perceptual meanings and health judgments identified that the assessment of environmental health was the most important feature of the environment described by both scientific and lay participants.

The participants had a consistent view of a healthy coral reef, suggesting that the ability to identify the health was not related to present day experiences. By combining subjective judgments and ecological measures the point at which the environment is deemed to loose value can be identified; for these coral reefs if the level of damage rose above 10.3% and the cover of branching corals dropped below 17.1% the reefs were described as unhealthy. The most effective measures were used to describe the effectiveness of a management strategy implemented to reduce anchor damage on coral reefs. Therefore, by combining this information a management agency can involve the community in identifying when remedial action is required and when the management policies have been effective.

## 21.812

**Destructive Fishing Practices: Identifying Its Triggering Factors And Understanding The Interplays Of Institutions in Coral Reef Management in Spermonde Archipelago Indonesia**

**Rio DESWANDI*[1]**, Marion GLASER[2]

[1]Social Science, Bremen University, Makassar, Indonesia, [2]ZMT, Bremen University, Bremen, Germany

Spermonde archipelago is suspected as point of destructive fishing practices. This ongoing qualitative study employs in-depth interview and participant observation. Local perceptions perceive coastal resources as belong to nobody, the fish never been exhausted but seasonally fluctuated, the fortune of fishermen is god's authority, and coastal water is a borderless open access area. Therefore, it is unreasonable for them to exclude outsiders and to stop destructive fishing practices. Indeed, anglers are benefited from blast fishing and "protect" this activity as it has social value. They may collect the fish resulted from blast fishing. Empirically, it is beneficial to fish at the blast spot as more fish will be gathered few days after. Fishermen perceive blast fishing as non-destructive activity compare to cyanide fishing.

Before 1960s, traditional leader (gallarang) defined authorize users and legal fishing activities. This traditional system had been replaced by state system. Inherently, most fishermen do not recognized customary/traditional rules regarding fishing activities nowadays. On the other hand, government's measurements to stop destructive fishing practices are not yet effective. Limited budget and facilities compare to huge area remain a constraint. Government's regulations are not well-acknowledged by fishermen. Further, administrative boundaries generate obstacles in monitoring and law enforcement. Still, corrupt officers are suspected behind blast fishing.

As conclusion, local perceptions, economic/welfare issues, characteristics of coastal resources, ineffective regulations, and corrupt officers are among factors identified to trigger destructive fishing practices. Government's institution eliminates the wisdom of traditional management system in managing coastal resources. Considering the intertwined between local perceptions, economic issues, and traditional versus government management system, it is significant to understand how different institutions interact upon particular social and biophysical settings to formulate appropriate management systems.

## 21.813

**Marine Resource Management in Aceh, Indonesia: Practice And Perception**

**Stuart CAMPBELL*[1]**, Rizya LEGAWA[1], Ahmad MUKMUNIN[1], Tasrif KARTAWIJAYA[1], Rian SERIANTO[1], Fakhrizal SETIAWAN[1], Andrew BAIRD[2], Joshua CINNER[2]

[1]Marine Programs, Wildlife Conservation Society, Bogor, Indonesia, [2]School of Tropical Marine Biology, James Cook University, Townsville, Australia

Coral reef and socioeconomic surveys were conducted in north Sumatra, Indonesia to examine the influence of traditional fisheries management practices and socioeconomic conditions on coral reefs. We interviewed a total of 157 respondents within 7 different fishing communities of Weh Island to examine if the knowledge varied among fishing communities of the location of marine managed areas, their rules and perceived benefits, and if so, what socioeconomic factors explained such differences. We also tested for differences in corals and reef fishes near communities and whether or not differences could be explained by knowledge of rules, compliance or resource use. Both coral cover and fish biomass were generally greater where communities had effective controls on fishing activities than in communities without controls. Our findings were that the communities most effective at conserving marine resources had significantly higher awareness and knowledge of the location and regulations of adjacent marine managed areas, had higher education levels and were located at greater distances from fish markets than communities with limited management controls on fishing. A measure of compliance with fishing gear restrictions in managed areas most likely accounted for lower fishing pressure in these areas. Trophic behaviour may explain some of the spatial differences in fish biomass, with corallivores and omnivores showing stronger associations with marine managed areas where coral cover was greatest. We suggest that in Aceh, local forms of marine management, where there has been protection from blast fishing and there exists a measure of compliance with local fishing regulations, play a substantial role in the protection of coral reefs. Given the rapid expansion in community marine managed areas in Indonesia, and the paucity of data showing benefits to reef health, the current study illuminates our understanding of some socioeconomic factors that may best advance the conservation of Indonesia's coral reefs.

## 21.814

**Linking drivers of exploitation to key ecosystem processes in coral reefs**

**Matilda THYRESSON*[1]**, Magnus NYSTRÖM[1], Beatrice CRONA[1], Maricela DE LA TORRE-CASTRO[1], Jerker LOKRANTZ[1], Narriman JIDDAWI[2]

[1]Department of Systems Ecology, Stockholm, Sweden, [2]Institute of Marine Sciences, Zanzibar town, Tanzania

Coral reefs worldwide are in serious decline due to overfishing and other human-related interventions. Identifying socio-economic drivers and the scales at which they may act upon is critical as reef-resources become increasingly attractive on the global market. This study examines the impacts of artisanal reef-fisheries on reefs around Zanzibar by linking socio-economic drivers to the degradation of ecologically important species, or groups of species that maintain key ecosystem processes, such as herbivory. The aim is to identify what socio-economic drivers (e.g. subsistence provision, market demands, and subsidies for certain species or capital investment) are in place and discern their behavior and scale at which they operate. The study, which was performed between November 2007 and January 2008, builds on semi-structured interviews with 180 respondents (fishermen, hotels etc.) involved in the reef-fisheries. The results suggest that specific species (or groups of species) and/or size classes are exploited by different drivers operating at certain scales (i.e. locally, regionally and globally). These findings can be important for protecting ecosystem processes that underpin the resilience in coral reefs and the study further suggests that different processes may require different management strategies.

## 21.815

**Dilemma in Coral Conservation And Community Livelihoods. A Case Study Of St. Martin's Island, Bangladesh.**

**Mohammad ISLAM*[1]**

[1]Norwegian College of Fishery Science, University of Tromso, Tromso, Norway

St. Martin's Island is a marine protected area under the designation of ecologically critical area. The island is the only coral enriched ecosystem of Bangladesh having global biodiversity significances. The present study based on secondary data, primary data survey, participatory observation and in-depth interviews. The study aims to map out the dilemma in government efforts to coral conservation and community livelihoods. Heavy dependence of the community on fishery resources poses a particular threat to increasing vulnerability of the island's economy to potential adversity if the fishery ruin. Other marine resources of the coral ecosystem also play an imperative role in employment and income generation for the numbers of island dwellers. Government legislations for conservation of marine resources and increased tourism activities have resulted in conflict and anger from affected local communities. Increased tourism activities opened a new avenue of revenue generation for some island dwellers but mostly to the outsiders of the island. Thriving tourism practices in the island have negative impacts on the fragile coral ecosystems of the island. Fishers of the island are losing their land due to encroachment of the elite hotel owners for developing infrastructures. Restrictions on the resources exploitation compelling many people jobless, having negative impacts on livelihood security. So, for subsistent living, over-exploitation of coastal fishery resources and uses of destructive fishing gears, excessive extraction of corals, sea weeds and algae goes unabated. Thus a conflict has unfolded between government efforts for coral resources conservation and that of managing the resources in a way that does impact negatively on the economic benefits and livelihood security of the island dwellers.

## 21.816

**Training For Local Inhabitants Of A Coral Reef Island At Southern Caribbean in Order To Develop Activities Sustainable With Ocean Life**

**Carlos BOHORQUEZ*[1]**

[1]National Fisheries Center, SENA, Cartagena, Colombia

Local inhabitants of some coral reef island near to the Colombian mainland on the Caribbean coast have limited education and labour opportunities. These people depend on the natural offer to obtain an income. SENA is offering to them technical courses that give to them skills for work and alternatives to generate an economic activity. During some courses offered in Isla Fuerte, Colombian Caribbean were design some ecological projects including mangroves restoration, underwater tour, fishery turism and sea turtle rescue and education visitor center between others. The last two projects, have a real viability in order to be sustainable and enough profit to assist the people involved covering their living expenses on a seasonal base. In the middle term future in would be true during the complete year if current turist and occasional visitants maintain a permanent interest in use those services and if there the trend to increase the tourism is maintained. Projects as mangroves restoration and underwater tour have some strong difficulties as not enough technical acknowledgement, minimal experience, no demand and very scarce funding sources. The remain population still have to obtain their survival from traditional activities as agriculture and some cattle, activities not environmental friendly as the projects mentioned before. Other business ideas that would employ a lot of people on the island with minimal impact on the coast and near shallow coral reefs as a call center has not been explored and currently there is not human resource with the necessaries capacities available for it.

## 21.817

**Practice Makes Perfect? An Iterative Approach To Participatory Modelling For Coral Reef Management**

**Deborah CLELAND*[1]**, anne DRAY[1], Rollan GERONIMO[2], Annabel TRINIDAD CRUZ[3], pascal PEREZ[4]

[1]RSPAS, ANU, canberra, Australia, [2]IMS, UPS, QUEZON CITY, Philippines, [3]IMS, UPS, Quezon city, Philippines, [4]RSPAS, ANU, Canberra, Australia

As human activities continue to devastate coral reefs across the globe, new and innovative approaches are needed to link government, communities and researchers to improve reef management. As these new approaches are developed, it is crucial to explore how effectively they are able to bring together diverse stakeholders to integrate knowledge and build relationships to support sustainable reef management. To this end, this paper uses an iterative methodology, drawing upon an initial participatory modelling experiment completed in Mexico, to guide the design of a new model and role-playing game 'ReefGame', which was implemented in the Philippines.

This research provides two important lessons for developing participatory modelling for coral reef management. Firstly, a comprehensive understanding of local complexities is critical in developing models that can effectively engage local people in dialogue and learning processes. Secondly, and notwithstanding the central role of contextual detail, explicitly extracting structural similarities over differing social and economic contexts plays an essential role in improving useful outcomes both for reefs and the people who depend on them.

## 21.818

**The International Year Of The Reef 2008 in Germany**

**Georg HEISS*[1]**, Reinhold LEINFELDER[1]

[1]Museum of Natural History Berlin, Berlin, Germany

This poster will highlight activities linked to the International Year of the Reef – IYOR 2008, within Germany as well as coral reef research and outreach activities with German participation globally.

The concerns of coral reefs have attracted more attention in developed countries in recent years, mostly linked to the attention that was directed to global climate change and the accelerating loss of biodiversity. The fact that coral reef ecosystems are seen as being the first victims of climate change has contributed to this situation.

Shortly after the declaration of IYOR 2008 in Cozumel in October 2006, German scientists, NGOs and government representatives came together to form an IYOR coordination team and an Advisory Council, which started their activities in early 2007.

The high priority allocated to the issues concerning coral reefs and the role that European countries have to play is demonstrated in the fact that Federal Environment Minister Sigmar Gabriel agreed to act as the patron of IYOR 2008 Germany.

Main goals of IYOR Germany are to inform the public and decision makers about the threats coral reefs are facing, and to intensify international cooperation between Germany, coral reef countries and international organisations in research, conservation, public outreach and sustainable development.

At submission time (December 2007) media attention had already increased and several articles were published. Daily and weekly print publications, TV stations, diving and travel magazines, as well as popular scientific publications are planning to focus on coral reef themes, and in particular on the global coral reef crisis, throughout the year.

Special exhibitions and symposia are in preparation, seminar series for the general public are planned in several cities, books on warning signals from coral reefs are being prepared. Movie theatres will feature films about coral reefs and companies will support activities in-kind and financially.

www.iyor2008.de

## 21.819

**Lessons From Resilience Thinking For Ecosystem-Based Management in Coral Reef Systems**

**Karen MCLEOD*[1]**, Heather LESLIE[2]

[1]Department of Zoology, Oregon State University, Corvallis, OR, [2]Center for Environmental Studies, Brown University, Providence, RI

As the frequency, magnitude, and scale of threats facing coral reefs and other marine ecosystems escalates, how can management keep pace? Ensuring the continued delivery of key services from coral reefs is particularly challenging in the face of increasingly global drivers of change – namely, economic globalization and climate change. Ecosystem-based management (EBM) emphasizes management of human activities across sectors for whole systems (both social and natural), consideration of the cumulative impacts of all activities affecting the system, and long-term maintenance of the capacity of the system to deliver the range of services that humans want and need. Through a resilience lens, EBM also recognizes an uncertain future, embraces change, and considers the implications of the linkages between reef ecosystems and human communities. We will present a synthesis of lessons learned from EBM efforts in both tropical and temperate systems and provide guidance for applying these lessons to coral reefs. First, we will discuss the design and implementation of EBM approaches and ways to tailor EBM for coral reef systems. Second, we will evaluate the efficacy of local management actions, adaptation, and mitigation strategies, especially in light of climate change. In particular, we will evaluate tradeoffs between managing to bolster resilience to a particular set of perturbations versus resilience to a broader range of perturbations, including novel or surprising ones. Throughout, we will highlight the roles of science and the consequences of ignoring linkages between social and ecological systems. The integration of resilience concepts into marine EBM efforts holds promise for conserving these fragile systems and the human communities that depend upon them.

## 21.820

**The Ecology Of The World's Largest Fish, *Rhincodon Typus***

**Mark MEEKAN*[1]**, Corey BRADSHAW[2], Steven WILSON[3], John STEVENS[4], Jeffrey POLOVINA[5], Brent STEWART[3]

[1]Darwin Office, Australian Institute of Marine Science, Brinkin, Australia, [2]Charles Darwin University, Darwin, Australia, [3]Hubbs Seaworld, San Diego, CA, [4]CSIRO, Hobart, Australia, [5]NOAA, Honolulu, HI

The past 15 years has seen rapid development of our understanding of the ecology and biology of whale sharks that aggregate seasonally at Ningaloo Reef, Australia. Monitoring fine-scale (metres to km) movement patterns suggests that whale sharks migrate to the reef to feed on seasonal aggregations of baitfishes and euphausiids. Satellite tagging has shown that sharks departing Ningaloo make frequent dives in excess of 980 m and migrate generally toward the northeast, often into Indonesian waters. Photo-identification (based on spot and stripe patterns) has confirmed that many sharks return to the reef, with some individuals resighted at intervals of more than a decade and a large number of individuals making frequent inter-annual visits. Photo-identification resightings have generated mark-recapture databases for estimation of population size and demographic parameters. Photograph matching has now been automated using open-access software (I3S) and match parsimony ranking, permitting faster and more reliable matching success than manual comparisons. Most sharks (74 %) individually identified in the Ningaloo aggregation from 1992-2006 have been male. Jolly-Seber open-population models suggest that sharks sighted at the reef are drawn from a super-population of 300-500 animals and Cormack-Jolly-Seber survival models demonstrate size-influenced apparent survival probability ranging from 0.59 (5-m shark) to 0.81 (9-m sharks) per year. Declines in relative abundance of up to 40 % were also evident in a 10-year sightings-per-unit-effort dataset collected by tour operators. There was also a continuous decrease in the average size of whale sharks from 7 m in 1994 to 5 m in 2004. Current and future studies of this aggregation include quantification of mortality sources and the development of microsatellite genetic tags for individual identification, validation of photo-identification and an assessment of ocean-scale gene flow.

## 22.821

**Estimating Populations Of Two Rabbitfish Species (*siganus Guttatus* And *siganus Javus*) in The Coral Reefs Of Singapore: A Pilot Study On The Use Of Software-Assisted Photo-Id**

**Marco PERRIG*[1]**, Beverly GOH[1]

[1]NSSE/NIE, NIE-NTU, Singapore, Singapore

The knowledge of population parameters and an understanding of the ecological interactions are important for proper management and conservation of living resources and ecosystems. Populations studies of fish species traditionally involve the use of physical tagging of animals in a mark and recapture methodology. However, tagging induced behavioural changes, stress, infection risks, and mortality are some undesired but unavoidable side effects of the methodology. For rare and highly endangered species that are susceptible to handling, or are difficult to trap, physical tagging is therefore unsuitable. Photo-ID is a non-intrusive method used to identify individuals, and has been utilized successfully in a wide range of species, especially marine mammals. However, this method requires the labour-intensive work of manually comparing photographs, and has found little application in fisheries where populations are commonly very large. Advances made in information technology have resulted in software that can assist in reducing the variability and time taken to compare digital images of individual organisms. This paper presents the results of a pilot study that explores the use of computer-assisted photo-ID in studying populations of two species of fish (*Siganus guttatus* and *Siganus javus*), that are known to inhabit coral reefs of Singapore and adjacent waters. The stability of colouration patterns and the uniqueness of individual patterns within each species are examined. In addition, the use of the software 'Interactive Individual Identification System (I3S)' as a tool to reliably and efficiently compare digital pictures of individuals of the two fish species will be tested.

## 22.822

**Use of a Model Selection Approach to Estimate Effects of Age, Size, and Density on Post-Settlement Survival of Yellow Tang in a Hawaiian MPA Network**

**Jeremy T. CLAISSE*[1]**, Sarah A. MCTEE[1], James D. PARRISH[1]

[1]Department of Zoology, University of Hawaii, Honolulu, HI

Major efforts have recently begun to manage the valuable and heavily harvested juvenile yellow tang, *Zebrasoma flavescens* (Acanthuridae), in the commercial aquarium fishery in the State of Hawaii. Perceived declines of fish populations led to the establishment of a network of MPAs which now prohibit aquarium collecting along more than 30% of the west coast of Hawaii Island. This led to the first serious life history studies of this species in order to better interpret extensive population monitoring data and to model effects of protection on yellow tang populations. Part of this effort included estimating natural mortality rates through the juvenile size range targeted by the fishery. Furthermore, because settlement rates are highly variable spatially and temporally in this system, it is important to understand how survival rates change as a function of age or size and density. We used a model selection approach implemented in Program MARK to estimate survival and resight probabilities and evaluate the effects of density and age on yellow tang recently after settlement and the effects of size in older juveniles. We found that survival of recent settlers decreased with density and increased with age. In older juveniles the effects of size varied between sites, but results were inconclusive, similar to other studies that have found relatively constant rates of survival in fish of moderate age. This approach may provide valuable insight for understanding the life history of a variety of coral reef species, which could lead to broader understanding of how population regulation occurs on coral reefs under both natural and fished conditions.

## 22.823

**The Coupling Of St. John, Usvi Marine Protected Areas Based On Reef Fish Habitat Affinities And Movements Across Management Boundaries**

**Mark MONACO*[1]**, Alan FRIEDLANDER[2]

[1]Biogeography Branch, NOAA National Ocean Service, Silver Spring, MD, [2]Biogeography Branch, NOAA NOS and The Oceanic Institute, Waimanalo, HI

NOAA's Biogeography Branch, the National Park Service and US Geological Survey are quantifying spatial patterns and habitat affinities of reef fishes in the US Virgin Islands. The objective of the study is to define the movements of reef fishes among habitats within and between the Virgin Islands Coral Reef National Monument (VICRNM), adjacent to Virgin Islands National Park (VIIS), and US Virgin Island Territorial waters. In order to better understand species' habitat utilization patterns and movement of fishes among management regimes and areas open to fishing around St, John, we deployed an array of hydroacoustic receivers and acoustically tagged reef fishes. A total of 123 fishes, representing 18 species and 10 families were acoustically tagged along the south shore of St. John from July 2006 to July 2007. Forty receivers with a detection range of approximately 350 m each were deployed in shallow nearshore bays and across the shelf to depths of approximately 30m. Receivers were located within reefs and adjacent to reefs in seagrass, algal beds, or sand habitats. Example results include the movement of lane snappers and blue striped grunts that demonstrated diel movement from reef habitats during daytime hours to offshore seagrass beds at night. Timing of migrations closely coincided with changes in sunrise and sunset. Fish associated with reefs that did not have adjacent seagrass beds made more extensive movements than those fishes associated with reefs that had adjacent seagrass habitats. The array comprised of both nearshore and cross shelf location of receives provides information on fine to broad scale fish movement patterns across habitats and among management units to examine the strength of connectivity between the marine protected areas and areas open to fishing.

## 22.824

**Abundance Of Economically Important Fish Species Inhabiting Patch Reefs in Shallow Water Near South Eleuthera, The Bahamas: Implications For Mpa Development**

**Annabelle ORONTI*[1]**, Christina ELMORE[2], Jill HARRIS[1], Aaron SHULTZ[1], Andrew FIELD[2], Andy DANYLCHUK[1]

[1]Cape Eleuthera Institute, Fort Lauderdale, FL, [2]The Island School, Fort Lauderdale, FL

Small patch reefs are common to the expansive shallow water banks of the Bahamian archipelago and can provide essential transitional habitat for fish and invertebrates, such as the Nassau grouper (*Epinephelus striatus*) and Caribbean spiny lobster (*Panulirus argus*). Given the economic importance of these species, patch reefs are often the focus of small-scale artisanal and moderate commercial fisheries. In recent years, evidence suggests that these fish stocks are in decline, and the Bahamian government is responding by imposing regulations, including size limits and a closed season when Nassau grouper aggregate to spawn. In 2000, the Bahamian government also proposed a network of marine reserves in an attempt to protect critical habitats for all life stages of commercially and ecologically important marine species, one of which is proposed for the waters off South Eleuthera. The purpose of this study was to establish a long-term monitoring program to assess the abundance of fish and invertebrates inhabiting small patch reefs in the region of the proposed reserve. Timed visual surveys were conducted on over 80 patch reefs in the spring and fall since 2004. Long-term trends indicate that the abundances of Nassau grouper (0.97 ± 0.37 SD) and spiny lobster (0.48 ± 0.48 SD) are relatively stable, and that only juvenile Nassau grouper inhabit these reefs. These results provide the only baseline data on the abundance of commercially important species in South Eleuthera and can assist the government with the planning and management of the proposed marine reserve. Collectively, our results suggest that marine reserves in the Bahamian Archipelago should include shallow water patch reefs as a way to provide protection for economically important fish and invertebrates in transitional habitats.

## 22.825

**Modeling Reef Fish Visual Census Data: Dealing with Zero Inflated Observations.**

**Alejandro ACOSTA*[1]**, Paul KUBILIS[2]

[1]Fish and Wildlife Research Institute/South Florida Regional Laboratory, Fish and wildlife Conservation Commission, Marathon, FL, [2]Fish and Wildlife Research Institute, FWC, Gainesville, FL

Monthly visual surveys (April to December) of reef fish populations in the Florida Keys were conducted since 2000 using stationary point count sampling methods. Each month, divers used SCUBA to conduct two 5m radius stationary point counts at 39 sites using a habitat-based, stratified random sampling design. During each sampling procedure, divers enumerated and assigned to 5cm size increments all groupers (Serranidae), snappers (Lutjanidae), hogfish (Labridae), angelfish (Pomacanthidae), butterflyfish (Chaetodontidae), triggerfish (Balistidae), and a few other species of recreational or commercial importance. A common feature of many multi-species ecological data sets is their tendency to contain many zero values, as is the case with visual census data. Statistical inferences based on such data are likely to be inefficient or inaccurate unless careful thought is given to how these zeros arise and how to best model them. To overcome this problem, we developed an exemplary zero-inflated data set and conducted analyses using Poisson or negative binomial regression models for uninflated or zero-inflated point counts. We also considered count regression models (hurdle models) in which the probability of zero counts and the mean of non-zero counts are modeled separately. In this paper, we propose a framework for understanding how zero-inflated data sets originate and deciding how to best model them using visual census data.

## 22.826

**Effect Of Marine Protection Areas On The Community Structure Of Coral Reef Fishes in Kenting National Park, Southern Taiwan**

**Jung CHEN*[1]**, Tung-Yung FAN[2], Kwang-Tsao SHAO[3]

[1]Institute of Marine Biodiversity and Evolution, National Dong Hwa University, Taiwan, Pingdung, Taiwan, [2]National Museum of Marine Biology and Aquarium, Taiwan, Pingdung, Taiwan, [3]Research Center for Biodiversity, Academia Sinica, Taiwan, Taipei, Taiwan

The establishment of the marine protection areas (MPAs) is considered an effective way to protect fishery resources from overfishing, but its effect has not been fully studied. The branching Acropora corals are important habitats for many fishes because they provide safe space and food. This experiment compared the community structure characteristics of fishes of the family Pomacentridae and Chaetodontidae in the large Acropora colonies of two MPAs (Houbihu and Inlet of the Third Nuclear Power Plant) and two non-MPAs (Tiaoshi and Little Bay) in the coral reefs of Kenting National Park, southern Taiwan. The fish communities within three 3¡Ñ3 m of Acropora coral colonies were surveyed by visual census. Preliminary results showed that the number of species, number of individuals, and biodiversity index of fishes in the MPAs (6, 66, 1.21 at Houbihu and 5, 65, 1.44 at Inlet of the Third Nuclear Power Plant, respectively) were higher than those in the non-MPAs (3, 33, 0.3 at Tiaoshi and 3, 3, 1.1 at Little Bay, respectively). These results suggest that the marine protection areas play an important role in maintaining the diversity and abundance of coral reef fishes.

## 22.827

**Reef Fish Spawning Aggregations in The Bay Of Bengal: Awareness And Occurrence**

**Jerker TAMELANDER*[1]**, Melita SAMOILYS[2], Shahaama SATTAR[3], Ukkrit SATAPOOMIN[4], Vineeta HOON[5], JK PATTERSON EDWARD[6], Stuart CAMPBELL[7], Manish CHANDI[8], Rohan ARTHUR[8], Shiham ADAM[3]

[1]IUCN, Dar es salaam, Tanzania, [2]CORDIO, Nairobi, Kenya, [3]MRC, Male, Maldives, [4]PMBC, Phuket, Thailand, [5]CARESS, Chennai, India, [6]SDMRI, Tuticorin, India, [7]WCS, Aceh, Indonesia, [8]NCF, Mysore, India

Reef Fish Spawning Aggregations (FSA) are critical in the life cycle of the fishes that use this reproductive strategy as sources of seed, but are also highly vulnerable to over exploitation. FSAs are known to occur in many species of reef fish in the Caribbean, Pacific, and the Western Indian Ocean. However, with the exception of the Maldives little if any research has been focused on FSAs in the Bay of Bengal. Interview surveys were conducted among fishing communities in selected areas of India, Indonesia, Maldives, Sri Lanka and Thailand in order to determine the level of awareness of FSAs among fishers; which reef fish species form FSAs; sites of aggregation formation; seasonal patterns; and to assess fishing pressure on and status of FSAs. Results show that only a minority of fishers possess reliable knowledge of spawning aggregation sites, species and times. Possible FSAs were reported from all areas studied. FSAs were confirmed in Vaavu atoll, Maldives, with sites and times identified for groupers (*Epinephelus fuscoguttatus, Plectropomus areolatus and P. pessuliferus*). Highly likely FSAs were identified in Phuket, Thailand, and the Gulf of Mannar, India, with opinions of species and spawning aggregation timings, including lunar phase, shared among several fishers. Species observed aggregating included the families Serranidae (*Epinephelus coioides* and *E. lanceolatus*), Lethrinidae (*Lethrinus lentjan*), Scombridae (*Rastralliger brachysoma* and *R. kanagurta*) and Carangidae. As has been found in many other parts of the world, FSAs in the Bay of Bengal are targeted by fishers. The results from this study will be used to increase awareness among communities as well as managers and policy makers of the ecological significance and vulnerability of reef fish spawning aggregations in order to design and implement suitable management responses.

## 22.828

**Marine Fisheries Management in Sierra Leone: Achievements And Challenges**

**Sheku SEI*[1]**, Mohamed .B.D. SEISAY[2], Heiko SEILERT[3], Ibrahim TURAY[1]

[1]Statistics and Research Unit, Ministry of Fisheries and Marine Resources, Jomo Kenyatta Road, Freetown, Sierra eone, Freetown, Sierra Leone, [2]Statistics and Research Unit, Ministry of Fisheries and Marine Resources, Jomo Kenyatta Road, Freetown, Sierra Leone, Freetown, Sierra Leone, [3]Gopa Consultants, Institutional Support for Fisheries Managment in Sierra Leone, Ministry of Fisheries and Marine Resources, Jomo Kenyatta Road, Freetown, Sierra eone, Freetown, Sierra Leone

The fisheries of Sierra Leone is classified into three subsectors: the highly mechanized export oriented industrial marine fisheries, the labor intensive, artisanal marine fisheries, which is the main sources of local fish supply, as well as the inland fisheries/aquaculture subsector. The Sierra Leone policy framework sets out objectives and strategies for comprehensive management of each of these subsectors. The legal framework for fisheries management in Sierra Leone is the 1994 fisheries management and development act complemented by the 1995 fisheries regulations. Fisheries management measures include access limitations by licensing (fishing effort regulations), mesh size regulations, gear restrictions, area limitations, landing, import and export obligations, and the enforcement of fisheries regulations through fisheries surveillance patrols and penalties for violations. These measures are based on the collection and analysis of statistical, data from artisanal and industrial fisheries. Surplus production models are used to estimate potential yields. Current data suggests a standing stock of nearly 300 000 metric tons, pelagic fish constituting about 90 % of the estimated biomass. Commercial fisheries production is estimated at 130 000 metric tons, with the clupeids constituting over 75 %. The estimated maximum sustainable yield in the year 2000 was about 180 000 metric tons. Fisheries management efforts are being enhanced by donor interventions. Major challenges are combating illegal fishing and piracy, as well as artisanal/industrial conflict resolution.

## 22.829

**Commercial Topshell, *trochus Niloticus* Fisheries in The Pacific. Present Status, Management Overview And Outlook For Rehabilitation**

**Kalo PAKOA*[1]**, Kim FRIEDMAN[1], Emmanuel TARDY[1], Ferral LASI[1], Mecki KRONEN[1], Aliti VUNISEA[1]

[1]SPC, Noumea, New Caledonia

In surveying coral reef fisheries as part of a Pacific-wide programme, the status of trochus fisheries was recorded across more than 70 sites in 17 Pacific island countries and territories. Surveys show that *T. niloticus* was present at 72% of sites, and that 67% of sites had at one time received trochus through successful or unsuccessful introductions. Historical records and current data show these fisheries to be highly productive, with current status reflecting the differing harvesting regimes in place.

Shallow water snorkel and SCUBA assessments reveal stocks to be depleted at most sites; the main aggregations within 92% of sites had a mean density below a suggested threshold of 500 trochus $ha^{-1}$. However, there are examples of well managed fisheries, and the prospect for recovery in fisheries under pressure still exists; 44% of depleted fisheries had trochus at >500 $ha^{-1}$ in at least one SCUBA survey station.

Catches also differed markedly between historical and current records. Virgin fisheries were yielding 4000 trochus $fisher^{-1}$ $day^{-1}$, whereas our records show fishers in seven countries making multiple fishing trips (mean of 33 ±6SE trips $yr^{-1}$) for small catches (mean of 17 ±6SE trochus $trip^{-1}$). In fact in non-regulated fisheries, 61% of these fishers reported catches of <10 shells $trip^{-1}$.

This paper highlights the monitoring and management measures in place across the Pacific, and uses in-water and socio-economic information to suggest optimal mechanisms for successful management in a regional context. Special attention is also given to the progress being made through initiatives to introduce trochus, for developing or re-establishing productivity.

## 22.830

**Exploitation Of Reef Resources: Grouper And Other Food Fishes in Andaman And Nicobarislands**

**Rajan PONAMKULAM*[1]**

[1]Zoological Survey of India, National Coral Reef Institute, Port Blair, Andaman Nicobar Islands, Port Blair, India

Exploitation of reef resources in the Andaman Islands has become an important component of the Island's fisheries sector. Two forms of reef fisheries are recognised: the general reef fish fisheries, targeting at a large number of different commercial species and grouper fishery, targeting at commercial grouper species. Both of these fisheries are expanding today. The developing new fishery poses both a threat and an opportunity: over exploitation of resources and due to high profits poachers from the neighbouring countries like Burma, Thailand and Indonesia to engage in for example cyanide and dynamite fishing which is clearly detrimental to the environment. To address the consequences of fisheries diversification, strengthening and relations with other resource users, fisheries management has become a need. To come up with recommendations for developing and managing reef fish fisheries, the available qualitative and quantitative information has been analysed in the present scenario of expanding reef fish fisheries. 46 species of grouper are reported from the islands that support 34.31% of grouper so far known to science. At the present time highest prices are paid for groupers (including *Epinephelus, Cromileptes and Plectropomus spp*.) For the reef fisheries the following recommendations: boost knowledge of fishermen on the surroundings, recognize the permissible gear for reef fishing, implement the existing rules and regulations and appraisal the management laws. For the grouper fishery it has been recommended to impose a minimum commercial size limit of 12 inches and 16 inches for the medium and large size groupers of fish. Keep some areas temporarily closed and open for fishing and do experimental aquaculture of groupers. This would help the consumer and the coral reefs. Improving the collection of data is a common suggestion for both fisheries. Marine reserves may be the only sensible way of maintaining stocks of more susceptible grouper fishes.

## 22.831

**Reef Fish Densities Inversely Follow Human Population Levels Across American Samoan Islands**

**Robert SCHROEDER*[1]**, Marc NADON[1], Benjamin RICHARDS[1], Brian ZGLICZYNSKI[2], Marlowe SABATER[3]

[1]Coral Reef Ecosystem Division, JIMAR-University of Hawaii and NOAA-Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Coral Reef Ecosystem Division, NOAA-National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, HI, [3]American Samoa Department of Marine and Wildlife Resources, Pago Pago, American Samoa

Coral reef fish assemblages in American Samoa were surveyed biennially during February-March of 2002-2006 to assess their density relative to island human population size. Three underwater visual monitoring methods were used: belt transect (all fish all sizes), stationary point count (fish >25 cm), and towed-diver count (fish >50 cm). Seven islands were surveyed: Tutuila and Aunuu (population ~56,000), Manua (Ofu, Olosega, and Tau, population <400 each), Swains (~5-10 people), and Rose Atoll (uninhabited). Total mean fish biomass and numeric density were highest at Rose and Swains (~1.5 t/ha, ~450 fish/100 m2) and lowest at Tutuila/Aunuu and Manua (~0.7 t/ha, ~230 fish/100 m2). Similarly, biomass of large fish (mainly jacks, barracuda, snapper, and shark) was ~2-4 times higher at Rose and Swains than at Tutuila/Aunuu and Manua. Dominant fishery targets surveyed were surgeonfish and parrotfish, except at Swains where grouper and variable schools of jacks were common. Biomasses of grouper, shark, and wrasse were generally low at all islands. Numerically these same taxa were common, while shark and large grouper were few. Swains consistently had the lowest density of parrotfish, which was the most abundant large fish around Manua. These results should contribute to the scientific basis for management.

## 22.832

**Piscivores Of The Caribbean: The Curse Of Too Many People**

**Christopher STALLINGS*[1]**

[1]Florida State University Coastal and Marine Lab, St Teresa, FL

Artisanal fishing in developing nations, like industrial and recreational counterparts in developed nations, typically targets large-bodied, top trophic-level fishes. However, few data have been available to assess the impacts of such extraction on predatory fish populations and the ecological communities to which they belong. Here, I overcome this difficulty by using a publicly-accessible, fisheries-independent database to provide a broad-scale, comprehensive analysis of human impacts on predatory reef-fish communities across the greater Caribbean region. I demonstrate that the composition of these communities varies substantially and that overall abundance and diversity of predatory reef-fishes decrease over a gradient of human population density. Across the region, as human population density increases, abundances of large-bodied fishes decline, and fish communities become dominated by a few smaller-bodied species. Complete disappearance of several large-bodied fishes indicates ecological and local extinctions have occurred in some densely-populated areas. These findings fill a fundamentally important gap in our knowledge of the ecosystem effects of artisanal fisheries in developing nations.

## 22.833

**Size Spectra Analysis As Tool To Examine Management Effectiveness Of Marine Protected Areas**

**Tasrif KARTAWIJAYA*[1]**, Rizya ARDIWIJAYA[1]

[1]Wildlife Conservation Society - Indonesia Marine Program, Bogor, Indonesia

Following extensive community consultation and resource assessment Karimunjawa National Park (KNP), Indonesia, was re-zoned in 2005. The aim was to improve the health of coral reefs and increase the biomass of reef fish. We evaluated the effectiveness of zoning by comparing the abundance and size of reef fishes among no-take zones, enter but no-take zones and fishing zones. The census included all reef fish species and each fish was placed into size class categories of 5cm increments from 0 to 40+ cm. Biomass was calculated using established weight-and-length relationships. The biomass of large fishes was generally higher in no take zones (mean ± S E: 536 ± 113 kg $ha^{-1}$) than in enter but no-take zones (353 ± 63 kg $ha^{-1}$) and fishing zones (301 ± 39 kg $ha^{-1}$), although the effect was not significant. Size spectra analyses showed that reef fish structure did vary among management zones with reef fishes in size class of 15-20cm and 35-40cm most abundant in the no-take zone. Fish in the no-take zone were mostly of target species, including fusiliers, emperors, snappers and groupers. In contrast, small (5-10cm) non-target species, mainly wrasses and cardinal fishes, were more abundant in the fishing zone. The higher biomass of large sized fishes inside no-take zones is most likely because fishing pressure has been reduced. Although enforcement of fishing regulations inside the park remains inadequate, the results suggest that fishing restrictions are receiving support among fishers and if support continues fish stocks in all zones may increase.

Key words : Karimunjawa National Park, effectiveness management, size spectra, biomass.

## 22.834

**Management Of The Aquarium Fishery Of The Maldives**

**Marie SALEEM*[1,2]**, Fahmeeda ISLAM[1]

[1]Marine Research Centre, Male', Maldives, [2]Seamarc Pvt. Ltd., Male', Maldives

The marine aquarium trade of Maldives is believed to have started around 1979. During the early years most exports were to Sri Lanka, and over the years the fishery has expanded, Europe becoming the major destination. This is reflected in the higher revenue earned relative to the quantity exported in more recent years. In 2006 there were 7 registered companies, trading a total of about 140 species of fish and 5 species of invertebrates. Although the contribution of the marine aquarium trade to the total value of marine exports is minimal, there is a potential for conflict of interest between the fishery and tourism, the major source of foreign exchange earnings. At present, a species-based quota system is in effect, which has strengthened monitoring of the trade and facilitated management of the fishery. It is based on export data from the Maldives Customs Services and on general demographic information of species such as rarity in the natural environment, as well as tolerance of species to captivity. Random checks of the fish exports is planned to be implemented following the introduction of a fish guide software which can be used by all stakeholders including the government authorities and the exporters themselves. There are no designated areas for collection of aquarium fish. It should be noted that there are changes in collection areas over time. This pattern of resource use may act as indirect time area closures and aid in the replenishment of fish stocks. Apart from a study carried out in 1994, no stock assessment studies have been undertaken for species targeted by the aquarium fishery. Such a study is planned to be carried out early next year and is highly necessary for the review of the quotas.

## 22.835

**Assessing the Conservation Efficacy of the Dry Tortugas National Park (Florida, USA) Research Natural Area, a No Fishing Reserve**

David HALLAC[1], John HUNT[2], **Douglas MORRISON*[3]**, Bill SHARP[4]

[1]US National Park Service, Homestead, FL, [2]Florida Fish and Wildlife Conservation Commission, Marathon, FL, [3]US National Park Service, Key Largo, FL, [4]Florida Fish and Wildlife Conservation Commission, Tallahassee, FL

A Dry Tortugas National Park (DTNP) coral reef fisheries assessment conducted in 1999 and 2000 concluded that many gamefish species are overfished. The decline in reef associated gamefishes, primarily grouper and snapper species, is a major DTNP resource stewardship issue. The U.S. National Park Service (NPS) is implementing a DTNP no fishing, no anchoring marine reserve, termed the Research Natural Area (RNA), covering 46% of the park. NPS and the Florida Fish and Wildlife Conservation Commission, with the assistance of other scientists, have developed a science plan for assessing the conservation efficacy of the RNA. This plan will test the following hypothesized effects of no fishing reserves: increased abundance, size, and productivity of target fishery species within the reserve; the abundance and size of target species increase in areas adjacent to the reserve due to net emigration from the reserve; improve fisheries (e.g., greater catch per unit effort) in areas proximate to the no-fishing zone; and regional enhancement of target species via greater larval export from the reserve. The plan has six major objectives or topics: quantify changes in the abundance and size-structure of exploited species within the RNA relative to adjacent areas; assess net emigration of targeted species from the RNA; monitor changes in catch rates of exploited species outside the RNA; evaluate the effects of RNA implementation on marine benthic biological communities; assess the reproductive potential of exploited species by evaluating egg production and larval dispersal; and appraise the socioeconomic effects of RNA implementation. The performance measures and scientific activities for each topic are presented.

## 22.836

**Technique To Monitor And Study Fish And Their Habitat Below Scientific Diving Depths.**

**Daniel MERRITT*[1]**, Kevin WONG[2], Michael PARKE[2], Chris KELLEY[3], Jeff DRAZEN[4]

[1]Coral Reef Ecosystem Division, JIMAR, University of Hawaii, Honolulu, HI, [2]Coral Reef Ecosystem Division, PIFSC, NMFS, Honolulu, HI, [3]Hawaii Undersea Research Laboratory, Honolulu, HI, [4]Department of Oceanography, University of Hawaii, Honolulu, HI

NOAA's Pacific Islands Fisheries Science Center has developed a bottom camera bait station (BotCam) as a fisheries independent method to monitor and study fish species that are found at depths exceeding standard scientific diving regulations. This autonomous stereo-video equipped camera system has been deployed primarily in water depths between 50 and 300 meters to target bottomfish species such as snappers and groupers. It is just as useful in shallower waters. This presentation will outline the capabilities and technological advances of the BotCam and describe the spatial sampling methods developed to facilitate its use in relative abundance population studies. We used derivatives of multibeam bathymetry and backscatter imagery within a geographic information system environment to develop stratified random sampling plans for protected and non-protected fishing areas. Details of video analysis methods and data from a pilot experiment done in and around a restricted fishing area (RFA) in Hawaii are presented. Results from this study corroborate depth ranges and zonation of the target species as well as habitat preferences. The results from this study clearly demonstrate that the BotCam is an effective tool for monitoring and studying deepwater habitats and their associated fish populations. This system is currently being utilized to monitor a newly implemented network of bottomfish RFA's established by the State of Hawaii.

## 22.837

**Trajectories Of Ecosystem Change in An Extremely Degraded Reef in The Philippines**

**Rollan GERONIMO*[1]**, Porfirio ALIÑO[1], Fernando CASTRENCE, JR. [1], Andre Jon UYCHIAOCO[2]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]Partnerships in Environmental Management for the Seas of East Asia, Quezon City, Philippines

The Bolinao-Anda reef complex in the Philippines has been in various states of degradation and overfishing since the first systematic surveys were conducted in the 1980s. It has been subjected to a wide range of stresses for three decades. The massive bleaching in 1998 reduced live coral cover from 45% to 17% in three sites surveyed a year before and after the event. While the reef has yet to recover completely from this disturbance, it was again recently hit by bleaching.

Given the overexploited state of the reef fish communities in the Bolinao-Anda reef complex and other degrading influences, are the reef fishes of the system recovering or changing? Fisher population growth, continued overfishing and other stressors continue to affect the reef. On the other hand the establishment of Marine Protected Areas and other management interventions have also been initiated.

Coral reef benthic and fish data obtained from 1995 to 2006 were analyzed to determine the changes in reef community structure throughout this time. Results show no change in fish biomass from 1995 to 2002 but increased from 2003 to 2006 while fish densities fluctuated throughout this time. Changes in fish community composition were also evident with lower trophic levels such as herbivores and zoobenthivores increasing in total biomass in the last four years. These trends possibly indicate that reef fishes are growing to larger sizes than before and may be a partial indication of the positive impacts of protection.Other larger-scale natural processes can also have masked the direct effects of management given that unprotected sites are also showing the same increasing trend in fish biomass.

## 22.838

**Do Mangroves and Seagrass Beds Enhance Growth of Juvenile Coral Reef Fish?**

**Monique GROL*[1]**, Martijn DORENBOSCH[1], Eva KOKKELMANS[1], Ivan NAGELKERKEN[1]

[1]Animal Ecology and Ecofysiology, Radboud University Nijmegen, Nijmegen, Netherlands

Mangroves and seagrass beds have long been considered important nursery grounds for various species of juvenile reef fishes due to their higher abundances in these habitats compared to coral reefs. It is assumed that these putative nurseries provide juveniles with more shelter, higher food availability, and higher growth and survival rates than on the reef. However, this nursery function is still ambiguous, and experimental field studies testing this hypothesis in these tropical habitats are missing. In this study, growth rate of juvenile *Haemulon flavolineatum* and the availability of its preferred food were determined in seagrass, mangrove and coral reef habitats. It was hypothesized that somatic growth rates as well as the amount of preferred food are higher within these putative nurseries than on the reef (according to the nursery hypothesis). Growth of small juveniles (3.5 – 4.2 cm FL) was studied at two Caribbean islands using *in situ* experimental growth cages. Gut content analysis of the caged fishes showed that Copepoda were by far the most consumed food items by juveniles in all three habitats. Copepoda in the plankton samples were more abundant on the reef than in the mangrove/seagrass habitats. Growth rates of fishes showed the same pattern: higher growth rates in length and weight, and a higher weight-length ratio on the reef compared to the mangrove/seagrass habitats. Based on these observations it appears that the coral reef would be a more suitable habitat for small juveniles, when not taking other factors such as predation risk into account. Nevertheless, highest juvenile fish abundances are found in mangrove/seagrass nurseries where predation risk, but also growth rate, is lower. Therefore, it appears that a trade-off exists between food abundance/growth rate and predation pressure/mortality risk, where fish select habitats that minimise the ratio of mortality risk to growth rate.

## 22.839

**Management Options To Be Adopted By Artisanal Fishers in Colombian Caribbean**

**William ZUBIRIA-RENGIFO*[1]**, Roberto RIVERA[2], Isabel Cristina CHACON-GOMEZ[1]

[1]Universidad Nacional de Costa Rica, Puntarenas, Costa Rica, [2]Ed. Bahia Centro, Corporacion Colombia Internacional, Santa Marta, Colombia

Along Colombian Caribbean, one of the fishing gear that is mostly used is called “chinchorro”. It is a conical shaped net. The holes in that net are very small. Therefore, it generates a big damage on the ecosystems. When they separate what was captured, most of the animals are dead. About 35 % of what is captured with this net is composed by juveniles of fish and other organisms that are not commercially attractive. The low selectivity of this net, added to the great effort becomes a big suffering for the different species and it is not regulated by authorities. The reason why most fishermen use it is because it is cheap, it captures a lot of fish and it does not need a big boat to be maneuvered. Besides, when it breaks for any reason (mainly coral damage), it is easy and cheap to repair. Based on observations during the artisanal fishery monitoring at the Colombian Caribbean during a project developed by International Colombian Corporation and the Colombian Institute for rural development, it was possible to establish some interesting conclusions about the problems occurring there. It is definitely needed to generate some alternatives that give fishermen the possibility to work without affecting the ecosystems so much. The easiest solution to propose is to increase the size of the hole, as a strategy that diminishes the capture of small fish and not target species. This would have to be regulated and monitored for a long time until fishermen change all their gears. One of the possibilities is to motivate them to change the gear by giving them some help by organizing their commercial activity or giving them some financial support as a reward.

## 22.840

**Assessing The Socio-Economic Impact Of Export Trade In Coral Reef Resources On Fijian Society**

**Louise TEH*[1]**, Lydia TEH[1], Benjamin STARKHOUSE[1], Ussif Rashid SUMAILA[1]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

Rising demand for coral reef resources worldwide has spurned an active international trade in reef fish, invertebrates, and corals that are sourced primarily from tropical developing nations. Although these trades tend to be lucrative, it is unclear what economic benefit flows to the exporting country. Our purpose is to use Fiji as a case study to investigate this question. We test the hypothesis that trade in coral reef resources provides net economic benefits to Fijian society. We assess Fijian coastal communities’ economic dependence on coral reef trade and analyse the coral reef resource supply chain to determine the allocation of benefits among agents in each step of the trade. Coastal communities’ reliance on coral reef trade is examined under the context of a livelihood approach. The economic analysis will be based on data collected from trade statistics and from key informant interviews which will be conducted in early 2008. Our research will provide a basis for reef resource managers to assess the socio-economic costs and trade-offs associated with reef management policies (e.g., Marine Protected Areas) and changes to market demand for coral reef resources.

## 22.841

**The Impact Of The Export Trade in Coral Reef Resources-Perspectives From Coastal Communities And Implications For Managing Change**

**Lydia TEH*[1]**, Louise TEH[1], Benjamin STARKHOUSE[1], Ussif Rashid SUMAILA[1]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada

We aim to assess the impact of trade expansion in coral reef resources on Fijian coastal communities by investigating resource users' perceptions of i) ecological and socio-economic changes in the inshore fisheries in the recent past; ii) magnitude of this change and how it influences resource harvesting activities; iii) drivers that explain the change, and iv) fishers' response to the change. We conduct semi-structured interviews with fishers, supplemented with participant observations and relevant statistics, to characterise past and present reef fisheries condition, resource use patterns, and economic participation in the reef resource trade. Fisheries and socio-economic characteristics will then be compared against export trade volume over time to evaluate the relationship between trade expansion and ecological and socio-economic well-being. Fishers' response to export trade expansion will also be qualitatively assessed based on changes in fishing and livelihood strategies. Data for this study will be collected in early 2008; results from this study will inform about coastal communities' ability to adapt to trade induced changes, and aid in formulating environmentally and socially sustainable policies to govern the trade in coral reef resources.

## 22.842

**Effect Of Tourism Development On Economically Important Reef Fish Of Koh Kood, Trat Province, Thailand**

**Se SONGPLOY*[1]**, Nipat SOMKLEEB[1], Makamas SUTTHACHEEP[1], Sittiporn PENGSAKUN[1], Thamasak YEEMIN[1]

[1]Biology, Marine Biodiversity Research Group, Bangkok, Thailand

Koh Kood is located in Trat Province, the eastern part of the Gulf of Thailand. It is the most eastern island of Thailand near Cambodia. Since Koh Kood is not far from Mu Koh Chang where is a hot spot for tourism, it is developing to a new tourist destination. Infrastructure development and anthropogenic disturbances have been increasing during 2002-2007. The main objective of the present study was to compare economically reef fish densities between the surveys in 2002 and 2007 by using Fish Visual Census Technique. The dominant economically important reef fish were Chocolate hind (*Cephalopholis boenak*), Streaked spinefoot (*Siganus javus*) and Deep bodied fusiller (*Caesio cunning*). These three fish species were reported in many published papers studied in the Gulf of Thailand. The most expensive specie is Leopard coralgrouper (*Plectropomus leopardus*) which costs 1400 baht (≈43 USD)/kg. The results showed that densities of economically important reef fish, such as Humpback red snapper (*Lutjanus gibbus*), Brownstripe red snapper (*Lutjanus vitta*), Deep bodied fusilier (*Caesio cunning*), Chocolate hind (*Cephalopholis boenak*), Leopard coralgrouper (*Plectropomus leopardus*), Streaked spinefoot (*Siganus javus*), Orange-spotted spinefoot (*Siganus guttatus*), and White-spotted spinefoot (*Siganus canaliculatus*), between the surveys in 2002 and 2007 were not statistically different. The results suggest that tourism development on Koh Kood still has no effect on economically important reef fish because tourism development on the island is at the initial phase. However, there is high potential for tourism development on Koh Kood because of its natural resources and infrastructure development. Therefore, long - term monitoring programs and appropriate coral reef management strategies are necessary.

## 22.843

**Sacrificing Coral Reefs To Achieve The Progress: Life Of Blast Fishermen in The Spermonde Archipelago, South Sulawesi, Indonesia**

**Muhammad CHOZIN*[1,2]**

[1]Southeast Asian Studies Program, Ohio University, Athens, OH, [2]Marine Division, Research Center, Hasanuddin University, Makassar, Indonesia

Blast fishing is fishing method practicing by throwing a bomb made from mixed fuel-ammonium nitrate fertilizer ($NH_4NO_3$) into sea in order to quickly catch fish. However, it is tremendously destructive to coral reefs. It is estimated that more than 53% of Indonesia's coral reefs in Indonesia has been threatened by destructive fishing including blast fishing. Particularly, in the Spermonde archipelago, South Sulawesi, more than 75% of fishermen are practicing this fishing method. Supported by strong closed-networking system links capitals, market, government officers, and operators make the practices are prevalent.

My research focus is on socio-cultural aspects of blast fishermen society in an island within Spermonde archipelago. Using participant observation field work, I looked at vividly into the society to observe how deep the practice of blast fishing has a root from their cultures, beliefs, and custom. In addition, I also conducted interviews with fishermen, government officers, and fish traders. By doing so, I try to understand how the blast fishermen perceive themselves and others, how they deal with power of state, and how they response to the globalization.

Finally, I examine fishermen's opinion of the sustainability of their maritime resources including coral reefs and fish stocks. It seems that their awareness of environmental issues has no impact to their daily life. The desire to achieve the modern progress overcomes the need of resources sustainability. Even though they know the bad impact of blast fishing practice in the long run, they keep continue it because they are "greedy". Actually, a closely expose to Makassar's modern life (the capital city of South Sulawesi Province) but lack of education plunges them into greediness. The highly demand from global fish-market attracts them to use short-cut way in catching the fish. Moreover, the lack of law enforcement contributes the continuity of this practice.

## 22.844

**Ornamental Fish Trade in The Red Sea And Gulf Of Aden**

Maroof KHALAF[1], Mohamed ALI[2]

[1]Fish ecology and taxonomy, Marine Science Station, Aqaba, Jordan, [2]Marine Resources Research, Ministry of Agriculture and Fisheries, Um Al-Qaueen, United Arab Emirates

The communities of ornamental reef fish species from shallow water habitats along the coasts of Jordan, Egypt, Saudi Arabia, Yemen and Djibouti were surveyed by the visual census technique. A total of 118 transects of 100 m length and 5 m width (500 $m^2$) were performed at 32 sites. Some data on the marine ornamental fish trade was extracted from relevant government export statistics. Also, the authors visited the holding facilities of the companies involved in ornamental fish trade in Egypt, Saudi Arabia and Yemen and recorded all aquarium fishes present at the time. A total of 29,485 fishes were counted along the 18 transects in Jordan, 196,379 fishes were counted along the 31 transects in Egypt, 113,268 fishes were counted along the 33 transects in Saudi Arabia, 129,932 fishes were counted along the 18 transects in Yemen and a total of 53,856 fishes were counted along the 18 transects in Djibouti. Out of the 50 species counted 5 species dominated the Jordanian reef e.g. A. bicinctus (76.3% per 500 m belt transect of the total individuals counted in the Red Sea); 11 species dominated the Egyptian reef e.g. C. aygula (81.9%); 20 species dominated the Saudi Arabia Red Sea coast e.g. D. aruanus (84.9%); 7 species dominated the Yemeni Red Sea coast e.g. D. trimaculatus (80.7%) and 6 species dominated the Djiboutian coast e.g. C. melapterus (100%). Species needing special consideration such as species with poor survivorship in captivity, easily overexploited and ecologically important species were determined. Recommendations for management plans of the ornamental fish trade were presented.

## 22.845

**Ornamental Fish Trade in The Red Sea And Gulf Of Aden**

**Maroof KHALAF*[1]**, Mohamed ALI[2]

[1]Marine Science Station, Aqaba, Jordan, [2]Ministry of Agriculture and Fisheries, Um-Alquin, United Arab Emirates

The communities of ornamental reef fish species from shallow water habitats along the coasts of Jordan, Egypt, Saudi Arabia, Yemen and Djibouti were surveyed by the visual census technique. A total of 118 transects of 100 m length and 5 m width (500 m²) were performed at 32 sites. Some data on the marine ornamental fish trade was extracted from relevant government export statistics. Also, the authors visited the holding facilities of the companies involved in ornamental fish trade in Egypt, Saudi Arabia and Yemen and recorded all aquarium fishes present at the time. A total of 29,485 fishes were counted along the 18 transects in Jordan, 196,379 fishes were counted along the 31 transects in Egypt, 113,268 fishes were counted along the 33 transects in Saudi Arabia, 129,932 fishes were counted along the 18 transects in Yemen and a total of 53,856 fishes were counted along the 18 transects in Djibouti. Out of the 50 species counted 5 species dominated the Jordanian reef e.g. *A. bicinctus* (76.3% per 500 m belt transect of the total individuals counted in the Red Sea); 11 species dominated the Egyptian reef e.g. *C. aygula* (81.9%); 20 species dominated the Saudi Arabia Red Sea coast e.g. *D. aruanus* (84.9%); 7 species dominated the Yemeni Red Sea coast e.g. *D. trimaculatus* (80.7%) and 6 species dominated the Djiboutian coast e.g. *C. melapterus* (100%). Species needing special consideration such as species with poor survivorship in captivity, easily overexploited and ecologically important species were determined. Recommendations for management plans of the ornamental fish trade were presented.

## 22.847

**Differential Effects Of A Marine Partially-Protected And Unprotected Area On Shore Reef Fish Communities And Populations**

**Maria Catalina REYES-NIVIA*[1]**, Alberto RODRIGUEZ-RAMIREZ[2]

[1]Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, Amsterdam, Netherlands, [2]Programa Biodiversidad y Ecosistemas Marinos, Instituto de Investigaciones Marinas y Costeras INVEMAR, Santa Marta, Colombia

In developing countries, marine protected areas (MPAs) are being used as fisheries management tools, but these areas are not always fully closed to fishing and may be located adjacent to highly disturbed reefs. To determine whether partial protection affects coral reef fishes, combined metrics such as community composition and density of selected populations were evaluated over a large spatial scale. The roving diver technique was used to determine species richness and relative abundance of all species and belt transects (30x2 m) were used to estimate density of families. Twenty fringing reefs located on leeward and windward sides along Santa Marta coastline were surveyed. Nine reefs were part of the MPA "Tayrona Natural National Park" (TNNP) in the Colombian Caribbean, whilst the other 11 were situated close to the three major urban settlements in the area. Sampling design included the variability at these two spatial scales (protection and wave exposure levels). Spatial distribution of reef fish community differed between protection levels, whereas there was not clear grouping by sheltered or exposed sites. Significant spatial variation in density of damselfish, grunts, and, snappers was found, displaying higher values inside the MPA. Parrotfish showed responses to both spatial factors with higher abundances associated to both marine park and sheltered reefs. Grouper species abundance was low (< 1 ind/60 $m^2$) across the study area. Overall there appears to be some spatial variations in reef fish communities and particular populations probably influenced by the MPA presence. These outcomes demonstrate however that the marine parks not fully-fishing closed do not offer protection to fishery target families (i.e. groupers) and indirectly suggest that fishing pressures are uniform along the study area.

## 22.848

**Fish Community Structure, Habitat Diversity And Fishing Pressure in Gulf Of Guinea Reefs (Tropical Eastern Atlantic)**

**Carlos Eduardo FERREIRA*[1]**, Sergio FLOETER[2], Claudio SAMPAIO[3], Luiz ROCHA[4]

[1]Marine Biology, Universidade Federal Fluminense, Niteroi, Brazil, [2]Dept. de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianopolis, Brazil, [3]Museu de Zoologia, Univesidade Federal da Bahia, Salvador, Brazil, [4]Hawaii Institute of Marine Biology, University of Hawaii, Kane'ohe, HI

The Island of São Tomé is located about 500 km west of the coast of Africa, in the Gulf of Guinea. Its marine fauna is one of the least known in the world. Due to its high levels of endemism, the region is considered a marine biodiversity hotspot. In February of 2006 we performed a quantitative survey in seven sites along the island. These sites showed different levels of coral cover, wave exposure and fishing pressure. Abundance of reef fish was sampled by 20 x 2 m strip transects (n = 20) in all sites. Percent cover of benthic organisms was simultaneously sampled by photoquadrats. Fishing intensity was assessed by estimating the number of fishermen per 10 km2. One site, Kia presented mean total density (886 $\pm$ 254 SE) and richness per census (16 $\pm$ 0.6 SE) higher than any other site. This difference was due to high abundance of planktivores including *Myripristis jacobus*, *Chromis multilineata* and *Paranthias furcifer*. These three species, together with *Thalassoma newtoni*, are the most abundant fishes in all sites ($p < 0.001$ for all except Diogo Vaz). Trophic comparisons indicate diurnal planktivores and mobile invertebrate feeders as significantly dominant fish groups in all sites ($p < 0.01$ for the most), except for Hirundino where territorial herbivores were second on the rank. Canonical correspondence analysis showed the percent cover of coral and rubble as the most important descriptors of sites with higher abundance and richness. Abundance was also negatively correlated with fishing intensity. The abundance of targeted species was extremely low indicating that decades of artisanal fishing has possibly led the reef fish stocks to decline. Thus, the need for the establishment of marine protected areas is evident.

* funded by National Geographic Society

## 22.849

**Unregulated Collecting Is Severely Impacting An Endangered Coral Reef Fish in Indonesia**

**Alejandro VAGELLI*[1]**

[1]New Jersey Academy for Aquatic Sciences, Camden, NJ

The geographic range of *Pterapogon kauderni* (The Banggai cardinalfish) is limited to the shallows of 32 islands within the Banggai Archipelago. *P. kauderni* is a valuable model for comparative studies of coral reef fishes. It has direct development (absence of a larval stage), one of the highest recorded population genetic structures, and an ontogenetic shift in habitat - microhabitat utilization. However, it is threatened in the wild due to an enormous demand for the international ornamental fish trade.

Its conservation status has been researched since 2001 by conducting surveys, censuses, and by interviewing fish collectors and buyers throughout the Archipelago. In 2001 about 700,000 specimens were collected. By 2004 average population density was reduced by 90%, and two populations had been eliminated. In 2007 at least 900,000 were harvested out of an approximate total population size of two million specimens. Five populations declined to less than 150 individuals and all populations showed significantly lower densities than their estimated historical baseline.

Habitat and essential microhabitats are being eliminated by the widespread practice of dynamite fishing, and the appearance of coral fields covered by a fungus-like organism and algae are further diminishing habitat availability.

Continued collecting, if not regulated, will deplete many more populations. An effort to include *P. kauderni* in CITES was defeated in June 2007 based on unfounded concerns about local economic impact. In September 2007 the IUCN, based on the same data, listed *P. kauderni* as "Endangered".

It is suggested that *Pterapogon kauderni* to be included in CITES. Trade regulation and monitoring would ensure its survival and provide incentive to develop commercial aquaculture activities that are currently hindered by availability of cheaper wild caught specimens. It would also allow local people to sustainable harvest it over time.

## 22.850

**Abundance Trends Of Fishes in The Tortugas North Ecological Reserve And Adjacent Management Zones**

**John BURKE*[1]**, Mark FONSECA[2], Mike BURTON[3], David GLOECKNER[3], Brian DEGEN[4], Vanessa MCDONOUGH[5]

[1]NOS, CCFHR, NOAA, Beaufort, NC, [2]NOAA, Beaufort, NC, [3]NOAA, NMFS, Beaufort, NC, [4]NOAA, NOS, CCFHR, Beaufort, NC, [5]NPS, Homestead, FL

Abstract- Surveys of the eco-tone between the Tortugas banks and surrounding soft bottom shelf were conducted annually (2001-2005) with the goal of monitoring the impact of the implementation of the Tortugas North Ecological Reserve (TNER). Visual surveys of fishes were conducted annually at ten permanent stations, initially selected randomly, from each of three zones differing in their management restrictions: the TNER, Dry Tortugas National Park (DTNP) and Exclusive Economic Zone (EEZ). Counts of exploited species suggest a positive trend over the period. Significant increases were evident in counts of targeted commercial species (yellowtail snapper, white grunt, hogfish, black grouper, scamp and mutton snapper) and landings of these species from the Tortugas increased over the period. Increased abundance of commercial species is not part of an overall expansion of the reef fish community around the Tortugas Banks as counts of the most frequently sighted reef species (*Thalassoma bifasciatum*, *Chromis scotti* , *Scarus inserti, Coryphopterus personatus*, *Stegastes variabilis*) generally declined or exhibited high variability over these years. Differences in abundance, consistent with expected changes in fishing mortality among management zones, was evident for yellowtail snapper suggesting that reduction in fishing mortality was not the sole factor responsible for increases of exploited fishes.

## 22.851

**Banggai Cardinalfish: Towards A Sustainable Ornamental Fishery**

**Samliok NDOBE*[1,2]**, Abigail MOORE[3]

[1]Marine & Fisheries, Sekolah Tinggi Perikanan dan Kelautan (STPL-Palu), Palu, Indonesia, [2]Aquaculture, Tadulako University (UNTAD), Palu, Indonesia, [3]Marine, Yayasan Palu Hijau, Palu, Indonesia

Central Sulawesi Province, Indonesia in the heart of the Coral Triangle has over 4,500km of coastline and over 700 islands including the Banggai Archipelago, established as Banggai Kepulauan District in 1999 and covering almost all the native distribution of the Banggai cardinalfish, *Pterapogon kauderni*. A paternal mouth brooder with direct development and traded in large numbers as an ornamental fish, *P. kauderni* was recently proposed for listing in CITES (Convention on the International Trade in Endangered Species) Appendix II by the USA (application withdrawn at the 14th Conference of the Parties in June 2007) and has since been listed as Endangered on the IUCN (International Union for the Conservation of Nature) Red List.

Local activities have been underway since 2005 to develop sustainable management of *P. kauderni* including addressing concerns regarding the Banggai cardinalfish fishery and trade as well as the conservation of the shallow reef, reef-flat, seagrass and lagoonal areas which are the main habitat of the species. The CITES proposal in 2007 brought the Banggai cardinalfish into the limelight at national and international levels, and a multi-stakeholder multi-year national strategy has now been developed. The first author has been appointed as a member of the Banggai Cardinalfish Centre established by the District Head of Banggai Kepulauan District as the District co-ordinating agency for all aspects of Banggai cardinalfish management.

This paper will provide an overview of developments from 2004 to 2007 in which the authors have been involved, including initiatives under the Sea Partnership Programme and the national strategy for 2008-2010. The latest developments during early 2008 as the strategy begins to be implemented will also be presented.

## 22.852

**Preliminary Assessment Of The Harvest And Status Of The Humphead Wrasse Cheilinus Undulatus (Varivoce), in The Southern And South-West Viti Levu Region, Fiji Islands.**

Aisake BATIBASAGA[1,2], **Aisake BATIBASAGA*[3]**

[1]Fisheries, Ministry of Fisheries &Forest, Suva., Fiji, [2]Research Division, Suva, Fiji, [3]Ministry of Fisheries&Forest, Suva, Fiji

A preliminary assessment of the harvest trends and the present stock status of the Humphead wrasse (Cheilinus undulatus or Varivoce), was undertaken in five villages in Southern Viti Levu, as well as five adjoining villages of the province of Nadroga, usually referred to as the Coral Coast region.

The study initially commenced from 15 July 2004, of which the objectives were to specifically determine the current status of the Humphead wrasse fishery in these coastal villages, through questionnaire surveys, and complimented by rapid biological stock assessments through the use of underwater visual census (uvc) techniques.

Collation of information on catch trends from the interview of key fisher-folks was also undertaken. The study was to compliment, and expand on the research work on Humphead wrasse, previously undertaken by other researchers since 2001. The Fiji government had also established a ten-year moratorium on the harvest of this fish for market sales from 2004- 2014.

This study would help to ascertain the benefits ensuing from the establishment of marine reserves across these coastal villages.

The species has been noted to be sensitive to fishing pressure, and most of the study sites across Fiji have recorded a declining catch , due largely to over-fishing, and the use of destructive fishing methods ; compounded by increasing night dive spear-fishing.

The study was projected to be completed from October, 2006; but have been extended to include the assessments of the efficacy and benefits of establishing locally managed marine reserves. Five village elders and fishers were interviewed in each village (see appendix 1).

Key words: harvest, current status, humphead wrasse, questionnaire surveys, biological assessments, and marine reserves.

## 22.853

**Strategies And Difficulties in Implementing Mac Standards At The Community And Ecosystem Level: A Lesson Learned From Seribu Islands, Indonesia**

**Silvianita TIMOTIUS*[1]**, Safran YUSRI[1], Muh SYAHRIR[1], Nugroho SUSILO[1], Idris . [1]

[1]TERANGI Foundation, Jakarta, Indonesia

Ornamental trade of marine species has increased significantly during the last decades in Indonesia although most of these fisheries are left unmanaged. In order to prevent coral reefs degradation, a coral reefs management program has been implemented by TERANGI in Seribu Islands since 2002. The program at first only consisted of MAC Certification implementation and targeted only to selected fishermen and middlemen. This approach was not effective due to several problems such as limited group cohesion, lack of program awareness, inadequate law enforcement, lack of leadership in the community, no coordination between government and the community, and lack of stakeholder involvement. To deal with these problems, the program then developed to use a holistic approach since 2004. Fishermen and middlemen were facilitated to organize a community group, and empowered through a series of trainings to comply with MAC Collecting Fishing and Handling Standard. In order to manage the ecosystem itself, a Collection Area Management Plan was developed with participation from related stakeholders. The key to the development success is the cooperation between government and community, thus making rule enforcement and integrated management possible. After following the program, fishermen and middlemen have experience benefits (i.e. reduced fishing cost, less illegal retribution, less rejected catch) and stopped using cyanide. Difficulties were still encountered in fisheries monitoring and evaluation. The trade documentation form is too difficult for fishermen and middlemen hence require simplification. Our regular stock assessment using modified MAQTRAC protocol also insufficient, several most traded species can't be monitored in the surveys. Complementary methodologies should be developed to fill the information gap. Organizational aspects of the community group are also needed to be strengthened. Since the program have a promising result, it is suggested that a holistic approach should always be used to manage a coral reefs ecosystem complex.

## 22.854

**Short-Term Recovery Of Exploited Coral Reef Fish Communities Under Customary Management in New Ireland, Papua New Guinea**

Ryan WALKER[1], Fraser HARTLEY[1], Tau MOROVE[1], Maunoa KARO[1], **Helen PERKS*[1]**, James COMLEY[2]

[1]PNG Marine Program, Wildlife Conservation Society, Kavieng, Papua New Guinea, [2]University of the South Pacific, Institute of Applied Science, Suva, Fiji

Papua New Guinea (PNG) supports some of the world's most healthy and biologically diverse coral reefs. Coastal communities have customary tenure over fringing reefs and inshore fishing resources. Closure of an area of reef to harvesting has historically been employed as a form of customary management. This study investigates the short-term recovery of moderately exploited coral reef fish communities under such a management system. Fish size, abundance, species diversity and habitat variables were surveyed by underwater visual census at three managed sites immediately before closure and at three nearby fished (control) sites. Surveys were then replicated one year after closure of the managed areas. After one year of closure, our results suggest a significant increase in biomass and diversity of the fish communities within managed areas, compared to the control sites. More detailed analysis suggests significant increases in biomass and diversity within the herbivorous and invertivorous trophic levels plus an increase in piscivore diversity within the fish communities at the managed sites. Piscivore biomass significantly decreased within the control sites. The density of the fish communities remained largely unchanged, with the exception of piscivorous fish, which showed signs of significant increase within the managed areas. Hard coral cover, however, appeared to deteriorate significantly within both managed and control sites and concurrent increased algal cover suggests possible wider environmental influences. These preliminary results show that the closure of moderately exploited reefs by coastal communities in PNG can result in improvement of the health of reef fish communities after just one year.

## 22.855

**Participatory Reef Fisheries Monitoring in Punta Cana, Dr**

**Benjamin KUSHNER*[1]**, Megan STONE[2], Renata FERRARI[2], Liana TALAUE-MCMANUS[2], Felimon GAYANILO[3], Dan HOLSTEIN[3], Kristine STUMP[3], John MCMANUS[3], Jake KHEEL[4]

[1]Punta Cana Ecological Foundation, Milton, NH, [2]Marine Affairs and Policy, University of Miami Rosenstiel School of Marine & Atmospheric Science, Miami, FL, [3]National Center for Coral Reef Research, University of Miami Rosenstiel School of Marine & Atmospheric Science, Miami, FL, [4]Punta Cana Ecological Foundation, Punta Cana, Dominican Republic

The Partnership for Ecologically Sustainable Coastal Areas (PESCA) is a collaborative research initiative between the University of Miami and the PUNTACANA Ecological Foundation on the coast of Punta Cana in the Dominican Republic. It aims to provide a greater overall local understanding of the ecology and management of reef resources. PESCA utilizes reef-based fisheries monitoring to evaluate the variability and abundance of catches, value of fishery, dependence on fishery and, potential impacts on targeted reef species.

Weekly participatory catch abundance surveys and interviews were conducted at the Punta Cana Marina to collect data concerning the length, weight and state of maturity of catches to identify patterns in fishing techniques, target species and sale of these catches. Interviews determined that over thirty fishermen contribute to the fishery, classified as snorkel-based and boat-based fishers. Both yolas and buzos catches are heavily dominated by parrot fish (Family Scardidae), but yolas also receive a large portion of their catch from conch (Strombus gigas) and lobster (Panularis argus). Yola catches predominantly have a greater average length and average weight than that of snorkel-based fishers' catches.

We will incorporate the results of the study into community-based environmental education modules. With increased environmental awareness, we envision working with major stakeholder groups including local fisher organizations and tourism developers in promoting better-informed management decisions including defining user and protected zones in the Punta Cana reef ecosystem.

## 22.856

**Trap Impact On Coral Reefs: Affects Of Wind-Driven Trap Movement in The Florida Keys**

**Cynthia LEWIS*[1]**, Stopher SLADE[2], Kerry MAXWELL[1], Thomas MATTHEWS[1]

[1]Fish & Wildlife Research Institute, Florida Fish & Wildlife Conservation Commission, Marathon, FL, [2]North Carolina Division of Marine Fisheries, Morehead City, NC

The decline in reef habitat throughout the Florida Keys has been attributed to global, regional, and local anthropogenic environmental stresses. Frequent winter storms, not to mention periodic hurricanes, move traps and cause widespread damage to benthic habitat. When coupled with the high number of traps deployed in Florida Keys waters, the damage to sessile fauna and loss of benthic cover caused by traps is an added stress that needs to be managed along with the many other threats to coral communities.

To assess the impact of traps on coral communities following winter storms, lobster traps were placed in hardbottom and reef habitats commonly used by commercial fishermen in the Florida Keys. Trap movement, percent cover, and benthic faunal injuries were measured after 26 storms, which occurred over three winters. Traps moved when storms with sustained winds greater than 15 knots persisted for 2 or more days. Winter storms above this threshold moved buoyed traps a mean distance of 3.97 m, 3.10 m, and 0.56 m per trap and impacted a mean area of 4.96 m2, 2.85 m2, and 0.78 m2 per trap at 4 m, 8 m, and 12 m depths respectively. Traps without buoys and lines, simulating derelict traps, moved a mean distance of 0.42 m and impacted a mean area of 0.75 m2 per trap. Injuries due to trap movement included scraped, fragmented, and dislodged sessile fauna, resulting in significant damage to coral, octocoral, and sponges. Overall loss of benthic cover along the trap movement path ranged from 11% to 17% depending on habitat. During normal fishing operations, traps typically shifted in place as they settled, with relatively minor impact on benthic habitat.

## 22.857

**Does Commercial Line Fishing On The Great Barrier Reef Put The Bite On Reef Sharks?**

**Colin SIMPFENDORFER*[1]**, Michelle HEUPEL[2], Ashley WILLIAMS[3], David WELCH[3,4], Aaron BALLAGH[3]

[1]Fishing and Fisheries Research Centre, James Cook University, James Cook University, Qld, Australia, [2]School of Earth and Environmental Sciences, James Cook University, Townsville, Qld, Australia, [3]Fishing and Fisheries Research Centre, James Cook University, Townsville, Qld, Australia, [4]Queensland Department of Primary Industries and Fisheries, Townsville, Qld, Australia

The interaction of reef sharks with the commercial line fishery on the Great Barrier Reef (GBR) was examined using data from compulsory fishery logbooks, commercial fishery observers and fishery-independent surveys. Grey reef shark (*Carcharhinus amblyrhynchos*) was the dominant species caught by line fisher (62-72% by weight), while whitetip reef shark (*Triaenodon obesus*) (16-29%) and blacktip reef shark (*Carcharhinus melanopterus*) (6-13%) were also regularly encountered. Annual reported commercial landings of reef sharks since 1988 have mostly been less than 20 t (live weight) for the whole GBR, but peaked at over 30 t from 2001 to 2003. The majority of the commercial landings were reported by a small proportion of the overall fleet, with less than 10 vessels per year reporting landings of more than one tonne. Although most vessels did not report shark landings, observer data indicated that on average each fishing dory catches a shark every second day, although most were released. Fishery-independent surveys found that the rate at which reef sharks were lost by line fishers was approximately 2.2 times the number that were successful brought to the boat. Observer and fishery-independent data indicated that there were no differences in catch rates between regions of the GBR, and suggested that catch per unit effort since the early 1990s have been relatively stable. The fishery-independent surveys indicated catch per unit effort on reefs zoned as non-fishing were more than double those zoned as open to fishing. No-fishing zones may therefore provide some level of protection to reef sharks from fishing pressure.

## 22.858

**The Effect Of Temperature And Pesticides On The Damselfish *acanthochromis Polyacanthus***

**Emmanuelle BOTTE*[1,2]**, Carolyn SMITH-KEUNE[1], Sue CODI-KING[2], Andrew NEGRI[2], Dean JERRY[1]

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia, [2]Australian Institute of Marine Science, Townsville, Australia

Over the last century and as a result of global warming, the Great Barrier Reef has experienced an increase in sea surface temperature. In addition, the coastal reefs from the Great Barrier Reef lagoon are likely to be impacted by direct anthropogenic disturbances, as they receive outflow from fifteen river catchments. Toxic compounds can spread in fringing reefs and impact the health of these ecosystems and their inhabitants. In order to detect the declining health of reef fish, I will characterize the response of a common and abundant damselfish, *Acanthochromis polyacanthus,* to temperature, pesticide (chlorpyrifos) and the combination of both stresses, at the phenotypic and molecular level.

Damselfish will be kept in captivity. After acclimation, they will be exposed for 4 days to a temperature stress, a chlorpyrifos exposure stress or a combination of both stresses. The environmental conditions will then return to control levels for 6 weeks. Eight fish will be sacrificed at t=0h, t=2h, t=24h, t=96h and t=6 weeks after the first day of exposure. Growth, plasma glucose and cortisol levels will be assessed as phenotypic measures of stress. The degree of inhibition of acetylcholinesterase (the target of chlorpyrifos) will be determined by enzymatic assay. The expression level of acetylcholinesterase and two heat shock proteins (hsp70 and hsp90) will be measured in liver and muscle tissues, using quantitative PCR and ELISA.

I expect to find a dose-response pattern as we intensify the stress. The combination of mild stresses may also be more deleterious than an acute but individual stress. Ideally this study will be a basis for the development of biomarkers for temperature and pesticide exposure. It will be one of the first investigating the effect of a combination of environmental stresses on the physiology of a tropical marine organism.

## 22.859

**Mpa Effects On The Structure Of Population Of *epinephelus Merra* in Reunion Island (Sw Indian Ocean): An Initial Study.**

**Karine POTHIN*[1]**, Emmanuel TESSIER[2]

[1]Faculty of Sciences, University of Reunion Island, Marine Ecology Laboratory, Saint-Denis, Reunion, [2]Parc Marin de La Reunion, Saint-Leu, Reunion

A new Marine Protected area have been created in february 2007 at Reunion Island to protect coral reefs. Although a previous study was effected on the biodiversity of coral reef fishes, this work is a complementary evaluation of the effects of the MPA on the structure of the population and the life traits of one commercial and target species, the grouper *Epinephelus merra*. This protogenous and sedentary species lives exclusively on the reef flat. Hence, it is easy to get to the structure of all the population. It is now exploited by traditionnal fishers, fishing by foot with bamboo lines. This species would benefit of the MPA by the adjustment of the sex-ratio of the population.

The first step of this study is to obtain informations about density and structure of population of *Epinephelus merra*. The data would be collected by visual census along Line Intercept transects. Each evaluation would be performed in the four reef units, in each of the three levels of protection (sanctuaries, no take areas, fished areas).

120 pairs of sagittal otoliths would be extracted (30 fishes in each of the reef units) in order to estimate the age of fishes. After preparation (thin slides), yearly marks would be read and theoretical growth curve established.

Third, the gonads of this species would be analyzed in order to define the size of sex change and the sex-ratio of the population.

This study would give the first informations of 1) the structure of the population of one commercial species of coral reef fishes 2) the impact of fishing on the population 3) the biology of the species (reproduction, growth). These informations are essential to adapt management rules for a long time exploitation. This is an original use of traditional stock assessement method to manage fisheries by foot.

## 22.860

**Spatial Distribution Patterns Of Abundance Of Major Life Stages Of Reef Fishes in Sulu Sea, Philippines**

**Melchor DEOCADEZ*[1]**, Eugene MOLEÑO[2], Arceo HAZEL[3], Jerome CABANSAG[4], Jonathaniel APURADO[5], Samuel MAMAUAG[1], Cesar VILLANOY[1], Porfirio ALIÑO[1]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Marine Fisheries and Technology, Mindanao State University, Cagayan De Oro City, Philippines, [3]DAI USAID Philippine Environmental Governance 2 Project, Philippines, Cebu City, Philippines, [4]Health and Sciences, 3St. Scholastica's College, Tacloban City, Philippines, [5]University of San Carlos, Cebu City, Philippines

Abundance of egg, larvae, juveniles and adults of commonly occurring reef fish taxa/species was determined at several sites along major marine corridors (Verde Passage, Cagayan Ridge and Balabac Strait) in the Sulu Seascape. Underwater fish visual census of the composition and abundance of reef fish juveniles and adults were undertaken. Presence/absence and abundance of taxa/species at each stage showed varying patterns among the corridor sites. For adults, there was variation in assemblage and abundance (and also biomass) across the major corridor sites (ANOSIM at $p < 0.05$). While some sites showed increasing similarities with decreasing distance (e.g. adjacent Cagayancillo-Tubbataha sites versus distant Cagayancillo-Batangas sites), some sites, however, showed contrasting patterns with distant sites (e.g. Batangas-Tubbataha) exhibiting similarities. For patterns of juvenile abundance, there were some similarities with those of the adults. Correlation between juvenile and adult abundance at some major sites was significant (ANOSIM at $p < 0.05$). These matching and mismatching of spatial patterns of distributions of the various life stages of benthic reef-associated fishes in Sulu Sea are influenced by two major factors. Local water circulation patterns at the different corridors in the Sulu Seascape, which potentially disperses egg and larvae within and between corridors shows shifting connectivity potential of fish populations. There is a concordance on the diversity of juvenile fish species in areas of high entrainment and adult fish species. On the other hand, disturbance and stresses such as over-fishing and habitat degradation will increase the mortality of the fish populations at varying stages of their life history and therefore reduces the connectivity potential in the same range of spatial scales in the Sulu Seascape.

## 22.862

**Behavior And Survivorship Of Hatchery-Reared Trochus Niloticus (Gastropoda:trochidae):implications To Restocking Efforts**

**Davelyn PASTOR*[1]**, Marie Antonette JUINIO-MEÑEZ, PH D[1]

[1]Marine Science Institute, University of the Philippines, Quezon City, Philippines

The activity pattern, anti-predation responses and survivorship of hatchery-reared topshell *Trochus niloticus* were studied in hatchery and tethering experiments to develop a restocking strategy to improve post-release survival of *Trochus*. Three juvenile sizes (1cm –3cm basal shell width) of topshells were tested in the hatchery to determine 24-hour activity patterns. The effect of sizes and conditioning treatments (unconditioned, habitat-conditioned and field-conditioned) on anti-predatory behaviors were scored in tank experiments. *T. niloticus* exhibited a diel activity pattern over 24-hours which varied significantly with type of substrate (e.g. greater movement in sand and bare tank; higher frequency of cryptic or hiding behaviors in high relief coral rubble substrates). Topshells exhibited significant avoidance behaviors in the presence of a crab predator, regardless of sizes or conditioning. Based on these initial results, a tethering study in two restocking sites (shallow intertidal and subtidal reef) was done to further gain insights on relative survivorship in the field. Survivorship was significantly higher in the shallow intertidal compared to subtidal reef area while conditioning treatments and bigger size (>3cm) appear to improve survivorship in the topshell's natural habitat. Based on the organism's diel activity pattern, deployment in the morning when topshells are cryptic could enhance refuge from predators. The release of bigger sizes in coral rubble substrates in the shallow intertidal zone improve post-release survival. Preliminary results on growth and survivorship of released sub-adult topshells (4-5cm) and constraints due to low recovery rates are discussed. The effect of the conditioning treatments on survivorship of hatchery reared topshells needs to be tested further for future restocking programs.

## 22.863

**Marine Protected Areas: Boon And Bane For The Philippine Small-Scale Fisheries?**

**Martina KELLER*[1,2]**, Matthias WOLFF[2,3], Rizaller C. AMOLO[1]

[1]Coastal Conservation & Education Foundation (CCEF), Cebu City, Philippines, [2]Center for Tropical Marine Biology (ZMT), Bremen, Germany, [3]Charles Darwin Research Station, Quito, Ecuador

Fisheries provide critically important food and income in many developing countries. Yet overexploitation, habitat degradation and poor or non-existent management mean that many small-scale, artisanal fisheries are in decline.

The same scenario is true for the Philippines where reef fisheries provide around 25% of the protein intake of the country.

Management of these fisheries is often inadequate or absent, partly because they are data poor. Baseline data and new management approaches, particularly those relevant to developing countries, are urgently needed.

No-take Marine Reserves (MPAs) are advocated widely as a management option for multi-species tropical fisheries as well as a potential solution to the loss of marine biodiversity, ecosystem structure and to overfishing, and thus for sustainability.

Tremendous work has been done on the qualitative merits of MPAs. In fact, however, the quantitative evidence to support MPA efficacy in protecting biodiversity and enhancing fisheries is highly limited, still allowing scepticism about MPA-benefits to local communities.

So far only few studies tackle the direct fish population and fisheries response to the establishment of MPAs. But: Do these fishery yields improve enough to compensate for the lost fisheries area? What would be the right management approach to consider both conservation and economic concerns? Underwater visual census, experimental fishing, fishery and socio-economic surveys are used to meet these questions.

Leadoff surveys show: When people are hungry, their need for food necessarily comes before their willingness to protect the environment, even in the long run conservation will provide them with more food. So any attempts to protect the oceans and marine life in the Philippines must also provide clear and clearly understood benefits, including more fish, to coastal people.

## 22.864

**First Description Of Post-Settlement Goliath Grouper (Epinephelus Itijara) And Details Of Early Life History Using Daily Otolith Increment Analysis**

**Monica LARA*[1]**, Jennifer SCHULL[2], David L JONES[1], Robert ALLMAN[3]

[1]CIMAS, University of Miami, Miami, FL, [2]NOAA/SEFC, Miami, FL, [3]NOAA/SEFC, Panama City, FL

The goliath grouper (*Epinephelus itijara*) is the largest Atlantic grouper and an important coral reef top predator. Information about the biology and ecology of this species is critical as it suffered a rapid decline in abundance since the 1950s and is now listed as threatened on the "red list" of the IUCN-World Conservation Union although populations show signs of recovering in the US. It is a species that uses different tropical and subtropical environments over its lifetime such as mangroves and coral reefs. Amazingly, little is known about the biology of this fish and the early life stages are virtually unknown. The early post-settlement and juvenile phases of this important reef fish have never been described.

Small juvenile goliath grouper were collected from September through December of 2001- 2004 in the Ten Thousand Islands region of southwest Florida's Gulf coast. These juveniles ranged in size from 15 mm SL and represent the smallest individuals of this species collected to date. The smallest individuals are newly settled and lack much pigment. A description of these juveniles is provided as well as illustrations of juveniles between 15 and 38 mm SL. Specimens ranging in size from 15 mm to 87 mm SL (n = 51) were used for otolith studies. The age, age at settlement and days post-settlement were obtained using otolith increment analysis. Spawning dates, settlement dates and moon phases of these events were determined. These data present evidence of delayed metamorphosis in the larvae of this species.

## 22.865

**Essential Habitats For Juvenile Groupers in Coastal Waters Of Southern Gulf Of Mexico**

**Ximena RENAN-GALINDO*[1]**, Thierry BRULE[2]

[1]UMDI-Sisal, Fac. de Ciencias, UNAM, Sisal, Mexico, [2]Recursos del Mar, CINVESTAV-IPN, Unidad Merida, Merida, Mexico

Essential fish habitats provide juveniles to the most important reef fisheries in the Gulf of Mexico and Caribbean Sea. The structure of fish communities is enhanced in systems that have interconnected mangroves, sea grass beds and coral reefs. Many commercially important reef fish species use these habitats as nursery grounds. Grouper fishery, for example, is one of the most important economical activities in the Gulf of Mexico. Nevertheless, there is little information on groupers nursery grounds in the coastal ecosystems of the Southern Gulf of Mexico. This study aims to identify and characterize essential fish habitats for different juvenile grouper species, to provide useful scientific information to support management decisions. Five fishing zones along the Yucatan coast were studied for 18 months during 2000 and 2001 and three main essential habitats were identified (seagrass beds, rocky reefs and hard-bottom coral communities). Using different kinds of fishing gear 1,517 juvenile groupers (sexually immature) belonging to Ephinephelus morio (N= 436), Ephinephelus adscensionis (N= 2), Ephinephelus striatus (N= 2), Mycteroperca bonaci (N= 139), Mycteroperca microlepis (N= 937) and Mycteroperca interstitialis (N= 1) were captured. Newly settled M. microlepis (SL= 1.5 to 5.2 cm; N= 28) and M. bonaci (SL= 1.8 to 2.7 cm; N= 5) where caught only in seagrass beds habitats. E. adscensionis, E. striatus, M. interstitialis and large M. bonaci prefer rocky reefs, E. morio juveniles preferred hard-bottom coral communities, whereas M. microlepis were associated to seagrass beds. These results could be used as basis to create MPA's where fishing restrictions to certain species, areas or gears (such as trawling) could be applied.

## 22.866

**Population Dynamics Of An Artisanally Harvested Giant Clam *(Tridacna Maxima)***

**Annie YAU*[1]**, Hunter LENIHAN[1]

[1]Bren School of Environmental Science & Management, University of California, Santa Barbara, Santa Barbara, CA

An important challenge in fisheries management is the identification of factors driving and limiting population growth. Traditional, artisanal fisheries still exist worldwide and are important food sources for local consumption. Although giant clams (Tridacnidae) are extensively aquacultured and harvested throughout the Indo-Pacific, surprisingly little is known about natural population dynamics. In Mo'orea, French Polynesia, a coral reef lagoon management plan established in 2002 sets a size limit (120 mm) and spatial closures on artisanal harvest of the giant clam *Tridacna maxima*. To better understand specific factors affecting the population dynamics inherent in this managed population, individual clams at 12 different sites were marked and measured in 2006 and re-measured in 2007. An analysis of the biotic and abiotic factors affecting mortality and growth was performed on this continuing demographic study of *T. maxima* in Mo'orea. Preliminary results demonstrate size-dependent mortality and growth, with smaller clams exhibiting higher relative growth rates and mortality rates. Multiple regression revealed growth rates do not vary with mantle color, site, height in the water column, orientation on substrate, or substrate type. However, mortality does vary with site, height in the water column, and substrate type. Similar mortality patterns inside and outside reserves suggest that the lagoon management plan is not effective or not being enforced. The paucity of live legal size clams and the abundance of legal size shells in recent midden piles suggest that this population of *T. maxima* is overfished. High mortality and scarcity of large fecund clams and low recruitment indicate that reproductive input may be limiting population growth, thus hindering effective fishery management.

## 22.867

**Fish Spawning Aggregations At Gladden Spit, Belize-A Slippery Subject**

**jocelyn FINCH*[1]**, **Julianne STOCKBRIDGE*[2]**, Shayne PECH[3], Lindsay GARBUTT[3]

[1]Toledo Association for Sustainable Tourism and Empowerment, Punta Gorda, Belize, [2]The Nature Conservancy, Belmopan, Belize, [3]Friends of Nature, Placencia, Belize

Gladden Spit Silk Cayes Marine Reserve (GSSCMR) protects an important spawning aggregation site for over 24 species of reef fish, including a variety of snapper, grouper, jacks and other reef fish. In addition the spawning aggregation site is an attraction for whale sharks (*Rhincodon typus*) that predictably aggregate to feed on the fish spawn. The spawning site at Gladden is of critical ecological, economic and social value and demands innovative management. In 2002 a local Non-Government Organization (NGO), Friends of Nature (FoN), signed a co-management agreement with the Belize Fisheries Department for the management of GSSCMR. Over the past five years Friends of Nature has worked closely with local stakeholders, NGO's, the Government of Belize, the Nature Conservancy, and other partners to improve management of this important multiple species fish spawning site. A key component to the on-going management has been the monthly monitoring of spawning aggregation using the Reef Fish Spawning Aggregation Monitoring Protocol for the Mesoamerican Reef and the Wider Caribbean. After five years of active management, including monitoring, enforcement and education, FoN has collected a significant amount of information about the status of the site and particularly the status of the aggregating species. In order for FoN to effectively manage GSSCMR and maintain a sustainable fishery, it becomes critical for managers and researchers to evaluate what, if any, impact is actually being felt at the site. Through careful evaluation of the data collected and discussions with resource users it should be possible for managers to determine the impact of GSSCMR on the fisheries resources and to evaluate the next steps in order to ensure effective and adaptive management of these important resources.

## 22.868

**Evolution Of Small Scale Fisheries Net Gears Selectivity To Preserve Marine Turtles in Martinique And Guadeloupe, Fwi**

**Laurent LOUIS-JEAN*[1]**, Philippe LENFANT[2], René GALZIN[2], Eric DELCROIX[3], Jean-Philippe MARÉCHAL[4]

[1]OMMM, Fort-de-France, Martinique, [2]EPHE - University of Perpignan, Perpignan, France, [3]Réseau tortues marines de Guadeloupe, Trois-Rivières, France, [4]OMMM, Fort-de-France, France

The conservation plan for marine turtles in the FWI has been approved by the National Council for Nature Conservation in 2006. A major objective was to identify the main threats on marine turtles. Local fishing gears kill hundreds of turtles every year through by-catch. Bottom trammel nets and gillnets targeting fishes, queen conch and spiny lobsters are first concerned. Their number and use have increased in the past few years. It is believed that their impact on marine resources is not compatible with long term management. In this study, experimental fishing was conducted to compare species selectivity between new designed nets and the current gears used in the FWI. The productivity of both gill nets and trammel nets was compared. Parameters such as height and mesh size were studied. Changes in catches were also compared to determine the weight of each parameter. Three specific study areas were chosen according to targeted species and marine turtles presence. Our objective is to develop gears and techniques that would preserve marine resources and significantly reduce marine turtles by-catch in the long term. Finally we should select the most selective - modified or new - fishing gears with no or significant reduced impact on marine turtle population in the FWI.

## 22.869

**Influence Of Habitat Structure And Population Density On The Distribution And Survival Of Four Species Of Harvested Coral Reef Fishes**

**Clare WORMALD*[1]**, Mark STEELE[2]

[1]University of Rhode Island, Kingston, RI, [2]California State University Northridge, Northridge, CA

Effective conservation and management strategies are needed to sustain harvested coral reef fish populations that are impacted by habitat loss and overexploitation, however, little is known about how the demographic rates of harvested reef fish respond to changes in habitat quality or to fluctuations in population density. This study examined four species of ecologically similar, harvested coral reef fishes to evaluate habitat associations and assessed the influences of habitat and population density on survival.

The degree of habitat association differed among the four study species. Densities of schoolmaster snapper (*Lutjanus apodus*) and French grunt (*Haemulon flavolineatum*) were strongly tied to habitat structural components (coral and limestone boulders), whereas white grunt (*H. plumierii*) density was not predictable based on this aspect of the habitat, and lane snapper (*L. synagris*) density was negatively associated with this habitat attribute.

Despite the varied relationships between density and habitat features, correlative tests did not reveal any influence of habitat on survival of the four species. Nor did correlative tests reveal any effects of density on survival. A large-scale density manipulation experiment with the schoolmaster snapper, however, revealed that survival was positively affected by density. The positive effect of density on survival of the schoolmaster snapper contrasts with the results of most studies on small, non-exploited coral reef fishes. The inverse density dependence detected in the schoolmaster snapper implies that regulatory mechanisms that would help populations recover from overfishing may be absent in this species, but that marine protected areas may be particularly effective for management and conservation of this and similar species.

## 22.870

**Body Size And Abundance Relationships in Tropical Eastern Pacific Reef Fishes: Testing The Energetic Equivalence Rule**

**Carlos MUÑOZ*[1]**, Fernando A. ZAPATA[1]

[1]Department of Biology, Universidad del Valle, Cali, Colombia

The Energetic Equivalence Rule (EER) proposes that the energy required by a species population is independent of its body size. The EER is evident when the body size–abundance and metabolic requirements-body size relationships are linked and the slopes (allometric coefficients) from these relationships have the same magnitude and opposite sign. To test the generality of the EER we examined the relationship between body size and abundance in reef fishes from the Tropical Eastern Pacific (TEP). We used abundance data gathered from published studies done in different localities from the TEP (Gulf of California, Costa Rica, Colombia and Galapagos islands) covering much of the TEP region. Body size data were obtained from several papers and digital data bases. Abundance was generally negatively correlated with body size with allometric coefficients ranging between -0.06 and -0.42. Although abundance scaled as a negative power of body size according to the EER, the magnitude of the allometric coefficients between abundance–body size and metabolic requirements–body size relationships differed significantly ($p \leq 0.0002$ in all cases). Thus, the EER is not supported by our analysis in TEP reef fishes. Among reef fishes bigger species appear to have a greater energetic impact on the environment than the smaller ones.

## 22.871

**Rotary Time-Lapse Photography: A Non-Destructive Technique For Fish Population Assessment**

**Ian MACDONALD*[1]**, Doug WEAVER[2]

[1]Physical and Environmental Sciences, Texas A&M University - Corpus Christi, Corpus Christi, TX, [2]Coastal and Marine System Sciences Program, Texas A&M University - Corpus Christi, Corpus Christi, TX

We describe application of an autonomous digital camera system for estimating fish population size, habitat fidelity, and behavior. A 5 megapixel digital camera and an 120 watt/sec strobe are co-axially mounted on a rotating pedestal inside a thick-walled glass tube (i.d. 12 cm). A programmable controller operates the camera and a stepper motor, which rotates the pedestal. At preset intervals or specific times the camera takes a picture with synchronous strobe and the pedestal rotates a specified number of degrees (e.g. 36°); rotation is unimpeded and can continue an indefinitely or reverse. Typically, 10 images complete a 360° rotation and can be viewed as separate files or fused as a panoramic image of deployment site. Power is supplied by an internal battery, mounted on the pedestal, or an external battery connected through a slip-ring.

We tested this system on the Flower Garden Banks in the Gulf of Mexico. The deployment site was the edge of a large sand flat on the main reef crest at 28 m depth. Images were collected at 18 min intervals over a 23 day deployment, totaling 1840 images and 184 rotations. Effective visibility was 8 m from the camera during daylight and 5 m during nighttime. Biofouling on the glass tube began to cause noticeable degradation of image quality after approximately 14 days. A significant fraction of the common reef fish known from the Flower Gardens were identified and enumerated, providing details of behavior patterns and habitat preferences.

## 22.872

**The Use Of Abc Curves As Health Indicator For Reef Fish Communities**

**Sachiko HAYASAKA*[1]**, Horacio PEREZ[2]

[1]Ecología de arrecifes, Unidad de Investigación del Centro de Ecología y Pesquerías, Boca del Río, Veracruz, Mexico, [2]Ecologia de Arrecifes, Unidad Investigaciòn del Centro Ecologìa y Pesquerìas, Boca del Rio, Veracruz, Mexico

According to Warwick (1986), the health of benthic communities can be measured by using Biomass - Abundance Curves (ABC). Under unpolluted conditions, biomass will become dominated by few large species, which are in equilibrium with available resources. When polluted conditions are present, the numerical dominants are smaller species which are out of equilibrium with resources. The curves for unpolluted communities are represented with biomass curve above the abundance curve. As pollution increases the curves become overturned. The purpose of this project is to test these curves to evaluate their potential use on reef fish communities. We studied eight reefs, five from the North area which are near the coast and urban activities (Anegada de Adentro, Verde, Pájaros, Sacrificios, Ingeniero) and three from the South area, far away from the coast (Santiaguillo, Enmedio and Blanca) for one year starting July 2006. The censuses were visual at two depths (3 and 15 m) with five replies, having a total of 240 censuses. We found values indicating healthy and unhealthy reef fish communities, which varied during the year. In general, shallow sites showed healthy values meanwhile deep sites showed unhealthy ones. When a season analysis was made the values obtained during rainy season were mainly of unhealthy conditions. No clear pattern was observed between the distance to the coast and the health measure. Finally, comparing zones with different fishing pressures, we observed healthy values for the shallow sites with low fishing, but this pattern was not maintained for the deep sites. In spite more studies are required, however the use of ABC curves showed potential for their use in fish communities.

## 22.873

**Within Island Gradients in Human Disturbance Alter Demography Of Coral Reef Fishes**

**Mary DONOVAN*[1]**, Sheila WALSH[2], Stuart SANDIN[2], Ben RUTTENBERG[1], Scott HAMILTON[1]

[1]Marine Science Institute, University of California Santa Barbara, Santa Barbara, CA, [2]Scripps Institution of Oceanography, La Jolla, CA

Fishing down top trophic levels of coral reef fishes has potentially large implications for ecosystem function and fisheries management. Previous studies looking at the demography of coral reef fishes have generally focused on single species of fish with particular importance to fisheries. In this study, we examined demographic patterns of five coral reef fish species from different trophic levels collected from three regions around Kiritimati Island in the Line Islands. The three regions vary in the level of human impact; fishing pressure tends to decrease with increasing distance from the main population center on the island. We compared demographic responses of fishes from these regions and assessed the individual effects of fishing pressure, benthic habitat, and primary productivity (e.g., chlorophyll a). We employed standard techniques using otolith ageing to describe the demography of these fishes. We found significant differences in growth rates and longevity among regions and trophic levels that were most likely explained by differences in predator communities. This study highlights the impacts of anthropogenic effects, such as fishing, and its effects on multiple trophic levels, and that these effects can vary over small spatial scales, such as within a single small atoll. In regions with large impacts by humans, the removal of piscivores may reduce predation of lower trophic levels which leads to increased growth rates and longevity compared to regions with less human impact.

## 22.874

**Indications Of Recruitment Enhancement in The Sea Urchin Tripneustes Gratilla Due To Stock Restoration Efforts**

**Marie Antonette MEÑEZ*[1]**, Davelyn PASTOR[1], Helen Grace BANGI[2]

[1]University of the Philippines, Marine Science Institute, Diliman, Quezon City, Philippines, [2]Mariano Marcos State University, College of Aquatic Sciences and Applied Technology, Currimao, Ilocos Norte, Philippines

Restocking of marine protected areas and grow-out culture of hatchery-reared *Tripneustes gratilla* juveniles were used to enhance the recovery of depleted reef fishery stocks. Insights on the impacts of these interventions were gained from field monitoring activities conducted in four sites in Bolinao, Pangasinan and one site in Poro Point, La Union Philippines between 2004-2007. Areas were surveyed using standard belt transect method (100m X 2m X 3 transects) to determine densities and size frequency distributions. Temporal trends in the incidence and abundance of recruits (<5.0 cm test diameter) where compared among sites. In Bolinao, >1 individual m-2 was observed for the first time in 2004 since the collapse of the fishery in 1992. The highest density was >4 individuals m-2in Lucero, Bolinao in January 2006. In Poro Pt., densities increased after initiation of grow-out culture activities in 2005 and peaked at >1 individuals m-2 in 2007. In both sites juveniles comprised up to over 80% of the sea urchins encountered in field surveys during October to February in 2004 to 2007. This indicates high benthic recruitment success during the prevalence of the SW monsoon in June through October. The positive correlation in the density of recruits and adults in the four sites in Bolinao, and the high incidence of recruits in the grow-out area in Poro Pt. suggest that the aggregation of adults enhanced benthic recruitment. The potential for a network of marine protected areas and grow-out culture to enhance larval sinks and sources for *T. gratilla* are examined in relation to simulations of larval dispersal given hydrographic conditions during different times of the year and the distribution of suitable reef habitats along NW Luzon.

## 22.875

**Fishing Community Council: Does it work?**

**Isabel MARQUES DA SILVA*[1,2]**, Julie GARNIER[3], Alison SHAW[4]

[1]Conservation, Maluane, Pemba, Mozambique, [2]Conservation, Zoological Society of London, London, United Kingdom, [3]Maluane, Pemba, Mozambique, [4]Zoological Society of London, London, United Kingdom

In an attempt to decentralise authority and empower local communities to manage their marine resources, a new decree was proclaimed in Mozambique in 2006, which legalised a Fishing Community Council or CCP. The CCPs have the right to control access and manage their resources within 3 nautical miles of their coastline and this provided the Vamizi community with the legal instrument they needed. Two CCPs have now just been legalised on Vamizi island and in Olumbe, the main village on the continent which also uses fishing grounds around Vamizi. In partnership with government, Maluane has supported the creation and capacity building of the CCPs. In order to develop the CCP capacity to make sound management decisions, training of some CCP members into basic reef monitoring was initiated in 2006. Their capacity in monitoring fish catch and undertaking fish stock assessment will soon be developed. This will also allow for the community-based monitoring of the effectiveness of management decisions, such as the newly formed marine sanctuary that both the CCP and Vamizi community have decided to create around the north-eastern section of the island. A unanimous decision to set aside a no-fishing area for one year was taken once the community had identified the critical issues and priorities and agreed on the solutions to solve these issues. Feed-back sessions on all survey results were conducted with all stakeholders which, combined with an on-going awareness programme on sustainable resource use conducted on the island, also contributed to this process. Logistic problems, in legalising the CCP, difficulties in the CCP members dealing with financial resources are some of the problems that are slowly being resolved. One point seems to be achieved: the reduction of the fishermen fishing in the Vamizi waters.

## 22.876

**Aspects Of The Reproductive Biology Of Two Serranidae Species in The Bahamas: Epinephelus Guttatus (Red Hind) And Mycteroperca Venenosa (Yellowfin Grouper)**

**Nicolle CUSHION*[1]**, Melissa COOK[2], Kathleen SULLIVAN-SEALEY[3]

[1]Biology, University of Miami, Coral Gables, FL, [2]NOAA Fisheries Service, Panama City, FL, [3]Marine Enviromental Studies Institute, College of The Bahamas, Nassau, Bahamas

Understanding the reproductive biology of reef fish is critical for managing fishery-targeted species. Behavioral, ecological and physiological aspects of reproduction need to be determined to understand how a species may respond fishing pressure and management initiatives. Groupers and hinds from the family Serranidae are some of the most heavily-harvested species in the Caribbean, yet many aspects of their reproduction are undocumented. Additionally, aspects such as spawning seasonality and the size of sexual maturity often vary for a given species throughout a region, thus population-specific information is needed. This study documents biological and physiological aspects of reproduction for Bahamian populations of Epinephelus guttatus (red hind) and Mycteroperca venenosa (Yellowfin grouper) for the first time. Sex ratios, changes in the seasonal gonadal development over an annual reproductive cycle and the size of sexual maturity are described for the species. Female gonads were classified into nine stages of maturity and males were classified into six stages of maturity based on histological structures. One major spawning period was found for M. venenosa from February to April, while only one major spawning month (February) was detected for E. guttatus. Both species are protogynous hermaphrodites and sex ratios were female-skewed and the size of sex change was found to be similar to previous studies of the species. These findings document aspects of reproduction and provide a framework for future studies.

## 22.877

**Tide-Related Variation in The Reef Fish Fauna Of Utría National Park (Colombia, Tropical Eastern Pacific)**

**Gustavo Adolfo CASTELLANOS-GALINDO*[1,2]**, Uwe KRUMME[1], Alan GIRALDO[2]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [2]Grupo de Investigación en Ecología Animal, Universidad del Valle, Cali, Colombia

On coasts with strong tides fishes regularly enter and leave the intertidal zone. These movements lead to mostly unknown changes in the subtidal fish community on short time scales. To examine the responses of a reef ichthyofauna to water level changes in a macrotidal area of the Tropical Eastern Pacific, a series of daytime underwater visual census over strip transects were carried out at different tidal stages (flood, high, ebb and low tide) in the Utria National Park, Colombia. Surveys took place during the dry season at four rocky reef sites. At each site, nine permanent 25 x 2 m transects at mid intertidal, low intertidal and subtidal areas were established (three per zone). Clear patterns of space occupation were observed for the reef fish families Labridae and Pomacentridae. *Halichoeres notospilus* (Labridae), and *Abudefduf concolor* and *A. troschelii* (Pomacentridae) used the intertidal zone at flood, high and ebb tide while the distribution of *H. nicholsi* and *H. chierchiae* (Labridae), and *Stegastes flavilatus* and *Microspathodon dorsalis* (Pomacentridae) was restricted to the subtidal area throughout the tidal cycle. Other reef fishes from the families Balistidae, Chaetodontidae, Haemulidae, Pomacanthidae, Scaridae, Serranidae and Tetraodontidae occasionally entered rocky intertidal areas when submerged. Ubiquitous reef species (Carangidae, Kyphosidae, Lutjanidae and Mugilidae) also used the intertidal zone intensively at flood, high and ebb tide**.** The small-scale tidal migrations of reef fishes may play an important role in their life cycle by connecting adjacent ecosystems and providing temporal refuge from subtidal predators. At the same time, the tide-related temporal colonization of the intertidal zone by a specific subset of reef fishes has to be considered in underwater surveys on macrotidal coasts.

## 22.878

**The Contribution And Impact Of Marine Protected Areas Towards Coral in Zanzibar Island**

Salim SAAD[1], **Salim SAAD*[1]**

[1]Department of Fisheries and Marine Resources, Ministry of Agriculture and Natural Resources, Zanzibar, Tanzania

Marine Protected Areas are increasingly being used to protect biological rich habitats, resolve user conflict, and help to restore over-exploited stocks and degraded areas (Agardy, 1993). In recent years the use of Marine Protected Areas (MPAs) as method of managing coastal fisheries has gained popularity, and increasing numbers of MPAs are being established throughout the World (D. Whitmarsh et al). Tanzania experienced a rapid establishment and expansion of marine parks and protected areas.

Most of marine protected areas was established for the purpose of conserving marine resources such as coral reefs, mangroves, dolphins, whales, fishes and sea turtles but at the same time to encourage tourist to visit within the areas to watch those resources and collecting entrance fees for the purpose of support community development within the villages which around the conservation areas. In Zanzibar for example, the number of tourists entering has increased by 35 percent between 1995 and 1999 from a total of 56,415 (1995) to a high of 86,925 (1999).

In Marine Protected Areas, number of tourism has been increased tremendously where in Chumbe Island Coral Park was from 1080 tourist in 2003 to 1969 tourists in 2006 while in Menai Bay Conservation Areas was 12,000 in 2003 to 23750 in 2006 where total of US$ 71250 was collected and has been used to conserve the area.

The impact which is facing the protected areas is the number of tourism enter in areas is too high and occurs in the low tide where some tourist are standing in the coral and break them.

## 22.879

**Assessing And Mapping The Distribution Of Fish Species And Guilds Across The Bermuda Reef Platform And Identifying Critical Marine Habitats For Spatial Protection**

Thaddeus MURDOCH[1,2], Matthew HAMMOND[1], **Joanna PITT*[2]**, Mandy SHAILER[3], Annie GLASSPOOL[3]

[1]BREAM: Bermuda Reef Ecosystem Assessment and Mapping Programme, Bermuda Zoological Society, Flatts Village, Bermuda, [2]Murdoch Marine Environmental Consultant Services Ltd., Paget, Bermuda, [3]Bermuda Biodiversity Project, Bermuda Zoological Society, Flatts Village, Bermuda

Bermuda supports the most northerly coral reef system in the world with the large majority of the species being derived from the tropical Atlantic. A high latitude outpost for Caribbean species, Bermuda supports a reduced species assemblage, with 22 species of hard coral, and a similarly under-represented icthyofaunal composition. Since accidentally colonized in 1609, accounts by the earliest explorers describe islands uninhabited by humans but rich in fish, birds and sea turtles. However, by 1627 the first restrictions regarding the harvesting of fish were passed due to a "scarcity of bait for necessary fishing". We will review the numerous fisheries laws, including spatial closures, size restrictions and species protections, which were enacted over the ensuing centuries in order to regulate harvestable marine resources.

Current management of important fish species has been constrained by a lack of data encompassing the entire Bermuda Reef Platform. Using AGRRA and REEF fish assessment protocols, 105 survey sites located in lagoonal, reef crest and forereef habitats across the entire Bermuda Reef Platform were surveyed for juvenile and adults of all ecologically and economically import fish species. Results demonstrate that herbivores and invertivore guilds were very abundant and speciose, but that piscivores were low in abundance and of critically poor species diversity, and therefore possessing weak ecological resilience. Results also illustrated that most fish species have distinctive cross-platform patterns of abundance, both within and across habitats. Univariate and multivariate data analysis demonstrated the existence of critical areas across the Bermuda Reef Platform for different species and guilds that would benefit from enhanced management and protection status.

## 22.880

**Artisanal Fish Catches Along Coral Reef Areas Of East Coast Of Zanzibar**

**Narriman JIDDAWI*[1,2]**

[1]MBRM, Institute of Marine Sciences, Zanzibar, Tanzania, [2]Department of Marine BIology and Resources Management, Institute of MArien Sciences, Zanzibar, Tanzania

Many countries with coral reefs are highly dependent on them for food and income. Reef fish associate closely with their habitat and catchability also depends on the gear and number of fisher used. The fisher of Zanzibar have been using traditional fishing techniques since time immemorial and usually and on the same fishing grounds. The number of fishing units have increased with time. In 2003 Census survey there were 18,000 fisher but this doubled in 2007. Some studies on fish monitoring have been done in some villages. This paper will present information on the changes in the number of fishing gears and vessels used in coral reef areas as well as information on landings of fish caught from these sites. The method used to get this information was through a census survey conducted throughout these villages to determine the fishing units and also monitoring of landed catch to determine the catch per unit effort, the sizes of fish as well as the income of the fisher folks. The results showed the common gears and vessels used are still basket traps and outrigger canoes respectively as these are afforded by most fishers. The fish species are determined by the type of gear used and over 150 were recorded. Despite fishing in the same sites since time immemorial the catch rates per fisher although has gone down but still are able to catch enough for survival. This could be attributed to the fishermen changing the fishing grounds with seasons leaving some to recover. This study therefore will provide information on the importance of the fisheries and will provide information for improving policy frameworks for the sustainable utilization of these resources and the development of these coastal communities.

## 22.881

**Density, Biomass, And Habitat Association Of The Rainbow Parrotfish, Scarus Guacamaia, in Alacranes Reef, Northern Yucatan Peninsula**

**Carlos GONZALEZ -SALAS*[1]**, Alfonso AGUILAR-PERERA[1], Harold VILLEGAS-HERNÁNDEZ[1]

[1]Departamento de Biología Marina, Universidad Autónoma de Yucatán, Merida, Mexico

The Rainbow parrotfish, Scarus guacamaia, considered one of the largest fishes of the world, attains a high biomass and has commercial value for some fisheries. It is a threatened species according to the IUCN Red list and the largest herbivorous reef fish occurring in the Caribbean region. Juveniles are associated to mangrove habitats compared to other available habitats (coral reefs, seagrass beds). In this study, we present a particular case of high abundance of juveniles and adults of S. guacamaia in coral reef habitats with a total absence of mangroves from Alacranes reef, northern Yucatan Peninsula. Mangroves appear not to function as obligate habitats and it is shown that seagrass and coral rubble appear as an alternative habitat for nursery, growth and reproduction.

## 22.882

**Contributions To The Biology Of The Mardi Gras Wrasse, Halichoeres Burekae, in The Western Gulf Of Mexico**

**Douglas WEAVER*[1]**, luiz ROCHA[2], Jessica MAISANO[3]

[1]Coastal and Marine Systems Science, Texas AM-Corpus Christi, Corpus Christi, TX, [2]Evolutionary Ecology, University of Hawaii, Honolulu, HI, [3]Department of Geology, University of Texas, Austin, TX

Tropical coral reefs of the world's oceans are often dominated by wrasses (Family Labridae), including numerous species of the genus *Halichoeres*. A new species of wrasse, *Halichoeres burekae*, was described from the Flower Garden Banks National Marine Sanctuary, and is commonly known as the Mardi Gras wrasse. Subsequent to the initial collection and species description, additional populations of the species were documented in Veracruz, Mexico and Seven and One Half Fathom Reef near Padre Island, Texas. We present detailed information on the morphological features of the Mardi Gras wrasse, genetic and morphological relationships to congeners, gonad morphology, and morphology of the skull related to feeding and social interactions. The Mardi Gras wrasse is currently known only from the western Gulf of Mexico, and differs from other planktivorous members of the genus in skull morphology, skeletal pigments, and life history. Feeding morphology of the skull of *H. burekae* contradicts previous hypotheses of morphological adaptations attributed to planktivory, and suggests alternative approaches to feeding modes in the genus.

## 22.883

**Differential Depth Effects Upon Biomass Patterns in An Herbivorous Coral Reef Fish Assemblage**

**Michael NEMETH*[1]**, Richard APPELDOORN[1]

[1]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

Herbivory is an ecological process that structures coral reef benthic communities and variations in the spatial distribution of herbivores may reflect differential grazing pressure. This study investigates spatial patterns of parrotfish and surgeonfish biomass on fore-reef habitats across the seascape. Abundance was sampled on 6 reefs along an inshore-offshore gradient in La Parguera, Puerto Rico to allow within reef (across depths) and among reef (cross-shelf) comparisons. Temporally replicated visual surveys were conducted along permanent belt transects (100m2) at three depth intervals (5, 10, 15 m) to obtain data on fish species density and lengths used to calculate biomass. La Parguera supports an active fishery and large species of parrotfish were rare or absent. The herbivorous fish assemblage was dominated by small-bodied parrotfishes *Scarus iseri*, *Sparisoma aurofrenatum S. viride* and the blue tang, *Acanthurus coerulus*. Overall, parrotfish biomass was 2.3 times higher at 5 m depth than at15 m; for surgeonfish it was 4 times higher. These depth-related differences were most notable at inshore reefs where biomass at 5 m was 3.2 and 10.9 times greater than at 15 m for parrotfish and surgeonfish, respectively; on offshore reefs the respective proportional differences were 1.8 and 2.8 times. Individual species followed this general pattern. In addition, higher biomasses were found at those reefs and depths within reefs characterized by higher relief and a greater % cover of live coral and coralline algae. Depth is a well known driver of herbivorous fish abundance, but along a cross-shelf gradient additional within reef factors interact to structure biomass patterns. That use of fore-reefs by the dominant species of herbivores is site specific but somewhat predictable has implications for management strategies that aim to promote fish grazing.

## 22.884

**Seasonality And Long-Term Changes in Reef Fish Population At Caye Caulker Marine Reserve, Belize, C.a.: 1: Preliminary Overview**

**Ellen MCRAE*[1,2]**

[1]The Siwa-ban Foundation, Caye Caulker, Belize, [2]Forest and Marine Reserves Association of Caye Caulker, Caye Caulker, Belize

Caye Caulker Marine Reserve (CCMR), Northern Shelf Lagoon, Belize, is centered along an 11-km stretch of the Belize Barrier Reef off the mangrove-sand island of Caye Caulker. Important time benchmarks to reef fish populations include Reserve enactment (Apr 1998); major near-miss hurricanes Mitch (Oct 1998) and Iris (Oct 2001), and direct hit Hurricane Keith (Sep-Oct 2000). Formal on-site management commenced 2003; however conservation zones, though proposed within the IMP (2004) and updated in 2006, have not as yet been formally gazetted by Government, resulting in some confusion about site use during the past four years.

Reef fish populations were noted in 30-minute timed rover diver mask and snorkel surveys in selected backreef and channel locations along reef ribbons at CCMR, , Belize, commencing 2005. Though most reef fish surveys concentrate on specific groups, this dataset was constructed around total biodiversity. In this overview patterns of reef fish occurrence at backreef and channel locations are analysed relative to conservation status of the areas. The most commonly observed species (sighted every site visit) fell into five families-Lutjanidae, Haemulidae, Pomacentridae, Labridae, and Scaridae.

For time series comparison a less formal dataset collected in the same areas ancillary to tourism from 1991-2007 was reviewed as to relative abundance, also alongside conservation status data. One major difference noted between the early data prior to CCMR enactment is the near absence of Lutjanids; this is undoubtedly a function of the unrestricted spearfishing that took place at the South Caye Caulker Channel and adjacent backreef areas.

## 22.885

**Movement Patterns Of Queen Conch, *strombus Gigas*, And Utilization Of Coral Reef-Associated Habitats in St. John, U.s. Virgin Islands**

**Jennifer DOERR*[1]**, Ron HILL[1]

[1]NOAA Fisheries Service, Galveston, TX

Habitat utilization and movement patterns of queen conch, *Strombus gigas*, differ by size and maturity status, making it important to identify areas and habitat types that may influence the recovery of this species. Estimates of home range size, distribution dynamics, and movement patterns in benthic habitats associated with coral reef areas are central to developing spatial management policies for fisheries and can prove invaluable in identifying essential fish habitats. Vemco VR2 autonomous hydrophone receivers and coded acoustic tags are currently being used to track long-term movements and spatial distributions of queen conch in two bays in St. John, USVI, Fish Bay and No Name Bay. Hydrophone arrays were placed in each bay to match detection zone boundaries with changes in benthic habitat types to allow discrimination of habitat use. Receiver placements near the mouths of the bays permit detection of conch moving from shallow to deeper waters, an expected seasonal movement associated with spawning. During each of three field visits per year, uniquely coded acoustic tags are cemented onto the shells of number-tagged queen conch of varying size and maturity. To date, a total of 41 acoustic tags have been deployed in Fish Bay and 26 in No Name Bay. Preliminary analysis of acoustic telemetry data shows limited movement of small conch with little variation in habitat use. As conch increase in shell size and maturity status, movement rates intensify and utilization of habitats becomes more variable in response to seasonal shifts in water temperature and the subsequent onset of spawning activity. Continued collection of acoustic data will provide information necessary to further understand habitat utilization and movement patterns of queen conch in the U.S. Virgin Islands.

## 22.886

**Composition Of One Of The Southern Reef Fish Community in Brazilian Coast.**

**Jonas LEITE*[1]**, Mauricio HOSTIM-SILVA[2]

[1]Programa de Pós Graduação em Zoologia, Universidade Federal do Paraná - UFPR, Rio de Janeiro, Brazil, [2]Centro de Ciências Tecnológicas, da Terra e do Mar, Universidade do Vale do Itajaí - UNIVALI, Itajaí, Brazil

The tropical Atlantic reef fauna encompasses four primary provinces: Brazil, Caribbean, the Mid-Atlantic Ridge, and the Eastern Atlantic. The freshwater outflow from the Orinoco and Amazon rivers, which spans 2300 km of the NE coast of South America, separating Brazilian and Caribbean reef habitats. The Brazilian coast is separated in tree different regions: Northeastern from the mouth of the Amazon river to southern Bahia, Southeastern from Espirito Santo to Santa Catarina, and four oceanic islands, Atol das Rocas, Fernando de Noronha, St. Paul's Rocks and Trindade. Santa Catarina state is the limit of distribution for the most of the Atlantic reef fishes. This research was carried out in Campeche Island (27º41'22'' S / 48º28'18'' W), in Santa Catarina state. There was used the method of visual sub-aquatic census with belt transect (20X2 meters). This non-destructive method was used for determination of richness and relative abundance without disturb the local fauna. The study area is characterized by rocky shores since the reefs formations do not occurs in this latitude. At the study area Serranidae (6 sp.), Haemulidae (5 sp.) and Pomacentridae (4 sp.) presented the higher relative richness. Two species presented the higher abundance, *Parablennius pilicornis* and *Parablennius marmoreus* . Three species are in the IUCN Groupers & Wrasses Specialist Group List: *Epinephelus marginatus, Epinephelus niveatus* and *Mycteroperca bonaci*. This species presented a great number of young individuals (<10 cm) of the spring end up to the autumn, showing the important of the island for the recruitment of this important fishing resource.

## 22.887

**Spatial Variations in Elemental Otolith Elemental Fingerprints For Two Reef Fish Species in Nearshore Nursery Habitats in St Croix And Puerto Rico**

**Ivan MATEO*[1]**, Edward DURBIN[2], Richard APPELDOORN[3], Aaron ADAMS[4]

[1]Fisheries Animal Veterinarian Sciences, University Rhode Island, Kingston, RI, [2]Graduate School of Oceanography, University Rhode Island, Narragansett, RI, [3]Marine Sciences, University Puerto Rico, Mayaguez, Puerto Rico, [4]Mote Marine Lab, Pineland, FL

Many coastal fish species have juvenile and adult life stages that occupy spatially separated habitats. The juveniles often recruit to nearshore habitats where they reside for months to years before migrating to offshore habitats to join the adult population. In addition, juveniles of many species with this life history pattern recruit to more than one type of nearshore habitat, for example mangrove and seagrass meadows, and those different habitats are likely to vary in quality. The highest quality juvenile habitats are often referred to as 'nursery' habitats. Determining which juvenile habitats are functioning as nursery habitats is important to understanding the ecological roles of the different juvenile habitats and applying this information to management of harvested fish populations and coastal resources.

This project aims to investigate the utility of naturally occurring habitat tags to determine habitat linkages in St Croix and Puerto Rico seagrass and mangrove habitats by juvenile french grunt and schoolmaster in St Croix and Puerto Rico. This is an initial crucial step to quantify the relative contribution and connectivity of mangrove and seagrass habitats for french grunt and school master adult populations

YOY fish were collected around mangrove and seagrass habitats in St Croix and Puerto Rico during May and June 2006. Trace elements concentrations were determined at discrete regions of YOY representing the postsettlement period (30-60 days) using laser ablation inductively coupled plasma mass spectrometry.

Significant differences in the concentration of several trace metals were found between mangrove and seagrass habitats using ANOVA and MANOVA. Linear discriminant function analysis classified otolith fingerprints between mangroves and seagrass habitats with 85% to 86% of accuracy

## 23.1000

**Managing Jamaica's Coral Reefs And Coastal Developments**

**Chalene ROYE*[1]**, Chalene ROYE[1]

[1]National Environment and Planning Agency, Kingston, Jamaica

The National Environment and Planning Agency (NEPA) is an Executive Agency of the Government of Jamaica whose focus is to promote sustainable development by ensuring protection of the environment and orderly development. Working alongside stakeholders NEPA is able to make more informed decisions in conserving Jamaica's natural resources.

An integral role of NEPA is to review and issue permits and licenses associated with environmental and development projects. One of these licenses focuses on granting permission for any modification of the foreshore and floor of the sea under the Beach Control Act (1956) (BCA). Before a license is issued a meticulous review of the proposed developments and its impact on coastal ecosystems is conducted. In so doing data is collected on coral reefs.

Jamaica's reefs predominate the northern coastline of the island boasting a large expanse of fringing barrier reefs stretching with gaps 150 miles on a narrow continental shelf. The island's reefs have been substantially impacted by intensive coastal developments. A primary contributing factor to deteriorating reefs is the tourism industry, where hotels have increased their capacity from having 700 to proposing 6000 rooms. This has contributed to reefs becoming more stressed with fewer reef building corals ranging from 5-37% coverage, herbivores (*diadema sp*. die off,1983) and a dominance of fleshy algae up to 57% in some areas. This has cumulatively reduced the availability of suitable substrate for coral recruitment hence retarding reef growth and building.

Since the introduction of the BCA, developers can no longer modify the coastline at will. The licensing regime introduces mitigation measures that seek to protect reefs from land based pollutants. This lessens the stress on the islands reefs creating a more sustainable reef ecosystem.

## 23.1001

**Ten Years Monitoring Of State Of The Coral Reefs Of Akajima Island, Okinawa**

**Hiroki TANIGUCHI*[1]**

[1]Akajima Marine Science Laboratory, Okinawa, Japan

The coral reefs around the Akajima Island, Okinawa, had been acclaimed as one of the most beautiful reefs in the world, and they enchanted many leisure divers in Japan and from abroad. However, since 1998, disturbances by bleaching and predation of crown-of-thorns starfish (COTS) have significantly threatened and degraded the coral reefs. The condition of corals was monitored consecutively since the global scale bleaching in 1998 at four stations with 1.6-6.3 m depth around Akajima Island by means of $0.5 \times 30$ m belt transect survey. In September 1998, during the massive coral bleaching, coral coverage at the monitoring stations ranged 29-37%. In order to enhance recovery of corals, all islanders of Akajima Island who are engaged in the local fishery and leisure diving service stopped their activities as well as boat anchoring on their own initiative, for three years after the bleaching, in a few zones where have been used as SCUBA diving spot most frequently. One of the monitoring stations existed in the protected zone (about $2 \times 10^5 m^2$). As a result, coral coverage in the protected zone increased significantly up to 53% by 2001. However, just about same time outbreak of COTS occurred around the island. The islanders then made effort to remove COTS exclusively from the protected zone. The coral coverage was remained about 20% there, although by 2006 it was sharply decreased to less than 5% at 2 stations outside the protected zone. If coral damage by the bleaching in 1998 is compared with that by the predation of COTS from 2001 to 2006, the latter was far significant than the former around Akajima Island. The COTS are disappearing after 2006, and many juvenile corals are being found in some areas. Recovery of coral coverage is expected in the near future.

## 23.1002

**Cross-scale institutional interactions and cooperative management: Lessons from community-based marine protected areas in the Philippines**

**Miguel CASTRENCE*[1]**

[1]University of Hawai`i at Manoa, Honolulu, HI

While marine protected areas (MPAs) are the most commonly prescribed solution for coral reef conservation, their success rate is poor. Since neither local nor higher level environmental regimes are effective in isolation, there is increasing interest in creating cross-scale institutional linkages through cooperative management arrangements. However, current efforts to scale up conservation initiatives are being undertaken without a clear understanding of cross-scale interactions and their impacts on management effectiveness. The relationship between MPA performance and institutional linkages was explored in a comparative analysis using data from two research studies conducted in over 40 community-based MPAs in the central Visayas region of the Philippines in 2000 and 2002. Data were collected through snorkel surveys of the reefs, official records, and interviews with fishermen, members of the MPA management committee, and key informants. Successful MPAs had a high degree of community participation as well as support from municipal governments, which upholds the argument for cooperative management. However, the manifestations of such arrangements are variable and context dependent. Interplay among institutions can be beneficial or harmful, thus it is important to consider how cross-scale institutional linkages can be enhanced to improve management effectiveness.

## 23.1003

**Sanganeb Atoll and Dungonab Bay National Marine Park; two marine Parks in the Red Sea of Sudan managed by an African private organisation.**

**David KOOISTRA*[1]**

[1]African Parks Network, Port Sudan, Sudan

The Red Sea and Gulf of Aden contain some of the worlds most diverse and varied tropical marine habitats and communities. The combination of broad diversity, great bio-geographic complexity, and high levels of endemism make the region of global importance for marine biodiversity conservation.

Sanganeb Atoll and Dungonab Bay National Parks lie on the western shore of the north-central Red Sea. The total area these parks cover is around 3000 km2. The Parks contains an enormous diversity of habitats, many still in very good condition, and a diversity of species including populations of several globally threatened or endangered flagship species.

A number of ecological and socio-economic characteristics of the area mean that the Sanganeb and Dungonab MPAs are of national, regional and international importance for biodiversity conservation, reef resilience studies, interconnectivity, and for sustainable use of living marine resources.

Both Parks are being managed by African Parks Network in partnership with the Sudanese Wildlife Administration. The African Parks Network is an African solution to Africa's conservation challenges. African Parks Network emphasis on the stimulation of responsible tourism and associated private enterprise as a mechanism for achieving financial sustainability of the parks as well as providing a foundation for sustainable economic development and poverty reduction.

## 23.1004

**Coral Reef Conservation Campaign -Brazil**

**Ana Paula PRATES*[1]**, Paula PEREIRA[1], Angela Ester Magalhães DUARTE[1], Maria Helena REINHARDT[2], Maria Carolina HAZIN[1], Beatrice PADOVANI FERREIRA[3], João Marcello CAMARGO[4], Livia de Laia LOIOLA[5], Clovis Barreira e CASTRO[6], Debora de Oliveira PIRES[6]

[1]Biodiversity and Forest, Ministry of the Environment (MMA), Brasilia, Brazil, [2]Conservation Units, Chico Mendes Institute, Brasilia, Brazil, [3]Oceanography, Federal University of Pernambuco/ Coastal Reefs Institute, Tamandare, Brazil, [4]Coastal Reefs Institute, Tamandare, Brazil, [5]CECIERJ Foundation, Angra dos Reis, Brazil, [6]Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

The Brazilian Ministry of the Environment (MMA) launched the Coral Reef Conservation Campaign in 2001, advocating that public awareness is key towards environmental conservation. This campaign has as it´s main objective promote principles of environmental friendly behavior based on the international "Leave no Trace" Campaign. Visitation to natural areas has been considered to be a significant alternative for sustainability. If uncontrolled, however, it might result on a serious threat to conservation of biodiversity. Being this the case, public awareness which considers the roles and function of wild areas might reverse potential negative impacts. In the first phase of the Campaign, managers of nine protected areas established in coral reef sites were called to be partners.

In 2005, MMA received financial support from the National Fish and Wildlife Foundation to produce outreach material and to elaborate training courses to 178 environment, tourism and education local agents, volunteers, and scuba diving operators in the five most visited Brazilian beaches with coral reef (Maracajau, João Pessoa, Porto de Galinhas, Tamandaré and Porto Seguro). Outreach actions were developed jointly with partners, such as non-governmental organizations (Coastal Reefs Institute and Mater Natura), Coral Vivo Project, Chico Mendes Institute and Brazilian Institute for the Environment and Renewable Natural Resources.

Different outreach materials were prepared: posters, folders, textbooks, stickers, t-shirts, caps and dvd-videos. They were delivered to travel agencies, town halls, visitor centers and scuba divers. We also established partnerships with air companies and a public TV channel to broadcast the video, also supporting its use at events, such as "Clean-up Day" in three beaches Natal, Tamandaré and Maceio. This specific event counted on more than 200 volunteers. In these paper we describe the methodology, dissemination and partnership strategy, and also we discus about the results and effectiveness evaluation of Campaign.

## 23.1006

**New Initiatives In Conservation And Management Of Coral Reefs In Andaman & Nicobar Islands (India)**

**Alok SAXENA*[1]**, Sujit SHYAM CHOUDHURY[2]

[1]Department of Environment & Forests, Government of India, Port Blair, India, [2]Environment & Forests, Andaman & Nicobar Administration, Port Blair, India

Conservation and management of coral reefs in Andaman & Nicobar Islands which are located in the Bay of Bengal off the eastern coast of India is one of the major objectives of the mandate of the Department of Environment & Forests. The routine conservation measures and management practices involve enforcing various regulations in vogue, regular patrolling in the sensitive areas and regulation of activities like fishing, tourism, diving etc in the Marine Protected Areas. In recent times, the Department has initiated a number of measures for better protection and more effective management of reef areas. More emphasis is now on awareness generation programmes targeting youth and the people living around reef areas so as seek people's participation in management of reef areas. Organizing nature camps, formation of nature clubs, regular film shows, distribution of publicity materials etc are some such measures. The increasing tourism in the reef areas has opened a variety of livelihood options to local people. The Department is assisting the locals through eco-development processes. In a number of villages, people have approached the Forest Department for involving them in ecotourism. Process of formation of eco-development has started in some areas through dialogue between the Department and local people. The Department is also promoting research in coral reefs of these islands. A number of scientific Institutes, Universities and non-governmental organizations are carrying out research activities in reef areas. The Department provides them all possible assistance to them for the purpose. The present paper deals with various initiatives taken by the Department and response of people to these measures. The results show emergence of a new relationship of mutual trust between the Department and the local people.

## 23.1007

**Threats To Coral Habitat in St. Martin Island, Bangladesh.**

**Mohammad Zahirul ISLAM*[1]**, Mohammad Sazedul ISLAM[2]

[1]Marine Conservation, Marinelife Alliance, comilla, Bangladesh, [2]Marine Conservation, WCRC, comilla, Bangladesh

St. Martin Island is only coral habitat in Bangladesh. The island supports coral community associated with diverse animal/plant group providing unique marine environment. Coral colonies are not extensive and reefs are not formed. So far 66 species has been described in a short survey with 15 families of sclerectinia. Despite the exploration of diversity the island ecosystem is under severe threats due to current developmental trends for tourism. Recent development changing the Island ecosystem severely impact biodiversity. Marine life is being eroded far before diversity exploration. About 150 species marine algae and 89 coral fishes identified. Since 2 decades coral extraction increased and intensified during 1990s onward through the tourism and curio business in Cox's Bazar curio Market. Recent mass tourism initiative increased one drastic activity, small Island Cheradia visit that is rich in coral colonies. During tourist season (Oct – May) thousands of boats travel Cheradia and anchor on live coral. No mooring buoys has been installed nor any initiative taken although it is major destruction activities on coral. Tourists are unaware about marine ecosystem and major contributor of plastic garbage during the last 5 years. All existing threats are originated mainly from tourism like: Coral damage by anchoring, oil spillage from tourist & fishing boats, coral extraction for curio, Intertidal/subtidal walking over coral colonies, Plastic waste & broken fishing nets dumping over living coral colonies, indiscriminate underwater recreational activities (scuba, snorkeling), Sewage disposal from hotel/resorts to seawater. To overcome the situation and to enhance the status, installation of mooring buoys, awareness raising, reduction of oil spillage, impose code of conduct for every activity (fishing/tourism), establish coral sanctuary & MPA in some part of high biodiversity with demarcation buoys and maintain protection is very urgent. Current tourism threats retarding coral growth, resulting more impact than previous coral extraction.

## 23.1008

**Marine Debris Location, Identification, and Removal from St. Lucie Inlet Preserve State Park, Florida, U.S.A.**

**Jamie MONTY*[1]**, Laura HERREN[1], Merle STOKES[2]

[1]Southeast Florida Aquatic Preserves Field Office, Florida Department of Environmental Protection, Office Of Coastal and Aquatic Managed Areas, Ft. Pierce, FL, [2]Reef Research Dive Team, Florida Oceanographic Society, Stuart, FL

The Florida Reef Tract extends from the Dry Tortugas in the Florida Keys to St. Lucie Inlet in Martin County, the northernmost portion of which is encompassed by St. Lucie Inlet Preserve State Park (SLIPSP). The 3,900 acres of SLIPSP submerged lands includes coral and worm reefs, and are considered the northern extent of tropical coral species in Florida. SLIPSP reefs attract a wide variety of user groups, including boaters, commercial and recreational fishermen, snorkelers, and SCUBA divers. Anecdotal evidence of increased marine debris impacting SLIPSP resources was the impetus for this project. Project objectives include: 1) determine the amount of marine debris within SLIPSP; 2) identify debris "hotspots"; 3) link debris to user groups for education and outreach targets; 4) determine marine debris impact on SLIPSP resources; 5) remove marine debris; and 6) establish a hotline for anonymously reporting debris lost within SLIPSP. Eleven marine debris survey/clean-up events were conducted between April 2006 and January 2007; 344 pieces of marine debris were located within SLIPSP and 60% of debris was removed. Fifty-nine percent of debris was associated with fishing and boating activities, and twenty-nine percent of debris impacted natural resources. A SLIPSP marine debris reporting hotline and response team were formed, and educational flyers advertising the hotline were distributed to local boating, diving, and fishing entities. Prior to this project, the lack of data regarding impacts to SLIPSP natural resources limited the ability of managers to make educated decisions. The unique partnership for this project among the state government, a non-profit volunteer dive team, and a commercial fishing organization, improved the protection of natural resources within SLIPSP, and can serve as an example of community-based restoration aiding marine protected area management.

## 23.1009

Managing Coral Reef in Indonesia. Lesson Learn From Coral Reef Rehabilitation And Management Program

**suharsono SUHARSONO*[1]**

[1]Resarch Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia

The Indonesian Government has launched Coral Reef Rehabilitation and Management Program (COREMAP) since 1998. It is aimed to enhance the health of coral reef and to increase the prosperity of costal community who depends much on the coral reefs ecosystem for their existence. Evaluation activities indicated that the success of the program of saving coral reef is primarily due to the success of the program component of community awareness, community surveillance, monitoring of coral reef health and training program. The components of community awareness and surveillance have given the most significant impact in reducing the rate of coral reef degradation. The most effective method for the community awareness program is trough television media as well as through the involvement of the community chief , be it an informal leader or government official, that actively campaigning on the importance of coral reef for the community. Handing over the right to manage and control the resource to the community has shown significant effect in increasing the catch which in turn increasing community income. Scientifically monitoring the coral reefs health as well as the socio-economic condition of the coastal people have been continuously done. The role of public communication component which produce a variety of dissemination products also has a big share in spreading up research products so that they can be absorbed and applied by the community. Training program without on the job guidance for certain period of time would surely fail. The success of training program and community guidance to do monitoring coral reef condition, supervision and training on how to diversify various fishery products and marketing constitute the main factor for the continuation of this program.

Research Center for Oceanography, Indonesian Institute of Sciences

Jl. Pasir Putih I, Ancol Timur Jakarta Utara 11048, Indonesia

Email: director-rco@indo.net.id

.

## 23.1010

**An Ecological Correction to Marine Reserve Boundaries in the US Virgin Islands**

**Rafe BOULON*[1]**, Mark MONACO[2], Alan FRIEDLANDER[3], Chris CALDOW[2], John CHISTENSEN[2], Caroline ROGERS[4], James BEETS[5], William MILLER[6]

[1]Resource Management, VI National Park/Coral Reef NM, St. John, Virgin Islands (U.S.), [2]NOAA, Silver Spring, MD, [3]The Oceanic Institute, Waimanalo, HI, [4]USGS, St. John, Virgin Islands (U.S.), [5]Univ. of Hawaii, Hilo, HI, [6]National Park Service - I&M, St. John, Virgin Islands (U.S.)

Marine reserves and other marine protected areas (MPAs) are important tools for management of marine ecosystems. Ecological and biological criteria are often not feasible to consider when establishing protected areas. In 2001, the Virgin Islands Coral Reef National Monument (VICR) in St John, US Virgin Islands, was established by Executive Order. The VICR boundaries were based on administrative determination of Territorial Sea boundaries and land ownership at the time of the Territorial Submerged Lands Act of 1974. The VICR prohibits almost all fishing and other extractive uses. Surveys of habitat and fishes inside and outside of the VICR were conducted in 2002–2007. Based on surveys from 2002 to 2004, areas outside the VICR had significantly more hard corals; greater habitat complexity; and greater richness, abundance and biomass of reef fishes than areas within the VICR. The administrative (political) process used to establish the VICR did not allow a robust ecological characterization of the area to determine the boundaries of the MPA. Because of reduced habitat complexity within portions of the existing VICR, the enhancement of the marine ecosystem may not be fully realized and/or increases in economically important reef fishes may take longer to detect. Efforts are under way with the VI Delegate to Congress to increase amounts of complex reef habitat within the VICR by swapping a part of the VICR that has little hermatypic coral reef habitat for a wedge-shaped Territorially-owned area within the VICR that contains a coral reef with higher hermatypic coral cover. The simplification of the boundary will also enhance enforcement by reducing the confusion of fishermen and rangers as to where fishing is allowed.

## 23.1011

**St Croix East End Marine Park: The U.S. Virgin Islands' First Territorial Marine Park**

**Norman QUINN*[1]**, John FARCHETTE[2], Karlyn LANGJAHR[2], Paige ROTHENBERGER[2]

[1]Department of Natural Resources, St Croix East End Marine Park, Frederiksted, Virgin Islands (U.S.), [2]Department of Natural Resources, St Croix East End Marine Park, Christiansted, Virgin Islands (U.S.)

Established on January 15, 2003, the St. Croix East End Marine Park (STXEEMP) is the U.S. Virgin Islands' first marine park and represents the culmination of three years of collaboration between the federal and local government, non-governmental organizations, business representatives and other stakeholders. The park will protect the largest island barrier reef system in the Caribbean. As well as protecting significant marine resources the park is designed to promote sustainability of marine habitats, including coral reefs, sea grass beds and mangrove habitats and to preserve significant natural areas for the benefit of future generations. The STXEEMP is on the eastern end of St. Croix extending from the high tide boundary to the three nautical mile territorial waters limit and encompasses 155.4km2. The multi use design has four different managed areas: Recreation Management, Turtle Wildlife Preserve, No-Take and Open. The Recreation Management Areas (2.8%) are designated for snorkeling, diving, recreational fishing, bait fishing and boating while preserving resources. The Turtle Wildlife Preserve Area (7.0%) protects turtle nesting beaches for Green, Hawksbill and Leatherback turtles. The No Take Areas (8.6%) protect spawning, nursery, and residence habitat for various species. A monitoring program is designed to collect scientific information to assist in the wise management of these habitats and species to ensure that these marine resources are available in the future. The Open Areas comprise 81.6% of the park, encompassing all areas that are not otherwise delineated. Existing territorial restrictions govern the use of these areas; the only marine park restriction is the prohibition of the removal of coral or live rock in these areas. The park's education and outreach program's goals are to facilitate environmental awareness opportunities for the community, encourage a sense of user stewardship regarding the marine environment and promote the awareness of and support for the park.

## 23.1012

**The Use Of Simulated Visible/infrared Imager/radiometer Suite (Viirs) And Landsat Data Continuity Mission (Ldcm) Imagery For Coral Reef Monitoring**

**Leland ESTEP*[1]**, Joe SPRUCE[2], Slawomir BLONSKI[2], Roxzanna MOORE[2]

[1]SSAI, Midland, TX, [2]SSAI, Stennis Space Ctr, MS

The use of Rapid Prototyping Capability (RPC) technology resident to NASA Stennis Space Center (SSC), MS, was used to spectrally and spatially simulate NASA next-generation sensor imagery and environmental data products over two well-known coral reef areas – Looe Key, FL, and Kaneohe Bay, HI.

The study purpose was to perform a preliminary assessment on the capability of next-generation sensor systems, the Visible/Infrared Imager/Radiometer Suite (VIIRS) and the Landsat Data Continuity Mission (LDCM), to provide key data inputs to the National Oceanographic and Atmospheric Administration (NOAA) Integrated Coral Observing Network (ICON)/Coral Reef Early Warning System (CREWS) Decision Support Tool (DST). The DST data layers derived from the simulated imagery included maps depicting water quality parameters (chlorophyll (Chl) and the absorption coefficient (a)) and benthic habitat type.

The input, or parent, imagery used by the RPC for simulation of VIIRS and LDCM imagery included spaceborne (Hyperion) and airborne hyperspectral data (AVIRIS). Water quality and benthic classification reference data (e.g., from field surveys) was used to validate simulated data products. The results of this study suggests that next generation NASA sensors can provide valuable data inputs to the NOAA's ICON/CREWS DST, assuming data quality of the actual future sensors approximates original specifications.

## 23.1014

**Second And Third Order Management Issues in South Sinai Protected Reef Areas**

**Rupert ORMOND*[1]**, Wera LEUJAK[2], Mohammed SALEM[3], Ayman MABROUK[3]

[1]SaveourSeas Foundation, West Lothian, United Kingdom, [2]University Marine Biological Station Millport, University of London, Isle of Cumbrae, United Kingdom, [3]South Sinai Protectorates, Egyptian Environmental Affairs Agency, Sharm El Sheikh, Egypt

Over the last 15 years the whole of the Egyptian coast of the Gulf of Aqaba has been incorporated within a series of Marine Protected Areas. The relevant authorities (Egyptian Environmental Affairs Agency) have effectively implemented a series of first order management objectives. However the region has been promoted so successfully that some reef areas are now subject to a greater intensity of visitor use than any others worldwide.

Quantitative studies have elucidated a series of second order management issues:

i. The most popular reef sites are being so heavily used that, through incidental trampling and breakage, coral cover has declined, and at some sites the reef assemblage been changed.

ii. Largely as a consequence of this impact, and Crown-of-thorns starfish outbreaks, coral cover now appears to be in decline across the region.

iii. Public awareness initiatives have increased the care that visitors from traditional tourist source countries take to avoid coral damage, but there has been a recent large increase in the proportion of other tourists with little knowledge of or concern for marine life.

iv. With even larger numbers of developments and visitors, infringements of MPA regulations are becoming increasingly evident.

In response, the EEAA has supported research addressing a number of key third order issues:

a) What are the carrying capacities of different types of reef area? Data suggest that ecological carrying capacities may not be clearly defined, while at heavily used sites social carrying capacity may be the more important issue.

b) How can the behaviour of visitors with little concern for coral protection be more effectively controlled? Sanctions against tour operators and tour group leaders may be as important as positive publicity campaigns.

c) How effectively can the tools of integrated coastal zone management be applied to mange visitor behaviour as well as tourist development?

## 23.1015

**Community Participation in Coral Reef Management On Phuket Island, Thailand**

Pitul PANCHAIYAPHUM[1], **Hansa CHANSANG*[2]**, Krawi ONGSORANACOMKUL[3], Anuwat NATEEWATTANA[4]

[1]Department of Marine and Coastal resources, Phuket, Thailand, [2]Phuket Marine Biological Center, Phuket, Thailand, [3]Department of Fisheries, Phuket, Thailand, [4]Department of Marine and Coastal Resources, Bangkok, Thailand

In Thailand a pilot project in community participation in managing reefs of Phuket Island has been initiated since 1992. The communities along the west coast have been benefit from tourism by changing their occupation from coastal fisheries to tourism related occupation. They were encouraged in setting up associations which participated in various activities i.e., installation and maintenance of mooring buoys and assisting authorities in surveillance of illegal activities. The network of associations has been formed to exchange information and experiences among various groups. Increasingly the network began to settle the conflicting issues of reef resources among themselves. Parts of the activities were also supported by local government and private sectors. At present, the communities still depend upon supports from authorities in various ways i.e. some financial and logistic supports, and information regarding successful management elsewhere.

In conclusion it is shown that transferring management responsibility of reef resources to local communities is possible but it is a long term process. Close cooperation between government officials and communities is the key of success.

## 23.1016

**Improving Governance Of Marine Protected Areas Through Inter-Local Government Collaboration in Central Philippines**

**Rizaller AMOLO*[1]**, Rose-Liza EISMA-OSORIO[2]

[1]Local Governance for Coastal Management Project, Coastal Conservation and Education Foundation Inc., Cebu City, Philippines, [2]Coastal Conservation and Education Foundation Inc., Cebu City, Philippines

Establishment of no-take marine protected areas (MPAs) in the Philippines has become an efficient approach to address coral reef degradation and decline in reef fishery production by numerous local governments. In Central Visayas, Philippines, over 400 MPAs both declared by local ordinances and through the National Integrated Protected Areas System Act were established to improve marine habitats and increase fishery resources. However, only 20-25% has been effectively managed by local government units (LGUs) along with their constituents. Achieving its objectives, there is a need for LGUs to collaborate strategies to improve MPA management and maximize benefits. This paper examines the effect of collaboration of the LGUs in Southern Cebu and Siquijor province, in improving reef management by looking into various outcomes of effective governance. A 3-year biophysical monitoring of MPAs showed significant changes in benthic community and reef fish population. MPA governance rating has improved overtime. Effective coastal law enforcement within and outside MPAs has increased. Various strategies such as collecting user fee, joint enforcement effort, and effective community education and information dissemination were found to also be an emerging approach to increase support in management. Lesson learned in inter-local government collaboration includes: clarify organizational requirement prior to effective program implementation and effective joint law enforcement plays a crucial role to sustain collaborative support.

## 23.1017

**Recreational Diving Management in the Coral Reefs of Cozumel, Mexico**

**Luis SANTANDER*[1]**

[1]Division de Desarrollo Sustentable, Universidad de Quintana Roo, Cozumel, Mexico

The general objective is twofold: i) a review of the management principles and actions aimed to reduce the negative impacts of recreational diving in coral reefs; and, ii) point out the shortcomings of such principles and actions in Cozumel's MPA (Marine Protected Area).

The paper has a presentation and discussion of two principles and strategies for MPA: zoning and carrying capacity. The study includes a selection of other specific measures and actions designed to reduce the environmental impacts of recreational diving and it also deals with the characteristics and tendencies of the industry of recreational diving.

After the analysis of the international experiences in the management of recreational diving in coral reefs in MPA, the analysis is centered in Cozumel's MPA, mainly with data obtained from monitoring over 350 divers and 82 diving groups.

The quantitative results of physical contacts and sediment removals due to divers is explained in relation to behaviours and omissions of instructors and diving guides that fall beyond the scope of principles, policies and actions contained by management plans for recreational diving.

The main conclusion is that general management principles of MPA are usefull and important but have shortcomings. For example, i) carrying capacity (number of divers) can change drastically with different divers' profile and diving practices, or ii) restrictions in a zone not necessarily mean that the consequences of negative impacts in a nearby area of intensive use, are absent on the former. When it comes to standard actions to protect reefs from divers the main limitations come from the great diversity of physical and biological features of sites and from the different behaviours of divers.

## 23.1018

**Pre-Closure Evaluation Of Habitats And Fish Assemblages in Five Proposed Mpas Off The Us Southeastern Coast**

**Stacey HARTER*[1]**, Andrew DAVID[2], Marta RIBERA[1]

[1]NOAA Fisheries, Panama City, FL, [2]NOAA Fisheries, Panama CIty, FL

In 2002, the U.S. South Atlantic Fishery Management Council (SAFMC) proposed a network of marine protected areas (MPAs) along the outer continental shelf from Cape Hatteras, NC to the Florida Keys to protect seven reef fish species in the snapper-grouper complex. Thus far, three years of pre-closure data have been collected on habitat and fish assemblages at five proposed MPA sites. Data were collected in 2004, 2006, and 2007 both inside and outside the proposed MPAs using a remotely operated vehicle (ROV), stationary camera array, and fish traps. Five habitat types were delineated from ROV dives: sand, pavement, low relief rocky outcrops, moderate relief outcrops, and high relief ledge. All areas examined contained deep reef formations as well as several of the reef fish species targeted for protection including snowy grouper (*Epinephelus niveatus*), speckled hind (*Epinephelus drummundhayi*), warsaw grouper (*Epinephelus nigritus*), and blueline tilefish (*Caulolatilus microps*). Lionfish were also abundant in all areas investigated and their densities increased each year. This study presented a unique opportunity to establish baseline values for reef fish abundance and distribution prior to the projected 2008 closures to bottom fishing. This will obviate criticisms of many MPA studies comparing populations inside and outside closed areas, rather than single locations, pre- and post-closure. Monitoring should continue once the MPAs have been implemented to investigate deviations from pre-closure estimates of fish densities. It is likely that changes will take years to manifest themselves based upon the life history characteristics of the fish species targeted for protection.

## 23.1019

**Noaa Coral Reef Watch: Satellite Data Products For Coral Reef Managers, Through The World Bank/gef Coral Reef Targeted Research Program**

**Tyler R. L. CHRISTENSEN*[1]**, Alan E. STRONG[2], William J. SKIRVING[2], C. Mark EAKIN[2], Jessica A. MORGAN[1], Gang LIU[1], Scott F. HERON[2], Dwight K. GLEDHILL[1]

[1]IMSG at NOAA Coral Reef Watch, Silver Spring, MD, [2]NOAA Coral Reef Watch, Silver Spring, MD

The Coral Reef Watch (CRW) program monitors global sea surface temperature from NOAA's polar-orbiting satellites. We process these data into information tailored to coral reef applications, to pinpoint areas where thermal stress is putting the corals at risk for bleaching. Because our data products are generated twice a week, we can provide near-real-time global information. CRW is involved in a new global project: Coral Reef Targeted Research and Capacity Building, sponsored by the World Bank and the Global Environment Facility. Our major role in this project is to customize our data products for reef managers in the project's Centres of Excellence in Tanzania, the Philippines, Mexico, and Australia. We are also training local researchers on how to access our information, developing new data products for reef management, and researching innovative data delivery tools. In return, we are gaining crucial information about how to make our remote sensing data more accessible and more useful for on-the-ground coral reef management.

## 23.1020

**Status Of Coral Reefs Of India – A Revelation**

**Rama KRISHNA*[1]**, Rama KRISHNA[1]

[1]Environment, Zoological Survey of India, Kolkata, India

India is bestowed with a variety of reef regions on all its coastal sides and stands 10th in the listing of world reef area. The host of first International Coral Reef Symposium is far away from the first place in exposing the factual status of its reefs due to lack of proper monitoring mechanism, capacity and guide map for many decades. With the advent of the reef activity around the world due to the propulsion of a need to protect the reefs, Zoological Survey of India a wing of Ministry of Environment Forests has taken up the task of pacing forward in reef research. The result is a revelation. The diversity of the principal builders of the reefs (scleractinians) bulged beyond imagination and expected to increase further; Reefs of Gulf of Kutch, the northern most in India are not as less diverse as appeared; Status of Andaman reefs is not pale as exposed, study gained them the status of the best reefs in the Indian Ocean and as seeding grounds for affected reefs; Lakshadweep reefs, victims of global warming never lost their diversity as expected and fighting back to normalcy; Gulf of Mannar reefs are much diverse than exposed. The present paper discusses the reasons for the down play of the status of reefs and updates the present status of the reefs of India with the wealth of information collected by ZSI from its National and International surveys conducted for the past two decades. A guideline for better reckoning and creation of the health status of Indian reefs is also included for effective standardisation and consolidation.

## 23.1021

**Significance of Reading of a Spatial Structure of $10^1$ - $10^3$m Scale for the Conservation of Coral Reef Ecosystem**

**Tatsuo NAKAI*[1]**, Tsuyoshi SHIBATA[2], Hiroya YAMANO[3], Shigeki YASUMURA[4]

[1]Kokushikan University, Tokyo, Japan, [2]Naigai Map Corp., Tokyo, Japan, [3]National Institute for Environmental Studies, Ibaraki, Japan, [4]WWF Japan, Tokyo, Japan

Nansei Shoto (Ryukyu Islands), a chain of sub-tropical islands located in the Southern end of Japan and a northern margin of the 'Coral triangle', is rich in endemic and sub-endemic fauna and flora. Nansei Shoto is recognized as one of WWF global 200 ecoregions, which is a science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats. WWF Japan initiated the project to illustrate and evaluate the biodiversity priority areas (BPAs) of the Nansei Shoto Ecoregion.

We applied a spatial structure reading of physiographic unit (PGU) for selecting BPAs in Nansei Shoto. Physiographic and landscape ecological studies made it possible to set a PGU for a fringing reef. It is a special structure of $10^1$ - $10^3$m scale determined by a local topography such as reef, water channel, land mass to control seawater flowing. It is indispensable to analyze a spatial structure on this scale for the evaluation of the habitat diversity for reef corals and other living organisms. This approach has shown effectiveness for the conservation of coral reef ecosystem.

## 23.1023

**Why do Divers Dive Where They Dive? Understanding the Distribution of Divers across the Reefs for Ensuring their Sustainable Management**

Maria C. UYARRA[1], **Isabelle M. CÔTÉ*[2]**, Andrew R. WATKINSON[3,4]

[1]School Biological Sciences, University of East Anglia, Norwich, United Kingdom, [2]School Biological Sciences, Simon Fraser University, Vancouver, BC, Canada, [3]Tyndall Centre, University of East Anglia, Norwich, United Kingdom, [4]School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom

The popularity of coral reefs is continuously increasing within the diving industry. Due to the vulnerability of coral reefs to natural and human disturbances, a fundamental goal of coral reef managers is to regulate the distribution of divers across the reefs, which would allow the sustainable human use as well as their effective protection. Therefore, there is considerable interest in understanding the general rules that can explain the distribution of divers across reefs. We used hierarchical partitioning regressions to examine site attributes that influenced the popularity of dive sites within divers in the Caribbean island of Bonaire. We analysed information from dive guides, created indices for access and carried out ecological surveys at 76 of the 81 existing dive sites in Bonaire to assess the actual conditions of different attributes that characterise each dive site. Additionally, we asked 400 divers to indicate where they dived and how they accessed sites (by boat or from shore) during their holidays, and 8 of the 12 dive shops provided information on the dive sites used during 14,057 boat dive trips. This information helped us to develop two indices of dive site use (popularity), one for boat dive sites and another for shore dives. Coral reef related attributes, accessibility and the likelihood of sighting charismatic species contributed positively to where people went on boats, whereas the popularity of shore dives was mainly related to the difficulty of the dive. Identifying those attributes that affect dive site popularity will help to focus future management strategies.

## 23.1024

**Influence of Management on Resilience of Hard-coral Assemblages on Belize Reefs**

**Nadia BOOD*[1]**, Melanie MCFIELD[2], Richard ARONSON[3]

[1]Mesoamerican Reef, World Wildlife Fund, Belize, Belize, [2]Mesoamerican Reef, Smithsonian, Belize, Belize, [3]Dauphin Island Sea Lab, Dauphin Island, AL

Given the global deterioration of coral reefs, marine 'no-take' areas (NTAs) are seen as an important tool to foster their sustainable management and conservation. NTAs have been proven to effectively increase stocks of commercially exploited reef species. Less well-documented is their impact on hard-corals' health and reef resilience. We tested the hypothesis that NTAs would increase the resilience of reef ecosystems to large-scale disturbances and specifically whether hard-coral assemblages on managed reefs are better able to absorb impacts, resist macroalgal overgrowth and/or regenerate after disturbances. Belize's reefs experienced a punctuated reef decline in 1998, due to bleaching and hurricane damage. Our hypothesis was that reefs inside managed NTAs would be more resilient and exhibit a faster recovery to this disturbance, due to higher populations of herbivorous fish and higher herbivory rates. We tested the role of critical functional groups (i.e. reef framework builders and grazers) and protection status in relation to hard-coral recovery from two intensely damaging perturbations on Belize's reefs in 1998 (mass coral bleaching and Hurricane Mitch) on six paired reefs. Contrary to expectation, no significant difference in mean hard-coral cover was detected between non-NTA and NTA reefs. Furthermore, the density of juvenile corals was significantly greater on non-NTA reefs. NTA reefs exhibited a significantly higher macroalgal cover than non-NTA reefs. Based on a one-time sample of herbivore density, a significant difference between NTA and non-NTA reefs was not detected. This study demonstrates that hard-coral assemblages within the managed reefs were no more resilient than those of the unmanaged reefs, and that there are likely factors hampering coral resilience within and outside of the targeted NTAs with greater hindrance inside the NTAs. These results require more targeted investigations to ascertain the cause(s) of the lack of any measurable recovery six years after the punctuated reef disturbance.

## 23.1025

**Comparative Study Of Coral Cover, Fish Density And Fish Biomass in Biga Marine Reserve From 2003 To 2005**

**Daisy Desiree FLORES-SALGADO*[1,2]**

[1]Philippine LMMA Network, Quezon City, Philippines, [2]Earth Restoration Trust, Quezon City, Philippines

There are an increasing number of marine reserves in the Philippines, yet conducting adaptive management for these areas poses a challenge to local resource managers. The research used the Before and After, Control and Intervention (BACI) Analysis to compare these parameters. Fish visual census (FVC) was used to determine fish abundance, while Life form Intercept Transect (LIT) or Point Intercept Transect (PIT) were used to monitor coral cover. To determine if significant difference exists between the parameters being compared, t-test and/or Standardized Mean Difference (SMD) were used. The study aimed to provide information that may help local decision makers develop an adaptive management plan and to provide policy recommendation to the Local Government. Results show significant mortality in live coral cover both in the open (Control) and reserve (Intervention) areas from 2003 (Before) to 2005 (After) of 17% and 6%, respectively. The significant difference between the decrease in live coral cover outside the reserve compared to inside reveals the importance of management of marine reserves in preserving live corals.

Increased algal growth was also observed in both areas. There was a significant increase in fish density inside the marine reserve, including an abundance of damselfish, herbivores that feed on algae. No significant increase in fish density or biomass was observed outside the reserve in 2005, but there are evident signs of an increasing number of smaller fish in the open harvest. Simple economic valuation indicated the positive implications of having a marine reserve on food and livelihood. The study provided adaptive management strategies and policy recommendations to the stakeholders of Biga Marine reserve.

## 23.1026

**Private Management Of Coral Reefs: An Example From The Sugud Islands Marine Conservation Area, Sabah, Malaysia**

**Lydia TEH*[1]**, Louise TEH[1], Fung Chen CHUNG[2]

[1]Fisheries Centre, University of British Columbia, Vancouver, BC, Canada, [2]Reef Guardian Sdn. Bhd., Sandakan, Malaysia

Many marine protected areas (MPAs), particularly in developing countries, have been ineffective in achieving their conservation objectives due to a lack of financial resources to support enforcement and monitoring. Private investment and management in MPAs is a potential approach to address the pervasiveness of 'paper parks'. We evaluate the effectiveness of private management in conserving coral reefs, using a case study of the Sugud Islands Marine Conservation Area (SIMCA) in Sabah, Malaysia. SIMCA is managed by a private management company called Reef Guardian. The majority of management costs for the conservation area are met from conservation fees. With adequate funds and a sustainable source of financing, Reef Guardian has been able to invest in the personnel and surveillance technology necessary to enforce the rules and regulations of the 467 km2 conservation area. Enforcement capacity has also been strengthened through collaboration with local enforcement agencies. This has reduced anthropogenic threats to marine biodiversity, such as illegal fishing and turtle egg poaching. Underwater visual census shows that there is a comparatively high abundance of commercially important fish such as groupers within SIMCA. The mean number of annual turtle nestings increased from 101±13 (SD) to 205±82 after Reef Guardian

assumed management of SIMCA in 2003. Our results suggest that private management can be effective in conserving biodiversity in MPAs, and may well succeed regionally in suitable locations.

## 23.1027

**Florida Keys Coral Ecosystem Management: Can The Past Influence The Future?**

**Steven ROHMANN*[1]**, Catherine MARZIN[1], Loren MCCLENACHAN[2]

[1]NOAA, Silver Spring, MD, [2]Scripps Institute of Oceanography, La Jolla, CA

The Florida Keys coral ecosystem has changed significantly as a result of human visitation and settlement over hundreds of years. Historical data, including ships logs, fisheries reports, settlers' journals and diaries, maps and charts, and colonial and state records can be used to document the extent of cultural, social, economic, and ecological change over time in the Florida Keys. Education and outreach media products that connect humans with past and present coral ecosystems have the potential to stimulate public interest in coral ecosystem conservation, management, and restoration. These media products also may alter perceptions about the cultural, social, economic, and ecological value of coral reefs and may empower residents, visitors, and politicians to become more involved in the current and future conservation and management decision-making process. The effectiveness of the media products on public interest and perceptions can be deduced by tracking media product downloads from web sites, tracking the number of people viewing media products at venues and web sites, and estimating numbers of viewers of product-based Public Service Announcements. Effectiveness may be measured by conducting surveys of the knowledge, attitudes, and perceptions of Florida Keys visitors.

## 23.1028

**Analysing Factors That Contribute To The Success Of Locally-Managed Marine Areas: Preliminary Results And Lessons Learned**

**Toni PARRAS*[1]**

[1]The Locally-Managed Marine Area (LMMA) Network, Fort Lauderdale, FL

Officially launched in 2000, the Locally-Managed Marine Area (LMMA) Network is interested in learning how to improve marine management activities and increase conservation impact. Armed with the Network's Learning Framework, a guide that outlines specific factors and methods to measure biological and socioeconomic conditions at project sites, members set out to collect data to help determine the conditions under which locally-managed marine areas (LMMAs) work, do not work, and why.

Starting out with a handful of sites in 2000, the Network currently has more than 300 sites in different stages of implementation and monitoring, covering over 10,000 square kilometers. Of these, the Network has analysed data from 40 sites to assess the effectiveness of management efforts. A meta-analysis approach was used to compare datasets from various sites collected using different monitoring methods and indicator species. Comparisons were made by correlating select socioeconomic factors against overall LMMA Success. "LMMA Success" was determined by a change in live hard coral cover or abundance of specific indicator species.

While anecdotal evidence from various sites points to "LMMA success," data results show both positive and negative correlations between certain factors and LMMA success. For example, increased environmental knowledge among community members correlates to increased LMMA success, however an increased level of formal education negatively affects LMMA success (this may be attributable to fishers learning more effective and/or destructive ways of fishing rather than the importance of conserving and managing marine resources). One of the biggest lessons learned is the need to collect more data on common indicators from all sites in order to make useful comparisons. Other major outcomes of these efforts include increased community cohesion and empowerment, revival of traditional practices, and increased income in some cases. The Network hopes to draw more formal conclusions as more data become available.

## 23.1029

**Management Strategies And Intensity Of Use Of The Cozumel Reefs National Park, Mexico**

Rodolfo RIOJA-NIETO[1], **Charles SHEPPARD*[1]**

[1]Biological Sciences, University of Warwick, Coventry, United Kingdom

The Cozumel Reefs National Park is a heavily utilized Marine Protected Area (MPA) which provides around 30% of the revenue for Mexico's entire National Parks System. We utilized a Geographic Information System (GIS) and Local Ecological Knowledge from diving operators to evaluate effectiveness of park management strategies by comparing conditions in the MPA with an adjacent, unmanaged area. Aerial photography, a Landsat 7 TM image and hierarchical analysis of the benthic coverage of 318 ground truthed sites were used to produce a thematic map of the whole Island with 15 habitat classes. Using a GIS, habitat β-diversity, total area and fragmentation and size distributions of the patches of each of the habitat classes were compared. Coral reef diving sites, their ecological attributes (live coral cover, coral and fish species richness, reef fish abundance, presence of algae and presence of coral bleaching) and their intensity of use were characterized through the use of questionnaires given to 49 dive masters and diving instructors from the Island. Answers were assigned a score and ranked for analysis. The area and fragmentation of several habitat classes differed between managed and unmanaged areas, and a significantly higher β-diversity ($p<0.01$) was seen in the managed area. Habitat fragmentation distribution was similar between regions. All coral reef sites were shown to be heavily utilized and most of them are considered to be in good condition. No relationship was found between habitat perceived condition and intensity of use. Therefore some management strategies have a positive effect on the integrity of several important habitats, and this method was shown to be valuable in determining management effectiveness. As further use is forecast and additional management is needed, three sites located on the southwest of the MPA are proposed to be designated as strict no-access areas.

## 23.1030

**From Barrels To Augers: Managing A Transition in The Mooring Buoy Systems Of Bonaire National Marine Park.**

**Ania BUDZIAK*[1,2]**, Charles BEEKER[1], Ramon DE LEON[3], Claudia JOHNSON[1], Erle KAUFFMAN[1]

[1]Indiana University, Bloomington, IN, [2]Project AWARE Foundation, Rancho Santa Margarita, [3]Bonaire National Marine Park, Bonaire, Netherlands Antilles

Mooring buoy systems are effective at reducing anchor damage to the reef ecosystem. Implemented in the Bonaire National Marine Park (BNMP) in the 1970's, mooring anchors changed from their original form of cement filled 50-gallon metal barrels to one-ton cement blocks to auger pins. At present, the 5+-foot auger pins screwed into the substrate provide the most effective anchorage for boats. Management decisions in the BNMP center on retention or disposal of the barrels and blocks as new technologies replace old. However, the old anchors are substrate for coral growth. Data collected in November 2007 reveal the composition and status of anchors at 27/60 sites on the western coast of Bonaire. GPS location and depth of anchor barrels, blocks, and pins, and site-specific coral growth were documented. Preliminary analyses indicate that some first-generation barrels still provide effective anchorage, a few are far from their original positions, others are remnant and occur in association with cement blocks, some are damaged, partially buried or are inclined 45 or 90 degrees to the substrate. Barrels submerged for only 13 years have the original iron surfaces modified to calcium carbonate by natural marine processes and now serve as substrates for coral growth. Site-by-site documentation of the effectiveness of older generations of anchors for purposes of either boat mooring or preservation of incipient reefs will provide park officials with data useful in developing cost-effective management plans for the future longevity of the reef ecosystem.

## 23.1031

**The Colonial Tunicate *tridídemnum Solidum* in The Bonaire National Marine Park: Colony Removal As A Potential Management Strategy**

**Emily MCGRATH*[1]**, Rita PEACHEY[1]

[1]CIEE Research Station Bonaire, Kralendijk, Netherlands Antilles

Ecological work on coral reef habitats showcases the complexity and ferocity of spacial competition of invertebrates in the benthos. An organism's ability to dominate the substrate spatially plays an important role in benthic ecology. Sedentary marine invertebrates often rely on methods of overgrowth to dominate the slower growing scleractinian neighbors. The abundance and distribution of an important benthic competitor, *Tridídemnum solidum*, was examined in the Bonaire National Marine Park, Netherland Antilles. Found in many sites in the Caribbean, *T. solidum* is a formidable competitor on the reef. The colonial tunicates grow as mat-like sheets and are commonly seen growing over a variety of corals, macroalgae, and sponges. The growth rate of *T. solidum* is much higher than schleractinian corals, and so overgrowth of live tissue is common and typically results in bleaching.

To establish a baseline of *T. solidum* abundance and distribution on the reefs of Bonaire, replicate video transects were recorded in 1m wide belts running from 29 to 4 m depth perpendicular to shore. Videos were analyzed by selecting frames and recording colony size, depth, and substrate being overgrown. *T. solidum* colonies were restricted to the northeastern region of the island, possibly due to local current patterns and reproductive strategy.

Colony removal as a possible management measure was also examined; colonies growing over various substrata were removed at two sites at depths of 25 to 4 m. Six weeks later the sites were revisited and photographed. In 20% of previous colony sites small *T. solidum* recruits were present with a mean diameter of 2.5 cm. The transects are being monitored to determine the effectiveness of colony removal over time.

## 23.1032

**Twenty Years Of Reef Monitoring in Barbados: Benefits To Government And Lessons Learned**

**Renata GOODRIDGE*[1]**, Leo BREWSTER[2], Wayne HUNTE[3], Angelique BRATHWAITE[2], Leonard NURSE[1], Hazel A. OXENFORD[1]

[1]Centre for Resource Management and Environmental Studies, University of the West Indies, Bridgetown, Barbados, [2]Coastal Zone Management Unit, Bridgetown, Barbados, [3]Office of Research, University of the West Indies, Bridgetown, Barbados

Since 1987 the Government of Barbados (GOB) has monitored the health of the islandï¿½s coral reef communities in recognition of the key roles they play in coastal protection and the tourism industry of this small island developing state. In a unique unbroken collaboration with marine scientists from the University of the West Indies, this government-funded long-term coral reef monitoring programme is tracking key environmental health indicators (coral, sponge, fish and urchin species density and diversity, percent benthic cover by live coral, sponges, macro, turf and coralline algae) on 21 fringing reefs, 16 patch reefs and six bank reefs off the south and west coasts.ï¿½Standardised quantitative benthic surveys along ten 10 m line transects and ten 1x10 m band transects atï¿½permanently markedï¿½sites on these reefs are completed every five years, amassing a robust data set of trends in coral community health. The programme has required a high level of commitment from both institutions, to ensure continuity of trained personnel and financial resources. A five year resurvey schedule represents the best compromise between limited resources and adequate data to guide policy. Maintenance of marked sites and standardised survey methods have been challenging over the 20 year time span. However, the data set has allowed the GOB to follow how the islandï¿½s reefs are changing over time and identify the key causative factors. This information has been critical in informing Government policy and in developing an integrated coastal zone management plan. This is exemplified in the development and ongoing implementation of the multi-million dollar South and West Coast Sewerage Projects, commissioned as a result of early findings from the monitoring programme. The data set continues to inform the coastal planning process and forms the backbone of the Coastal Zone Management Unit's research programme.

## 23.1033

**Application Of Socio-Economic Research For Management Of The St. Croix East End Marine Park As A Pilot Mpa For The U.s. Virgin Islands' Territorial System Of Marine Parks**

**Karlyn LANGJAHR*[1]**, Nicholas DRAYTON[2]

[1]St. Croix East End Marine Park, Virgin Islands Coastal Zone Management Program, Frederiksted, Virgin Islands (U.S.), [2]Ocean Conservancy, Christiansted, Virgin Islands (U.S.)

The St. Croix East End Marine Park (EEMP) was established in 2003 to protect the coral reefs of St. Croix as part of the U.S. Virgin Islands Government's initiative to implement a territorial system of marine parks. Until 2007-2008, research conducted within the EEMP has focused primarily on the ecological and biophysical aspects. The purpose of this study is to address the gaps in socio-economic data pertaining to the EEMP. Understanding the human uses, impacts, benefits, and perceptions of the EEMP is critical for the marine park's successfully management, including the development of education and outreach programs. The qualitative and quantitative results from surveys, semi-structured interviews, and focus groups with primary stakeholders, community members, and visitors helped to identify EEMP management strengths and weaknesses. This study also recognizes the cross-links between socio-economic and ecological factors of the EEMP. Because the EEMP is a pilot MPA in the territory, the results of this study will help in the establishment of future territorial marine parks in the USVI.

## 23.1034

**Sensitivity of Corals to Turbidity and Sedimentation from Dredging: A Review**

**Paul ERFTEMEIJER*[1]**, Bernard RIEGL[2]

[1]WL / Delft Hydraulics, Delft, Netherlands, [2]Oceanographic Center, National Coral Reef Institute, Nova Southeastern University, Dania, FL

A review of published literature on sensitivity of corals to turbidity and sedimentation is presented with an emphasis on effects of dredging. Risks and severity of impact from dredging on corals are related to both intensity and duration of exposure to increased turbidity and sedimentation. Sensitivity of a coral reef from dredging impacts and its ability to recover depends on the ecological condition of the reef, its resilience and typical ambient conditions normally experienced. Corals experience stress from high suspended sediment concentrations (polyp) and their effects on light attenuation (algal symbiont). Minimum light requirements of corals range from <1% to as much as 60% of surface irradiance. Tolerance limits of corals for suspended sediment concentrations range from <10 mg $l^{-1}$ in pristine reef areas to 40 or even 165 mg $l^{-1}$ in marginal nearshore reefs. Enhanced sedimentation causes smothering and burial of coral polyps, shading, tissue necrosis and population explosions of bacteria in coral mucus. Fine sediments have greater effects on corals than coarse sediments. Sedimentation also reduces the recruitment, survival and settlement of coral larvae. Maximum allowable sedimentation rates for corals range from <10 mg $cm^{-2}$ $day^{-1}$ to >300 mg $cm^{-2}$ $day^{-1}$. The duration that corals can survive high sedimentation rates range from <24 hours for sensitive species to >14 days (complete burial) for very tolerant species. Hypotheses to explain substantial differences in sensitivity between different coral species include the growth form and orientation of coral colonies, the ability to actively reject sediment (polyp inflation, mucus production, ciliary and tentacular action), and the size of the coral polyp/calice. Validity of these hypotheses was tested on the basis of 53 published studies on effects of turbidity and sedimentation on 85 coral species, the results of which will be presented.

## 23.1035

**Post-Hugo Recovery Of A Protected And Unprotected Reef: St. Croix, Us Virgin Islands**

**Dana FISCO*[1]**, Monica ARIENZO[2], Connie SOJA[3], Dennis HUBBARD[4]

[1]Marine and Freshwater Sciences, Colgate University-KECK Consortium, Hamilton, NY, [2]Franklin and Marshall College, Lancaster, PA, [3]Colgate University, Hamilton, NY, [4]Oberlin College, Oberlin, OH

Over the past three decades Caribbean reefs have experienced a shift from coral to algal dominance. Reefs on St. Croix, US Virgin Islands, have experienced the full range of stresses credited with decline. In 1989, Hurricane Hugo caused extensive damage to reefs already impacted by White Band Disease. The proximity of reefs within Buck Island National Monument and unmanaged areas only 5 km away on St. Croix (Tague Reef) provides a unique opportunity to examine reef recovery under similar oceanographic conditions but different degrees of protection. Twenty-meter chain transects were surveyed at 3, 6 and 9 m depths at three sites on the two reefs. Equal areas were surveyed on each reef, spread over distances of 1-2 km. Data were compared to post-Hugo surveys at the three Tague Reef sites and the center site on Buck Island.

Present-day coral cover was identical on the two reefs when averaged for all sites and all depths (12%). On Tague Reef, coral diversity increased drastically at the 6 and 9 m depths in all locations but only slightly at the 3 m depth locations—solar panel 3 m transect showed a loss in diversity. Porites asteroides, increased in shallow water. Coral cover at the southern Buck Island monitoring site remained constant (12%) 18 years after Hurricane Hugo. A companion study revealed significant differences in the grazer populations at the two sites (parrotfish at Buck Island; Diadema on Tague Reef), but the general condition of the benthos appears to be similar. These data appear to indicate that either the higher abundance of grazing scarids at Buck Island is not sufficient to reverse effects of local nutrient increases and fishing outside the park, or that larger factors (e.g., bleaching and disease) are exerting the dominant control on reef decline and recovery.

## 23.1036

**Biodiversity Of Coral Reef in Sumbawa Sea, Indonesia:comparison Between Underwater Observation And Satellite Imagery**

**Susumu KANNO*[1]**, Masahiko YANAGAWA[1], Akihiko OHGANE[2], Kimiya HOMMA[1]

[1]Ocean Industry, Kyowa Concrete Industry Co., Ltd., Sapporo, Japan, [2]Zeal Oceanic Office, Sapporo, Japan

Biodiversity in coral reef is discussed with both in-situ observation using underwater trans-section method and satellite imagery in coastal area of Sumbawa Sea, Indonesia. Line trans-section was carried out over two thousands meter along the coast and the result showed that there is a lot of species of reef coral and their biodiversity is higher than another habitat area in Indonesia. Principal component analysis was carried out for coverage of each species, water quality, and topographic factors by using these results of identification about coral species. Coverage of Acropora, Porites, Favia species, and transparency at out side of reef have positive contribution. These items appeared in first component in the analysis too. On the other hand, chlorophyll, turbidity, and fetch have a negative contribution to the total environment in this coral reef. These mean that the environmental condition in this coral reef depends on purity and optical properties of ocean water. Usually hermatypic coral reef-building coral makes habitat in inside of clean and shallow coastal reef area. Then, the indicators of water quality appeared as high contribution as both positive and negative contribution; (1)coral species living in clear seawater, (2)quantity increasing with cleanliness of seawater as transparency, (3)one decreasing with the cleanliness as chlorophyll, turbidity, and fetch leading to spinning up of bottom quality. Finally, classification of bottom attribute and coral species has been made a trial by ALOS/AVNIR-2 satellite imagery with training data obtained by the underwater trans-section of bottom quality on the reef area. The bottom attribute in the reef was classified with coral coverage in the habitat, species of the coral, rock reef, dead coral, and coral sand relatively clearly. This method can be utilized for environmental management in coastal region based on not only qualitative analysis but also quantitative analysis.

## 23.1037

**Effectiveness Of A Marine Protected Area On The East End Of St Croix, U.s. Virgin Islands Using The Queen Conch Strobus Gigas, As A Sentential Species**

**Barbara KOJIS*[1]**, Norman QUINN[2]

[1]Department of Science and Math, University of the Virgin Islands, St Thomas, Virgin Islands (U.S.), [2]Coastal Zone Management, St Croix East End Marine Park, St. Croix, Virgin Islands (U.S.)

From October 1998 to September 2001, a previous study conducted surveys of the queen conch populations at six back reef embayments at the east end of St Croix. Population densities were higher in the northeast embayments (52.6 conch / ha) compared to the southeast embayments (33.6 conch / ha). About 87% of the conch measured were juveniles. Subsequent to that study, the 155 km2 territorial St Croix East End Marine Park was established in January 2003 and rules and regulations governing activities in the park were enacted in late 2007. Several back reef embayments were designated “No Take Areas” where the collection of all marine animals was prohibited. At around the same time, the seasonal closure for queen conch from July 1 – September 30 of each year was extended to December 31, 2007 by the Virgin Islands’ Department of Planning and Natural Resources because of the recent dramatic increase in the harvest of queen conch by commercial fishers on St. Croix and the determination that queen conch was being severely overfished on St. Croix. This study will: 1) compare the current population structure of queen conch in the back reef embayments with the previous study, 2) review compliance with the rules and regulations, and 3) discuss adaptive management strategies.

## 23.1038

**Gaining Ground in Improving Marine Protected Areas (Mpas): The Philippine Experience**

**Hazel ARCEO*[1]**, Porfirio ALINO[2,3], Vincent LUMBAB[1], Cleto NANOLA[4,5], Ma. Fe PORTIGO[6]

[1]DAI/USAID Philippine Environmental Governance 2 Project, Cebu City, Philippines, [2]DAI/USAID Philippine Environmental Governance 2 Project, Ortigas, Metro Manila, Philippines, [3]University of the Philippines - The Marine Science Institute, Quezon City, Philippines, [4]DAI/USAID Philippine Environmental Governance 2 Project, Davao City, Philippines, [5]University of the Philippines - Mindanao, Davao City, Philippines, [6]DAI/USAID Philippine Environmental Governance 2 Project, Pagadian City, Philippines

Several reviews about the status of MPAs in the Philippines have been conducted (e.g. Baling 1995, Haribon 1997, Alcala and colleagues) with insights on MPA sizes, management, gaps and challenges. This paper aims (1) to re-examine the evaluation by Aliño et al. (2001) and determine any improvements that may have resulted from the adoption of recommendations and good practices highlighted during this last review; and, (2) to evaluate the management effectiveness of at least ten MPAs by looking at ecological trends and the performance of the MPA managers. Biophysical information obtained using standard reef survey methods was used to determine ecological patterns while the MPA Rating System, developed by Coastal Conservation and Education Foundation (2005) and modified to include governance indicators, and community perception surveys were employed to assess performance. Results show an increase in the number of MPAs, now with over 1,100 existing MPAs, and an observed shift in the modal range of MPA sizes, with larger areas being placed under protection. Analysis from the sample MPAs shows that ecological trends are not always consistent with the performance evaluation results, and that biophysical and performance indicators can collectively present a more accurate description of the MPA management levels rather than each one alone. The rates of improvement among the MPAs also vary. Factors that may have influenced the differential rates include baseline ecological conditions, functionality of management groups including information, education and communication, compliance and enforcement strategies, implementation of other fisheries management interventions outside the no-take areas, and alliances with other managers. Insights from this study will be useful in setting the directions towards attaining more improved and well-managed MPAs. This requires the identification of priorities on how MPAs and MPA network interactions/synergies can be put in place.

## 23.1039

**Effectiveness Of A Small Mpa in Conserving Fish Resources**

**Victor NESTOR*[1]**, Charlene MERSAI[1], Geory MEREB[1], Yimnang GOLBUU[1]

[1]Research, Palau International Coral Reef Center, Koror, Palau

While there has been a proliferation of MPA establishment in Palau, little effort has been directed at evaluation of these MPAs' management and impacts. We evaluated whether a small 1 km2 MPA can be effective in conserving fish resources. Underwater surveys were carried out to obtain fish abundance, hard coral cover and rugosity in Ngelukes Conservation Area and Uedangel, its control site. Fish abundance in Ngelukes CA increased from a 48.9 ± 7.8 (Mean ± SE) in 2005 to 69.7 ± 25.0 and decreased to 53 ± 14.1 in 2007. For the control site, Uedangel, there was a different pattern with a consistent decrease in fish abundance over the three-year period. Fish abundance was 35.3 ± 7.2 (Mean ± SE) in 2005 and decreased to 28.1 ± 7.3 in 2006 and by 2007 the fish abundance was 27.1 ± 7.9. This fluctuation in fish abundance inside Ngelukes CA and the decrease in Uedangel from 2005-2007 were not significant so data for the different years were pooled. Analysis of the pooled data showed that there was a significant difference in the number of fish inside Ngelukes CA compared to its control site with mean fish abundance in Ngelukes at 57.2 ± 10.5 (Mean ± SE) compared with the control site, which only had a mean fish abundance of 30.2 ± 4.3. There was no significant difference in coral cover and rugosity between Ngelukes CA and its control site. Since there was no difference between rugosity and coral cover between the MPA and its control site, the differences in fish abundance between the MPA and control is more likely due to protection, rather than the type of habitat it has. The results of this study showed that even small MPAs could still be effective in conserving valuable resources.

## 23.1040

**Species Composition And Abundance At Two Protected Spawning Aggregation Sites In Palau With Different Length Of Closure**

**Geory MEREB*[1]**, Arius MEREP[1], Alan FRIEDLANDER[2], Yimnang GOLBUU[1]

[1]Palau International Coral Reef Center, Koror, Palau, [2]NOAA/NOS/CCMA-Biogeography Team, Waimanalo, HI

Grouper spawning aggregations are heavily targeted around the world. In Palau, Ngerumekaol and Ebiil Channels are both spawning aggregation sites that have been protected from fishing since 1976 and 2000, respectively. Groupers and other resource species were monitored monthly over a 1.5-year period at these two protected spawning aggregations and two nearby control areas. Surveys were conducted 2-6 days before the new moon of each month, which coincides with the peak aggregation period in Palau. At the aggregation sites, three grouper species (Plectropomus areolatus, Epinephelus polyphekadion, and E. fuscoguttatus) accounted for 78% of the number and 85% of the biomass of all resource species surveyed but comprised < 1% of the total number and biomass at control sites. Number and biomass of the three major grouper species pooled was significantly higher at Ngerumekaol compared to Ebiil. Plectropomus areolatus was the dominant grouper at both spawning sites and numbers, biomass, and size were all higher at Ngerumekaol compared to Ebiil. The larger Epinephelus fuscoguttatus , showed even more pronounced differences between the two sites with higher values also at Ngerumekaol. Epinephelus polyphekadion was the third most important species at Ngerumekaol but only one individual was encountered at Ebiil. Differences in densities and composition of grouper species at these two aggregations may be attributed to the differences in time since closure (Ngerumekaol = 31 years, Ebiil = 7 years). In addition, Ebiil is further from the capitol, Koror, and experiences problems with poaching. The peak spawning period at Ebiil occurs during the national open season for groupers and is therefore easier for poached fish to be sold. The lower numbers of E.fuscoguttatus and the near absence of E. polyphekadion at Ebiil may reflect the effects of previous and current overexploitation.

## 23.1041

**Learning From The Development Of Marine Protected Area Networks: Is Science Or Practical Realities The Guiding Force?**

**Stuart GREEN*[1]**, Alan WHITE[2], Stacey KILARSKI[2], Patrick CHRISTIE[3], Anna MENESES[4], Leah BUNCE[5], Giselle SAMONTE-TAN[5], Kate NEWMAN[6], Stuart CAMPBELL[7], Helen FOX[6]

[1]TNC, Tagbilaran City, Philippines, [2]TNC, Honolulu, HI, [3]University of Washington, Washington, WA, [4]TNC, Manila, Philippines, [5]CI, Washington, WA, [6]WWF, Washington, WA, [7]WCS, Bogor, Indonesia

Marine protected areas (MPAs) and networks of MPAs are an accepted means of protecting coral reef and associated habitats and enhancing near-shore fisheries. A growing number of MPA networks are being formed to provide important spatial links needed to maintain ecosystem processes and connectivity, as well as improve resilience by spreading risk in the case of localized disasters, failures in management or other hazards, and thus help to ensure the long-term sustainability of populations This study is part of the "Marine Learning Partnership" among four global non-government organizations engaged in the development of MPA networks in Indonesia, Papua New Guinea and the Philippines. The primary objective of the study was to assess the status of the MPA networks in varying stages of planning and implementation, identify major gaps in information, science, knowledge, and enabling conditions, and to generate and disseminate increased knowledge of MPA networks through collaboration. Methodology of the study included: field observation at six sites, implementation of a structured interview protocol that engaged the MPA managers and primary stakeholders at the field sites and in national offices, and a stakeholder learning workshop. Findings show that the six MPA networks are progressing towards their biodiversity conservation and fisheries management goals. To achieve measureable objectives of effective habitat protection and connectivity among the individual MPAs, MPA managers and stakeholders at the sites are discovering that there are many social and governance factors that must be addressed. The planning for each network is benefitting from improved science and practical guidance on how to build representative and resilient networks that will minimize loss from multiple local and global forces over time. Nevertheless, effective management of individual MPAs and networks is only beginning.

## 23.1042

**Effective Socio-Political Strategies That Help Support Ecological Resilience Of Marine Protected Area Networks Within The Coral Triangle**

**Anna MENESES*[1]**, Alan WHITE[2], Stuart GREEN[3], Stacey KILARSKI[4], Patrick CHRISTIE[5]

[1]Global Marine Initiative, The Nature Conservancy, Calamba City, Laguna, Philippines, [2]Global Marine Initiative, The Nature Conservancy, Kailua, HI, [3]Global Marine Initiative, The Nature Conservancy, Tagbilaran City, Bohol, Philippines, [4]Global Marine Initiative, The Nature Conservancy, Honolulu, HI, [5]School of Marine Affairs and Jackson School of International Studies, University of Washington, Seattle, WA

The Coral Triangle is the global center of marine biodiversity and one of the world's top priorities for conservation. Various organizations and partner groups are working to establish networks of Marine Protected Area (MPAs) within the Coral Triangle. Network designs are generally based on scientific principles of resilience, whereby focus is based on reefs that are most likely to survive threats. Criteria to form networks include among others: (1) protecting a representative range of habitat types and replicating these at multiple locations to spread the risk of habitat loss; (2) protecting coral communities that are resistant to bleaching; (3) understanding coral reef connectivity to other ecosystems and processes, and; (4) increasing management effectiveness of controllable/human factors. In this light, the "Marine Learning Partnership" Project (LMPP), involving four global NGOs, is working towards a framework for tropical marine conservation that emphasizes resilient and representative MPA networks. The objective of LMPP is to improve conservation field practice in scaling up from MPA sites to ecological networks, by generating and disseminating knowledge through inter-organizational collaboration. This required capturing and analyzing experiences gained among institutions working in six sites across countries through: (1) a survey using standard forms targeting MPA managers and primary stakeholders, and; (2) a stakeholder learning workshop involving representatives from participating countries. Since, ecological networking is relatively new, LMPP sites serve as "reality laboratories". We are realizing that certain initial socio-political arrangements are needed to support and sustain MPA network initiatives to achieve ecological resilience and economic benefits. The most effective socio-political approach taken by each of the six study sites will be presented to serve as models for others to learn from, considering various political set-ups and cultures across countries.

## 23.889

**The Economic Value Of Coral Reef Quality To Scuba Divers in Barbados**

**Peter SCHUHMANN*[1]**, James CASEY[2], Hazel OXENFORD[3]

[1]Economics and Finance, University of North Carolina Wilmington, Wilmington, NC, [2]Economics, Washington and Lee University, Lexington, VA, [3]CERMES, University of the West Indies Cave Hill, St. Michael, Barbados

The objective of this research is to estimate the economic value of coral reef quality as it relates to SCUBA diving. This value is derived using a stated preference (choice modeling) survey of resident and tourist divers in Barbados conducted in 2007. In addition to a variety of demographic variables, divers were asked about their level of experience, expenditures related to travel and diving, and encounters with specific species. Divers also completed a choice experiment, selecting between alternative dives with varying characteristics including price, crowding, fish diversity, encounters with marine turtles and coral reef quality. Coral reef quality was represented via a series of photographs representing a known range of live coral cover. Hence, a quantifiable measure of coral cover is presented in a qualitative fashion that divers can understand. Results indicate that willingness to pay for increased coral quality and other quality variables vary with diver experience, nationality and the quality of their most recent dive. The results of this study can be used to inform management decisions regarding reef use and can aid in the development of policies aimed at maximizing the returns from diving while reducing the negative impacts of tourism activities.

## 23.890

**Pacific Islands Climate Change Portal**

Mary Lou CUMBERPATCH[1], Marjorie ERNST[1], Stephanie FAUVER[2], Carrie HALL[1], Sarah VAN DER SCHALIE[1], **Linda PIKULA*[3]**

[1]NOAA, Silver Spring, MD, [2]NOAA, Charleston, SC, [3]NOAA Miami Regional Library @ AOML, Miami, FL

The National Oceanic and Atmospheric Administration (NOAA) has begun developing a Pacific Islands Climate Change Portal that will enable Pacific Island coastal managers to efficiently incorporate climate information and tools into their decision making.

Climate related resources relevant to coastal managers from various organizations currently exist, but they are scattered in many different locations—making access difficult and time consuming. To improve access to climate resources in the Pacific, NOAA is partnering with the Pacific Region Environment Programme (SPREP) and other organizations in the development of a portal that will be integrated with existing climate change decision support efforts in the region. The Portal is expected to be released in October of 2008.

The backbone of the Portal will consist of a searchable virtual library that provides links to science-based information and tools on specific subject areas such as sea level rise, water resources, and ocean acidification. The Portal will highlight suitable decision support tools, case studies, information on regional initiatives, climate services, training and education, and include links to data sources and partnership opportunities.

In the poster session, we will present an overview of the Portal and solicit feedback regarding portal resources, both existing or under development, intended to support coral reef management in the region in the context of climate change. NOAA will use the feedback provided by participants to further refine the content of the Portal.

## 23.891

**A Comparison of Coral Reef Management Strategies for Tourism in the Gulf of Thailand**

**Makamas SUTTHACHEEP*[1]**, Thamasak YEEMIN[1]

[1]Department of Biology, Faculty of Science, Ramkhamhaeng University, Bangkok, Thailand

Effective coral reef management can increase key ecosystem parameters such as fish biomass and diversity or live coral cover and maintain ecosystem processes and function. The objective of this paper is to compare management effectiveness of two popular diving sites, i.e., Mu Koh Chang and Koh Tao Group, in the Gulf of Thailand. Mu Koh Chang is relatively a new tourism destination in eastern part of the Gulf of Thailand. There are over 50 Islands in the area which harbor approximately 16 km2 of coral reefs. It was declared as a special administrative zone for sustainable tourism development through the Designated Area for Sustainable Tourism Administration (Public Organization) in 2002. An estimated 30% of the coral reefs are within the jurisdiction of Mu Koh Chang National Park which was established in 1982. Moreover Mu Koh Chang was selected as one of the coral reef demonstration sites under the UNEP/GEF Project on Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Collaboration between relevant agencies is the key factor for management effectiveness of coral reef based tourism. Koh Tao Group is one of the most popular diving sites in the South of Thailand for decades. The coral reef area around the islands is about 2 km2. The main landholder of Koh Tao Group is Treasury Department of Ministry of Finance. Some private companies leased the land for resort and diving business. There are no obvious national measures and policies to manage coral reefs of Koh Tao Group but cooperation of the Local Administrative Office, diving shops and volunteer groups play a major role for coral reef management. Consideration of socioeconomic factors and collaboration of stakeholders are very essential to improve management effectiveness of coral reefs in the Gulf of Thailand.

## 23.892

**Coral Reef Fish Community Metrics As Indicators Of Management Success**

**Chris CALDOW*[1]**, Randy CLARK[2], Alan FRIEDLANDER[3], Mark MONACO[2], Ben RUTTENBERG[4]

[1]Center for Coastal Monitoring and Assessment, NOAA, Silver Spring, MD, [2]NOAA, Silver Spring, MD, [3]Oceanic Institute, Waimanalo, HI, [4]University of California, San Diego, La Jolla, CA

With substantial impacts on coral reef ecosystems world wide, evaluating and communicating the efficacy of successful management strategies is imperative to maintain and restore community structure and ecosystem function. Measuring the degree of success and making comparisons across regions however is often hindered by a variety of factors including: differences in the ecosystem being managed and the management strategy, differences in data utilized to evaluate the strategy, and differences in the types and amounts of pressures facing the ecosystems. Recent studies have focused on the use of coral reef fish biomass as an informative indicator regarding ecosystem health and therefore management success. We evaluate a series of community metrics with our own census data collected utilizing a consistent sampling design and in-situ methodologies to survey coral reef fish populations in both relatively pristine and more heavily impacted ecosystems in the Pacific and Atlantic regions. Our findings suggest that community metrics such as species richness and abundance allow us to make distinctions between populations even over relatively small scales (neighboring islands); however, certain metrics such as high overall fish biomass and proportionally high biomass of species in higher trophic levels tend to provide the most significant contrast between relatively pristine areas and those subject to greater levels of threats and stresses. Having a robust yet simple indicator of ecosystem health such as biomass enables quantification of management success. In addition, the existence of a relatively unperturbed control site within a given ecoregion can provide quantifiable information on the characteristics of a healthy ecosystem and therefore provide a reference for comparison among sites within that ecoregion.

## 23.893

**Man Made Stress Reliever? An Alternative To Natural Coral Reefs?**

Petra ELMO[1], Petra ELMO[2], **Petra ELMO*[2]**

[1]Private, Dulles, VA, [2]private, Dulles, VA

A healthy coral reef with 50% living cover could grow 4mm per year. The average of living cover on coral reefs world wide is 32%.

2004 worldwide 20% of coral reefs were reported as destroyed. 50% of reefs are in danger of collapsing.

Human induced stress factors are: coral bleaching, ocean acidification, pollution, coastal construction, over fishing and tourism.

Many small island developing states derive a large part of their income through tourism, often through activities related to reefs (snorkeling, scuba diving).

How can some of the stress on natural coral reefs be relieved without reducing income through tourism?

One solution could be an underwater park like the one in Grenada. It was created in 2006 at Moliniere Reef, in an area that had experienced severe hurricane damage.

The park consists of about 60 statues, each related to Grenadian history respective folklore. The statues are made of different materials (steel, concrete). They are in 5 – 8 meters depth, so accessible to both divers and snorkelers.

Some of the exhibits already are partially covered with marine organisms. It is expected, that over time the exhibits change their appearance due to the developing growth of marine life on them.

The park addresses and inspires ecology, history/folklore and art.

Considering the economical success of some artificial reefs (mainly wrecks) and the (documented) reduced pressure on nearby natural reefs it may be beneficial for natural reefs to introduce more underwater parks like the one in Grenada.

To guarantee economical success of artificial reefs they have to be advertised. To really reduce the stress on the surrounding natural reefs any artificial reef – be it a wreck or an underwater park – has to be managed properly.

In my contribution I plan to address this topic.

## 23.894

**Is A Coralline Island Mpa Within A Lagoon Seascape Effective As A Whole? A Case Study in The South Lagoon Marine Park Of New Caledonia**

**Olivier CHATEAU*[1]**, Laurent WANTIEZ[1]

[1]LIVE, University of New Caledonia, Noumea, New Caledonia

Acoustic telemetry was used to examine the movement patterns of four commercial fish species (45 fish; *Epinephelus maculatus*, *Plectropomus leopardus*, *Chlorurus microrhinos* and *Scarus ghobban*) in a fragmented habitat in the lagoon of New Caledonia, over a period of 17 months. The studied area included a marine reserve and two unprotected reefs separated by large areas of lagoon soft bottoms (900 m and 2000 m). The fish were detected between few hours and 530 days. Most of them realized large movements within reef (several kilometres) during their monitored period. This result confirms that the closure of only part of a reef structure may not be effective for all the studied species. Nine fish (20% of the studied fish) and at least one specimen of each species carried out inter-reef movements during their monitored period. All of them moved across the reserve boundaries at least once. The minimum distance covered by these fish over the soft bottoms between the reefs ranged from 500 m to 10.3 km (mean: 4.3 ± 3.6 km). If the objective of the reserve is to protect resident populations, we suggest that larger reserves including several reefs, spawning areas and lagoon soft bottoms would be necessary. Another objective of marine reserves is the maintenance of adjacent fisheries through the net export of fish biomass from the reserve. Our results suggest that the three studied reefs are connected and show that 20% of studied fish were more or less exposed to fishing. Even if net export was not clearly demonstrated, our results support the hypothesis that the studied reserve could benefit the adjacent fished area by spillover.

## 23.895

**Stakeholder Perceptions And Observed Resource Quality in Caribbean Marine Reserves**

**Richard POLLNAC*[1]**, Tracey DALTON[1], Graham FORRESTER[2]

[1]Marine Affairs, University of Rhode Island, Kingston, RI, [2]Natural Resources Science, University of Rhode Island, Kingston, RI

Stakeholder perceptions can provide insights on environmental resource quality as well as highlight key factors influencing attitudes and behaviors associated with a resource. This study examines relationships between perceived and observed resource quality measures in marine reserves in the Caribbean and explores factors that contribute to congruence or dissonance between these measures. Data from key informant interviews, structured community surveys, and coral reef transect surveys conducted in nineteen marine reserves and their associated communities throughout the wider Caribbean are examined in terms of degree of homogeneity in intracommunity responses, degree of agreement between community members and project personnel, and congruence of responses of different responder types with observed coral and fish conditions. Individual community member background variables such as age, years of formal education, and occupation are examined in terms of their influences on perceived resource quality and the congruence between these perceptions and observed quality.

## 23.896

**Assessing Rarity Of Reef Fishes From Volunteer Fish Monitoring Data**

**Peter AUSTER*[1]**, Brice SEMMENS[2], Sean MONDE[1], Kimberly BARBER[1]

[1]University of Connecticut, Groton, CT, [2]NOAA Northwest Fisheries Science Center, Seattle, WA

Ecosystem approaches to management of coral reef ecosystems require data primarily focused on dominant species. This is well justified given the important ecological role played by these taxa. However, an important component of management includes conservation of biological diversity where rare species may be most sensitive to change and subject to extinction (i.e., local, regional). The status of such species may be unclear due to rarity in systematic surveys and surveys to assess their status generally require dedicated effort, are costly, and time consuming. Here we assess the value of using data from volunteer fish monitoring (Reef Environmental Education Foundation) and develop an approach for identifying species to target field surveys. Data from Bonaire, Netherlands Antilles was used given the large number of volunteer surveys available (n=5657 between 1995-2005). Species with sighting frequencies in the first quartile of data were defined as "rare" (i.e., those that occurred in only 1-8 surveys from the total pool). Analyses were performed on rare species as a group to determine limits in habitat, depth, and range along the reef tract in order to constrain future survey requirements. In general rare species were widespread along the leeward side of Bonaire and occurred across all habitat types and depths. Issues related to detectability and crypsis are considered problematic for survey design. Further analysis based on geographic range and known habitat requirements reduced the list to those taxa which may be most at-risk and require directed assessment and potential management attention.

## 23.897

**Empowering Fisherwomen Through Ict in Reef Conservation And Management – A Case Study From Tuticorin Coast Of The Gulf Of Mannar, Southeastern India**

Jamila PATTERSON[1], Eva LINDEN[2], Christin BIERBRIER[2], Dan WILHELMSSON[3], Inger LOFGREN[4], David OBURA[5], **Edward JK PATTERSON*[1]**

[1]Suganthi Devadason Marine Research Institute, Tuticorin, India, [2]Nyköpings Folkhögskola, Nyköping, Sweden, [3]Stockholm University, Stockholm, Sweden, [4]Lagman Linds v. 4 A, Stocksund, Sweden, [5]CORDIO East Africa, Mombasa, Kenya

To reduce pressure on coral reef resources and economic vulnerability of coastal communities, local fisherwomen Self Help Groups (SHGs) were empowered through provision of Information and Communication Technologies ICT and adult education in 5 coastal villages in Tuticorin district of the Gulf of Mannar (GoM) in the South-eastern India. Improved literacy levels, environmental education, as well as the provision of computer training and equipment, improved villages capacity for taking up alternative livelihoods and enhance their living conditions. The support to SHGs have been successful in demonstrating the potential as a non-threatening mechanism for mobilizing resources, providing affordable finance and social benefits to poorer fisher women, including self-reliance, awareness creation, capacity development, social solidarity and the empowerment of women.

The village coordinators from the five targeted villages were given training in adult and environmental education and computer applications. After the training, each village was provided with ICT components (include computer, printer, mobile phone, and internet). Several people, including school children are taking part in the adult and environmental education; and computer training. The villagers are showing keen interest and many old fisher women now taught to put their signature and also started reading. In addition, the SHG members in the targeted villages are also trained in other alternative livelihood activities such as vermi-compositing and hygienic fish drying methods. Now, they started enjoying the benefits from their livelihood activities. The creation of awareness about the environment along with the adult education, training in computer applications and other livelihood options helped the fisherwomen to earn additional income for their families, which is the key to reduce the destructive fishing practices and enhance living conditions in the coastal areas of GoM..

## 23.898

**Habitat Similarity Between The Artificial Reef And Surrounding Natural Hardbottom Of Broward County, Fl: Implications For Future Mitigation Planning**

**Stacy PREKEL*[1]**

[1]Marine Science and Biological Research, Coastal Planning & Engineering, Inc., Boca Raton, FL

**Abstract:** In order to mitigate for anticipated burial of natural hardbottom areas from Segment III of the Broward County Shore Protection Project, 3.6 x 10-2 km2 (8.9 acres) of artificial reef were built in August/September 2003. To determine if the artificial reef was approaching community equivalence to the surrounding nearshore natural hardbottom, benthic biological monitoring was conducted at five discrete monitoring events. Twenty-seven, 30-meter transects were monitored on the artificial reef and 26, 30-meter transects were monitored on the natural hardbottom. Biological monitoring utilized the Benthic Ecological Assessment of Marginal Reefs (BEAMR) methodology. Non-parametric multivariate analyses were applied to the functional group dataset using PRIMER-E® (v6) to detect site type similarity. A Multi-Dimensional Scaling (MDS) ordination was generated with associated one-way Analysis of Similarity (ANOSIM) from the transect-level data to present the differences between the functional group-level benthic communities of the artificial and natural substrate at each monitoring event. Results revealed significant differences ($p$<0.05) exist 36 months post-mitigation; however the R statistic decreased from 0.607 to 0.510 between 9- and 36-month post-mitigation. This indicates a temporal increase in community similarity between the artificial reef and natural hardbottom.

## 23.899

**Ecological Monitoring Of Coral Reef Fishes: A Tool For Integrated Coastal Zone Management From Mexican Caribbean**

**Silvia DÍAZ-RUIZ*[1]**, Christian ALVA-BASURTO[1], Arturo AGUIRRE-LEÓN[2]

[1]Hidrobiología, Universidad Autónoma Metropolitana, Unidad Iztapalapa, México, D. F., Mexico, [2]El Hombre y su Ambiente, Universidad Autónoma Metropolitana, Unidad Xochimilco, México, D. F., Mexico

Quintana Roo's coastal zone, in the Mexican Caribbean, possesses the second barrier coralline most important of the world, from Island Contoy until the territorial limits with Belize and Honduras. It is part of the mesoamerican reef system (SAM), representing an area of high biodiversity and of the tourist corridor Cancún-Tulum, with fishing moderate and intense tourist activity, it possesses varied biological systems (reefs, mangroves, marine grasses and coastal lagoons) and great variety of fishing resources (lobster, snail, fishes). The tourist and urban development, as well as climatic events in the region, they have caused degradation of the adjacent coastal systems and in particular a potential threat exists on the coral reefs and its biotic resources. For these characteristics, studies of ecology and evaluation of the system and communities of fish have been focused mainly to obtain detailed information of: 1) the environmental characteristics and 2) about taxonomy, biology and ecology of fishes in these systems. Ecological investigations in reefs of Cozumel, Puerto Morelos and Akumal has allowed to obtain information on: 1) definition of critical habitats, 2) composition, diversity, distribution and abundance in space and time, 3) it structures of groups of fishes, dominant species and of economic importance, 4) Interactions fish-habitat, 5) aspects of functionality of the ecosystem and the fish community. This information allows to establish a reference mark for the environment, the classification and the ecological administration of the uses and resources of the coastal area. The obtaining of systematic information on ecology and evaluation of coastal systems and its fishing resources constitutes a challenge and a tool to establish scientific bases of management and conservation, through use strategies planned to medium and long agreement term to the necessities of the socio-economic development of the coastal area of the Mexican Caribbean.

## 23.900

**American Samoa: Setting An Example. Managing Reef Fish Populations Through Protection.**

**Ben CARROLL*[1]**

[1]Dept. Marine & Wildlife Resources, Pago Pago, American Samoa

Recently the American Samoa Department of Marine and Wildlife Resources (DMWR) made the decision to take the necessary steps to fully protect (i.e. year-round, no-take of individuals of all sizes) all species of sharks, as well as four species of reef fish (*Cheilinus undulatus, Bulbometopon muricatum, Epinephelus lanceolatus,* and *Caranx ignobilis*). For many years there has been concern that reef fish populations in American Samoa have been depleted and that some species may have been overfished. Attempts to gain protection of these species have, however, failed as data doesn't exist to show that overfishing of these species has occurred and as such agreement was never reached concerning the need for any management action. In fact, despite a large increase in human population levels, reef fish populations in American Samoa have remained stable throughout the past thirty years while fishing effort, both commercial and subsistence, has declined due primarily to a shift in the resident population's focus away from subsistence activities and toward a cash-based economy. The decision to protect the species listed above was made based on their apparent current rarity making them particularly vulnerable to facing local extinction through any increase in harvest. This was considered sufficient reason to warrant granting them full protection regardless of the mechanism causing the perceived rarity. The decision to protect these species was aided by the fact that they are not specifically targeted or of particular cultural importance. The decision was also aided by the fact that some of these species are on various protection lists such as CITES, the IUCN Red List, and the NOAA Species of Concern list, together with the overall trend that some of these species are threatened in many places around the world, and the knowledge that certain species are of particular and significant ecological importance.

## 23.901

**Reef Monitoring Project For Kahoʻolawe Island Reserve, Hawaiʻi**

**Frank G. STANTON*[1]**

[1]Marine Option Program, University of Hawaii, Honolulu, HI

The coral reefs of Kahoʻolawe have been monitored sporadically since 1969 with no long-term management focus until recently. In 1994 the island and surrounding waters were set aside as a reserve for cultural and traditional activities by native Hawaiians and to restore the land and waters of the island. Five coastline access locations were designated for human activities, and a program was established in 2004 to monitor these sites and five control sites as part of a marine resource management plan. Monitoring originally included benthic cover and fish numbers but has expanded to include coral bleaching and disease monitoring. Overall, the reefs are in relatively good shape and considered among the best in the Main Hawaiian Islands. Noticeable decreases in some fish species have occurred at all sites and cannot be directly attributed to human activities at the five access sites. Coral bleaching occurs annually during the summer, but there has been no large-scale coral mortality from bleaching. Coral disease monitoring is still in a descriptive phase and has identified only low levels of incidence to date. The coral reefs of Kahoʻolawe must be managed as part of an island ecosystem because most of the impacts are related to natural and anthropogenic sources on land. Incorporating a coral reef management plan early in the management process has accomplished several things: 1) It has measured prior conditions before impacts occur at selected sites. 2) It has identified broader scale impacts that may not be directly related to coastal activities. 3) It has drawn attention to the need to integrate reef management with land management. 4) It has created a baseline of reef conditions that can be used when planning for other marine related activities such as fish farming or energy generation.

## 23.902

**Environment Impact Assessment: Effective to Protect Okinawa's Coral Reefs at Risk?**

**Seiji NAKAYA*[1]**

[1]Research Institute for Subtropics, Okinawa, Japan

Since its reversion to Japan in 1972, Okinawa has experienced drastic improvement of infrastructure, including construction of harbor, fishing port and seawalls, reclamation of coral reefs for industrial, business and residential sites, as well as terrestrial civil works for farmlands, roads, dams, and river embankment. As these often degrade coral reef ecosystems, the Environment Impact Assessment (EIA) was introduced to conserve environmental values. This paper aims to evaluate the effectiveness of EIA in terms of conservation of coral reefs in Okinawa Island.

I reviewed existing documents regarding major construction projects that are under planning, EIA or construction on or near coral reefs.

On-going projects include: (1) Reclamation of Awase wetlands for multipurpose ground, (2) Construction of 6 US Marine Helipads in a rain forest where endangered endemic species inhabit, (3) Reclamation for a US Marine air base, (4) Seaward extension of a commercial airport that shares the runway with Japan Air Self-Defense Force, (5) Extension of Naha Port including relocation of US Army Port on the precise natural shoreline. While EIA helped the public be involved in decision making process, EIA in Okinawa possesses flaws in the process as follows. (a) As EIA is conducted after details are determined, no comparison of environmental impacts among alternate plans, including a zero option, or major revisions of the plan can be made. (b) Information is open to the public in a late stage of the process. (c) Legitimate EIA is often exempted for unclear reasons. (d) Information on military issues is not provided.

Findings strongly suggest that public be allowed to participate in an early stage of planning, that information be accessible more freely, and that strategic EIA be introduced, especially for large-scale projects, if EIA is to be effective for conservation of coral reefs and related ecosystems.

## 23.903

**Spatial Diversity Of Coral Reef Communities in Sulu Sea Marine Corridors**

**Wilfredo Roehl LICUANAN*[1]**, Katrina LUZON[2], Porfirio ALINO[2]

[1]Biology Department and Shields Marine Station, De La Salle University-Manila, Manila, Philippines, [2]Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines

Most protected coral reefs and coral communities in the Philippines are in small fishery reserves chosen for their coral cover and fish biomass, rather than their biodiversity conservation value. In an effort to improve criteria for designing these small reserves, spatial arrangement, particularly patch sizes of the reef benthos, was examined using semivariograms computed from DCA ordination scores of raw data. The data were generated from reef photos taken at one meter intervals along 100m transect lines, deployed along depth contours at 27 reef sites in three locations in the Sulu Sea. These locations are along the Cagayan Ridge (including Cagayancillo, and the Tubattaha National Marine Park), and reefs in Balabac Islands, southern Palawan that lie in a strait connecting the Sulu Sea with the South China Sea. Three basic community types were discerned - Type 1 communities are made up mostly by sand, rubble, and macroalgae as typically encountered in reef flats and backreef areas; Type 2 communities are a mix of different forms of various coral genera (except *Acropora*); and Type 3 communities are made up mostly of *Acropora*, either in tabulate or branching form. These community types are typically seen as mosaics but their relative proportions vary with depth and exposure to monsoon winds, and appear to indicate disturbance history of a site. Type 1 and Type 3 communities are typically large patches, with the latter at shallow sites, and the former at deep or sheltered ones. Community mosaics dominated by both types have low diversity but the latter also has the highest coral cover. Type 2 communities, on the other hand, have small mosaic patches and steep species area curves. These are typically found at intermediate depths.

## 23.904

**Conceptualizing Fisher-Tourism Conflict in An Indonesian Mpa**

**Leila SIEVANEN*[1]**

[1]Environmental Anthropology, University of Washington, Seattle, WA

Bunaken National Marine Park, as an internationally recognized example of successful integration of economic growth (through ecotourism) and biodiversity conservation, has experienced a steady increase in foreign and domestic dive tourists over the past ten years. In marine protected areas (MPAs) funded by ecotourism, arguably the most common type of social conflict results from competition between fishers and tourists. Unresolved fisher-tourism conflict in MPAs is often directly related to management failure. To resolve the resulting conflict over space for livelihood and tourism needs in Bunaken, Park officials have implemented a co-management approach in which fishers and tourism operators participate in establishing exclusive zones separating fishing and diving activities.

Many scholars view competition over scarce coral reef resources as a major source of increasing social conflict in coastal Southeast Asia. In this view, conflict resolution can be achieved through fishers and divers jointly deciding where their respective activities can occur. Based on eighteen months of ethnographic fieldwork in Bunaken National Marine Park, I contrast two views of fisher-tourism conflict. Is this conflict better viewed as a conflict over scarce resources or a social conflict over access to natural resources? I argue that viewing conflict in MPAs as driven mainly by resource limitation omits the greater social and political context in which an MPA operates. My research showed that on–the-ground operation of the MPA favors non-consumptive over consumptive uses and implicitly favored dive interests over fishing interests. Understanding the social conflicts associated with the implementation of these assumptions in an MPA is key to successful management.

## 23.905

**The Manila Ocean Park: A Venue For Coral Reef Education And Research**

**Benjamin VALLEJO JR*[1,2]**

[1]Environmental Science and Meteorology, University of the Philippines, Quezon City, Philippines, [2]Manila Ocean Park, Manila, Philippines

This study documents the recently opened Manila Ocean Park efforts on coral reef education and conservation research. Among the major thrusts in coral reef education and research is on coral propagation under captive conditions. This study aims to establish a baseline for coral propagation for the aquarium trade, laboratory based research on coral health and the effects of global climate change. This research focus is tied to public education programs that emphasize active engagement in coral reef conservation

## 23.906

**Marine Biodiversity Conservation in The Kudat Priority Conservation Area, Sulu-Sulawesi Marine Ecoregion, Sabah, Malaysia : Applying The Ecosystem Approach.**

**Robecca JUMIN*[1]**, Yoke Lee LEE[1], Sikula MAGUPIN[1], Annadel CABANBAN[1]

[1]WWF-Malaysia, Kota Kinabalu, Malaysia

The Ecosystem Approach (EsA) was adopted by many countries that signed the Convention of Biological Diversity (CBD) but very little examples of its application are found in the world. As the framework for biodiversity conservation in the CBD, the Strategic Plan of Action for meeting conservation implies this application. The application of the EsA follows 5 general steps: defining the ecosystem; identifying stakeholders; knowing the resource uses; and identifying management strategy. As a stakeholder of the Sulu-Sulawesi Marine Ecoregion, WWF-Malaysia SSME Conservation Programme has embarked on the conservation of the Kudat Priority Conservation Area, Sabah, Malaysia following the concept of the Ecosystem Approach. This Project complements the establishment of the Tun Mustapha Park with the Kudat PCA, where collaborative management between local, resource-users and governmental agencies is the stated and desired management strategy. Thus, the Project began by knowing the stakeholders in the Area and gathering local knowledge on the coastal and marine ecosystems and the patterns of resource uses. The information gathered from this phase will define the community education and public awareness strategy to build community support. The results from this phase are presented in this paper and discussed against the 12 principles of the Ecosystem Approach. This phase and the future envisioned phases of the Tun Mustapha Park management uphold the principles for biodiversity conservation.

## 23.907

**Supporting The Suppliers; The Key To Sustaining The Marine Aquarium Trade?.**

**Gayatri REKSODIHARDJO-LILLEY*[1]**, Yunaldi YAHYA[1], Putu WIDYASTUTI[1]

[1]Marine Aquarium Council Indonesia, Denpasar, Indonesia

A responsible marine aquarium trade, based on informed resource management strategies and shared responsibilities through the whole trade chain, is urgently needed if the marine resources are to be conserved for the future. The trade's survival depends to a large extent on maintaining the health of coral reef ecosystems, and provision of greater financial incentives to the supply end of the trade chain is one means of achieving this.

For over three decades, Indonesia has been the major supplier of marine ornamentals, supplying the world with large quantities of wild-caught marine organisms of many species. However, poor management of the trade has led to over-collection and resource depletion, and stock mortality rates remain high.

Thousands of coastal communities depend on this trade as their only source of income. Up to three generations of collectors can be found living in some coastal villages. Coastal areas have become damaged through increasing levels of human impact, and the collectors have had to travel progressively further from their villages to fulfill their orders.

For the past four years, MAC has been working with local partners in coastal areas, focusing on resources assessment and reef conditions, development of collection area management plans, and capacity building of collectors in non-destructive collecting and post-harvest techniques. Three sets of data on resource assessment surveys have been collected in Buleleng district, North Bali during 2003, 2005 and 2007, as well as harvest data from 2005 to 2007. The accumulated data show that there is a chance that managed collection areas could provide a sustainable harvest of marine organisms for the aquarium trade. Currently we are working with collectors in Bali, Jakarta Bay, West Sumatra (Mentawai/ Padang) and Sulawesi.

## 23.908

**'Evidence-based' Coral Reef Conservation**

**Sue WELLS*[1]**, William SUTHERLAND[2]

[1]Zoology, University of Cambridge, Cambridge, United Kingdom, [2]University of Cambridge, Cambridge, United Kingdom

This paper provides preliminary results of an initiative to document scientific evidence of the impact of conservation actions and management interventions undertaken for coral reefs. Despite a massive investment in their protection, and the publication of much guidance for managers, reefs are in serious decline. Many interventions are based on good science, but others have evolved from personal experience and common sense. There is no single source that collates experiences and the impacts of different interventions, and this initiative is aimed at filling this gap through the website ConservationEvidence.com. Relevant data are extracted from scientific journals and other sources, and a list of common coral reef management interventions has been compiled. Each of these is being assessed according to the 'evidence' available. The study is incomplete but some examples can be provided:

A systematic review has been carried out and conclusions drawn (e.g. the impact of marine protected areas on coral reef fish populations);

A review has been undertaken but this is not systematic and comprehensive (e.g. the impact of coral reef restoration programmes);

There are only a few papers and the results can be summarised (e.g. the impact of fisheries gear exchange programmes on coral reef fish populations);

There are numerous papers and a systematic review is needed before sound conclusions can be drawn (e.g. the impact of artificial reefs on adjacent natural reefs); and

There is no information on the intervention in the sources used (e.g. the impact of awareness-raising programmes for local communities on the health of adjacent reefs).

This information will be of direct value to coral reef managers but will also help to identify research priorities for the scientific community.

## 23.909

**Patterns Of Spatial Variability in Distribution Of Benthic Invertebrates And Algae At Sharm El Sheikh (South Sinai, Egypt)**

Stefano ACUNTO[1], Jessika GIRALDI[1], David BALATA[1], Luigi PIAZZI[1], **Francesco CINELLI*[1]**

[1]University of Pisa, Pisa, Italy

A survey of benthic community was conducted as part of the project to construct an Underwater Observatory on the coast of Sharm el Sheikh (South Sinai, Egypt). To provide the first step of the Environmental Impact Assessment based on a BACI design (Before - After Control Impact), the spatial distribution of benthic invertebrates and algae was studied along the coast of Ras Mohammed National Park in the area of Marsa Ghoslani.

A nested sampling design was used at a hierarchy of spatial scales: 5 sites (100 s of m apart), 3 areas within each site (10 s of m apart) and 20 1m2 frames within each area were randomly selected. Plots were sampled using the photo-quadrats method. All samples were collected at a depth of 10 m on a gentle slope rocky bottom covered with sand and scattered coral assemblages.

A combination of univariate and multivariate analysis of the percentage cover was used to describe differences in the mean abundance of organisms identified at the genus level and, when necessary, grouped into broader categories.

Results showed significant differences in the distribution and abundances of organisms among sites as well as among areas, indicating that abundances varied at the scales of hundreds and tens of meters along the coast investigated. These results are likely to be due to spatial differences of the hydrodynamic conditions of the studied sites. One of the sites with the lowest percentage cover of living organisms was suggested as the most suitable for the location of the Underwater Observatory in order to minimize the impact of the structure.

## 23.910

**Newly Found Coral Reef At Hadd Tay Muang And Participatory Management Approaches By Communities**

**Kittipan SUBKOON*[1]**, Songpol TIPPAYAWONG[1], Jirapong JEEWARONGKUL[1], Supaporn BUANIUM[1]

[1]Marine and Coastal Resources Unit, WWF Thailand, Phang-nga, Thailand, 82140, Phang-nga, Thailand

In January 2006, a new coral reef at Hadd Tay Muang, Phang Nga Province, Southern Thailand was discovered by the staff of the Marine & Coastal Resources Unit (MCRU), WWF Thailand. The total coral reef area discovered so far was 2.7 $km^2$. More than 30 genera of hard coral were identified. Living coral was the most conspicuous portion in these reefs comprising 32-67.75% of the substrate cover. At present 315 species from154 Genus and 71 families of fish were also identified. The dominant families were Carangidae, 26 species, Pomacentridae, 22 species, and Serranidae, 22 species, implying a good status of reef and high biodiversity. Having no or inadequate management may lead to biodiversity degradation as the reef is under threats (e.g. commercial trawler, some destructive fishing gear). There is an urgent need in protecting this area before it is highly exploited from incoming stakeholders such as dive operators. WWF Thailand Marine Programme in cooperation with coastal communities has tried a number of manages approaches such as area zoning by scientific and socio-economic–based judgment to compromise between previous stakeholder and new-coming stakeholder. Mooring buoys installation and coral restoration have been in place for degraded area; artificial fish shelter for small-scale fishing is also provided as alternative fishing ground to satisfy fishing -based community and also decreases fishing impacts on the reef. Communication and Education are other issues that should be focused besides capacity building and awareness raising programme. These could ensure sustainable use of the reef and enhance more participation in marine resources conservation. Lastly, we highly expect to see more integration especially involvement from provincial authorities which could help sustain natural resources utilization throughout laws, regulations, effective strategic plans and long term supports.

## 23.911

**Learning About Reef Conservation And Management: Coral Reef Ed-Ventures, An Environmental Education Program For Schoolchildren in Belize**

**H. Allen CURRAN*[1]**, Paulette PECKOL[2], Susan ETHEREDGE[3], Miguel ALAMILLA, JR.[4]

[1]Geology, Smith College, Northampton, MA, [2]Biological Sciences, Smith College, Northampton, MA, [3]Education & Child Study, Smith College, Northampton, MA, [4]Hol Chan Marine Reserve, San Pedro, Belize

Efforts to conserve and sustain coral reefs for future generations are directly dependent on support of all stakeholders in tropical coastal communities, where healthy, well-managed reef systems are of great importance. However, local knowledge of reef ecosystems and conservation methods may be limited, and study of coral reef ecology and natural history commonly is not part of school curricula. Coral reefs provide an ideal topic for teaching schoolchildren about fundamental oceanographic, ecologic, conservation, and sustainability principles. Coral Reef Ed-Ventures was initiated in summer 2000 in cooperation with Hol Chan Marine Reserve on Ambergris Caye, as an outgrowth of a multi-year research program to monitor the health of Belizean reefs. Now in its ninth year, students from Smith College organize and run the program, which enables up to 60 local schoolchildren, ages 7 to 11, to participate in an intensive two-week summer program about coral reefs. The goals of the program are to increase understanding of a healthy reef ecosystem, to explore how various reef organisms interact, and to develop appreciation for threats to the reef and how to conserve and sustain reef resources. The curriculum emphasizes a methodology of critical thinking and inquiry-based science learning. Helping children to develop observation and recording skills is an integral part of active, hands-on classroom and field trip experiences. Lessons focus on marine science with a multi-disciplinary and multi-arts approach. Pre- and post-program questionnaires completed by the children are used as assessment tools. At the gala Coral Reef Ed-Ventures graduation ceremony, the children present a program about reef ecology and conservation for their parents and the community, and each child is awarded a Coral Reef Expert card.

## 23.912

**Pirates Of The Caribbean; Illegal, Unregulated And Unreported Fishing Threats To Coral Reef And Pelagic Marine Biodiversity**

**Steven LUTZ*[1,2]**

[1]Public Policy Office, Marine Conservation Biology Institute, Washington, DC, [2]Public Policy Office, Marine Conservation Biology Institute, Washington

Worldwide overfishing has greatly increased the pressure for fishing enterprises to pursue illegal fishing activities. Pirate fishing or Illegal, unregulated and unreported (IUU) fishing, by nationals of one country in another country's Exclusive Economic Zone, is a growing worldwide concern as it challenges local fisheries' management efforts, depletes already overfished coastal fisheries, and has been recognized as a major threat to marine biodiversity. Two cases of pirate fishing in the wider Caribbean region are discussed: pirate fishing in the Bahamas and at Navassa Island, a U.S. territory. Three classes of pirate fishing are reported: subsistence, recreational, and commercial, each having respective zones of activity. Reef fish, endangered sea turtles, corals, and pelagic species (such as tuna and swordfish) are targeted, with other species impacted as bycatch or through destructive fishing practices. Unchecked, the impact from pirate fishing will have serious negative consequences for coral reef and pelagic marine biodiversity.

## 23.913

**Evaluation Of Factors That Can Promote Resistance And/or Resilience To Climate Change Induced Coral Bleaching**

**Steve COLES*[1,2]**, J. Burke BURNETT[1], Stephen LEISZ[1], Rod SALM[3]

[1]Natural Science, Bishop Museum, Honolulu, HI, [2]Hawaii Institute of Marine Biology, Kaneohe, [3]Asia Coastal Marine Program, The Nature Conservancy, Honolulu, HI

Although there was no coral bleaching reported for Melanesia during the worldwide 1998 event, substantial bleaching occurred in eastern Papua New Guinea (PNG) waters in 1982-83, 1996 and 1999-2000, with coral mortalities up to 54%. However, no evidence of recent coral bleaching or related mortality was observed during 2001-2002 surveys in Indonesia's Raja Ampat (Four Kings) Islands off Papua province (western New Guinea). Reefs were evaluated to be in very good health and to have high resilience to bleaching related stress. Reefs in the area have the highest species diversity of any similar sized area in the world, with at least 537 species reported and over 75% of the world's scleractinians. Reef fish diversity was equally high, with at least 1074 species and more than 200 species at >50% of the sites surveyed in 2002. However, there was evidence of coral damage from blast fishing and other non-sustainable fishing practices, resulting in relatively low numbers of groupers, sharks, and Napoleon Wrasses that are targeted by cyanide fishing. The potential importance of this 4000 hectare region of high diversity as a source of recruits for other Indo-West Pacific areas more subject to coral bleaching and acidification impacts cannot be over-emphasized. Conservation initiatives to establish and maintain effective marine protected areas in this region should be developed within the context of existing community and societal structures directed toward non-extractive utilization of reef resources.

## 23.914

**Measuring Success in Coral Reef Management For The South Florida And Caribbean National Park Service Units – One Size Doesn't Always Fit All.**

**Matt PATTERSON*[1]**, Andrea ATKINSON[1], Jeff MILLER[2], Andy DAVIS[2], Rob WAARA[1], Brian WITCHER[1]

[1]South Florida/Caribbean I&M Network, National Park Service, Palmetto Bay, FL, [2]South Florida/Caribbean I&M Network, National Park Service, St. John

The South Florida/Caribbean Inventory and Monitoring network (SFCN) of the National Park Service is responsible for implementation of an ecosystem monitoring program to help park managers and scientists understand changes in key Vital Signs indicators. The SFCN is responsible for coral reef monitoring at five national parks ranging from 400 acres to 200 miles$^2$, and a consistent sampling design for all will help with park to park comparisons over time. The Marine Benthic Community vital sign indicator monitors changes in both shallow and deep coral reef ecosystems, seagrass, and water temperature. Coral reef ecosystem monitoring has been conducted at long term sites through this program since 1997, with several sites that have been the focus of decades of research and monitoring.

Dry Tortugas National Park is approximately 70 miles west of Key West, Florida, USA and protects 100 miles$^2$ of coral reef, seagrass beds, and sand substrates. In 2007, the SFCN used a Generalized Random Tessellation Stratified (GRTS) Sampling Design to provide a spatially balanced survey to characterize multiple sites for inclusion in a long term monitoring program for coral reef resources less than 19m deep.

Rapid habitat characterization at 157 cells (40m$^2$) was conducted, collecting information regarding habitat type, depth, rugosity, presence/absence of key invertebrates, and estimation of fish densities at multiple trophic scales. Point intercepts were run at 0.5m intervals from a center point in cardinal directions to determine relative percent cover values for stony corals, when present. This information will be used to identify sites with high stony coral cover for long term monitoring site inclusion. 27 sites surveyed had over 6% of live stony coral cover.

Sampling site installation will occur in 2008, in parallel with existing historic site monitoring to evaluate if parkwide trends correlate to historic site localized changes in cover values.

## 23.915

**The Challenge Of Managing Off-Shore Reclamation To Ensure Sustainable Coastal Ecosystems: Focus On Dubai**

**Hanneke VAN LAVIEREN*[1]**, Peter SALE[1,2], Paolo USSEGLIO[1]

[1]International Network on Water, Environment and Health, United Nations University, Hamilton, ON, Canada, [2]Biological Sciences, University of Windsor, Windsor, Canada

Significant and rapidly-expanding infrastructure development and land reclamation in coastal areas can create challenges for ecosystem management. Major transformation of Dubai's shoreline, through three manmade islands in the shape of palm trees is such an example. When completed, all planned marine projects will expand the Dubai coastline by 1500 km, leading to creation of novel systems and new hydrodynamics. Understandably, it is presumed that these development activities have already had impacts on near-shore ecosystems, particularly the existing coral reefs and sea grass habitats. Early studies by the UNU-INWEH team point to the extreme natural variations in salinity and temperatures of the Arabian Gulf waters, which together with the affects of global warming cause additional stress. With scarce pre-construction environmental baseline information available, ongoing transformations, and lack of strategic planning, the challenge is to manage these activities in a way to minimize coastal ecosystem impacts. To deal with this challenge, we are evaluating the current status of coastal ecosystems and improving our understanding of impacts of these developments and novel ecosystems created, with an aim to guide management practices for integrated coastal management. The work is based on collaborative partnerships throughout the region and reliance on existing knowledge base. In particular, research studies provide information regarding the ecology of the open rocky crescents and associated artificial reefs, midwater of the enclosed lagoons, and benthic systems on and in lagoonal floors. An environmental monitoring programme provides crucial management data. Transfer of knowledge gained from this project to relevant management authorities as well as to the scientific community in the region is important; the study team is actively engaged in regional training workshops designed for this purpose.

## 23.916

**Changes in The Coral Reef Populations Within A Community Managed Marine Protected Area in The Fiji Islands**

Helen SYKES[1], **Kenneth MACKAY*[2]**

[1]Marine Ecology Consulting Fiji Ltd, Suva, Fiji, [2]Institute of Marine Resources, University of the South Pacific, Suva, Fiji

Annual biological monitoring was used to assess the effects of ten years of community-managed conservation in a village–based "no-take" Marine Protected Area (MPA) in the Fiji Islands.

Surveys were carried out by a mixed team of marine scientists and community members, and compared with neighbouring reefs used for subsistence fishing. A variety of in-water survey methods were used, including community-based Catch Per Unit Effort (CPUE) for key invertebrate species, Manta Tows for broad-scale habitat and invertebrate animal assessment, Point Intercept Transects for coral cover, and Belt Transects for Fish Underwater Visual Census (UVC).

Within 3 years, fish populations had noticeably increased within the MPA, after 5 years many invertebrate populations had been restored. Poaching of finfish and shellfish occurred once stock rose, and is one of the major challenges now facing the project. So far this has not significantly impacted overall populations, suggesting the ecosystem is now adequately robust to withstand some harvesting.

Coral health improved in the MPA over the fishing grounds, but was retarded by a mass bleaching event in the second year of protection. However, increased numbers of herbivorous fishes reduced macroalgae cover within the MPA, creating better coral-growth substrate, in turn accelerating coral settlement and recovery in comparison with the heavily fished area where macroalgae continued to cover most available substrate, preventing new coral settlement.

Villagers report that they now harvest larger fish and more commercially important invertebrates in their fishing grounds bordering the MPA. In addition, their caretaker role for this MPA has generated an awareness of the need to conservatively manage marine resources for the future.

## 23.917

**Culture And Updated Traditional Management Tools For Serving Ownership in Locally Managed Marine Areas**

**Eric CLUA*[1]**, Bernard SALVAT[2]

[1]CRISP programme, SPC, Noumea, New Caledonia, [2]EPHE, Perpignan, France

A major proportion of coral reefs around the world occur in small island developing countries (SIDS). The status of these resources is declining, while these countries simultaneously face major challenges in sustainable development for their people. Reef conservation in SIDS cannot be approached in the same way as conservation in more developed countries, even though the tools such as Marine Protected Areas may be effective for both situations. One of the main differences relies on the widespread inability of government services within SIDS to ensure adherence to legal frameworks aimed at protecting the reef resources from irreversible depletion. This gap can be compensated with a strong ownership by local communities through locally managed marine areas. The emergence of a real ownership strongly depends on the ability of developing actors in promoting the cultural dimension as a root of the process of locally based management which should include traditional tools, even if they need, most of the time, to be updated regarding ecological constraints for a sustainable development of reef resources. Therefore, a particular focus should be put by developing agencies on the integration of human factors (anthropology, socio-economics) for insuring the success of the ground actions, with innovative tools such as human factor based Geographic Information Systems. Local ownership can also be boosted by real examples of grounds successes to be shown to candidate communities and another issue relies on the setting up of functional networks at a regional level. The Coral Reef Initiative for the Pacific (CRISP) is a US$ 10 million programme over 3 years which implements this specific approach. The concepts behind CRISP draw on the recommendations of the International Coral Reef Initiative, and specifically seek to find Pacific solutions to regional problems.

## 23.918

**Documenting Traditional Knowledge Of Marine Use And Resource Management in American Samoa**

**Arielle LEVINE*[1]**, **Bert FUIAVA*[2]**, **Fiailoa MAIAVA*[2]**, Risa ORAM[2], Fale TUILAGI[3], Fatima SAUAFEA-LEAU[4]

[1]Pacific Islands Fisheries Science Center, Honolulu, HI, [2]Department of Marine and Wildlife Resources, Pago Pago, American Samoa, United States Minor Outlying Islands, [3]National Park Service, Pago Pago, American Samoa, United States Minor Outlying Islands, [4]NOAA - Pacific Islands Regional Office, Pago Pago, American Samoa, United States Minor Outlying Islands

This poster describes a collaborative project to document traditional knowledge of marine use and resource management in American Samoa, undertaken by the Pacific Islands Fisheries Science Center and multiple partner agencies in American Samoa. The three primary components of this research project are detailed, along with lessons learned and their application to coral reef fisheries management. The first element involved conducting elder interviews to document local knowledge regarding traditional marine use and management, as well as changes over time in resource use and conditions. Topics of interest included changes in fishing methods and frequency over time, changes in species catch and abundance, and traditional methods of marine management. The second element involved in-depth archival research of early explorer accounts of fishing and marine management in American Samoa. Records from the American Samoa Historic Preservation Office, University of Hawaii library, and the Bishop Museum archives were studied to gain a greater understanding of historic practices and their application to modern coral reef fisheries management. The third element of this project includes video documentation of traditional fishing practices that are unique to the Samoa region and still take place in American Samoa today. These practices include the palolo harvest (a coral-dwelling polychaete worm that spawns once a year and is considered a traditional Samoan delicacy); atule (bigeye scad) fishing (a mass spawning event that takes place in several Samoan bays); and i'asina (juvenile goatfish) fishing using traditional basket weirs on the Manu'a islands. The final documentary will be made available for education and outreach purposes to illustrate American Samoa's strong marine heritage and traditional reliance on marine resources. The results of this research project are expected to strengthen management practices by incorporating traditional Samoan values and knowledge into the Territory's new marine protected area programs and other coral reef fisheries management activities.

## 23.919

**Factors Influencing Success Of A Marine Protected Area Network in Hawaii**

**Jim BEETS*[1]**, Brian TISSOT[2], Mark HIXON[3], Stephen THOMPSON[4], Mark MANUEL[5]

[1]Marine Science, University of Hawaii-Hilo, Hilo, HI, [2]Environmental Science, Washington State University Vancouver, Vancouver, WA, [3]Zoology, Oregon State University, Corvallis, OR, [4]Cascadia Conservation Trust, Sisters, OR, [5]Tropical Conservation Biology & Env. Sci., University of Hawaii-Hilo, Hilo, HI

As Marine Protected Area (MPA) Networks gain management support, the importance of documenting factors that affect their effectiveness increases. Previous work showed greater abundance of juvenile and adult fishes harvested for the aquarium trade in individual MPAs compared to adjacent control sites within the MPA Network on the western coast of the island of Hawai'i (Tissot et al. 2004). The present study evaluated the relative contribution of habitat characteristics, adult abundance, and current exposure to the greater juvenile abundances observed within MPAs. Oceanographic, substrate and habitat characteristics were sampled with juvenile and adult fish abundances at three paired sites (MPA vs. control) along the western coast of the island of Hawaii. All three factors contributed to greater juvenile abundance of the study species, but differed in relative contribution among sites. We demonstrated the importance of selected factors to the effectiveness of a MPA network. Based on our results, we emphasize the value of consideration of several factors that potentially influence success of the defined goals for specific MPAs or networks.

## 23.920

**Atlanta's Willingness-To-Pay For Fijian Coral Reef Conservation: How Do Individuals Value Reefs Even When Distant And Can This Inform Market-Based Management Strategies?**

**Carolyn FONSECA*[1]**, Doug NOONAN[1]

[1]School of Public Policy, Georgia Institute of Technology, Atlanta, GA

Environmental policies often blend biological and social components. However, this area-of how knowledge experience and behavior affect perceptions of coral reef value-is still young. To date, few studies if any have sampled populations distant from reefs. Research has focused primarily in local coral reef valuation. The valuation literature for reefs is incomplete, missing information about how individuals (who do not live near reefs) value this ecosystem. The primary objective of this paper is to learn the value of Fijian coral reef conservation by non-Fijians. Fiji is about to begin a new program called "Adopt-a-Coral-Reef" whereby individuals can go online and purchase a coral or part of the reef. This study has the potential to inform coral sale price. The Contingent Valuation Method (CVM) has primarily been used to determine damages or to measure Willingness-to-Pay (WTP) for a particular service. Limited knowledge exists on how CVM might inform market-based management tools such as the Fijian program. Empirical research is needed to understand the effectiveness and generalizability of CVM. The model of this study investigated the influence of environmental behavior, previous culture experience, problem definition, coral reef knowledge, and ocean activities on coral reef WTP. Surveys were mailed to 2000 Atlanta GA households from November 2007 to January 2008. Preliminary results suggested a $12.6 average WTP by Atlanta for the Fijian reef program. Knowledge and previous experience were not significantly related to WTP. The findings imply that Atlanta households have the potential to contribute to the Fijian coral reef program. This study and similar research could provide stakeholders information on the most effective use and sources of funding. In conclusion, there is a need to learn more about how scale affects valuation. If the goal is to influence WTP, then knowing which factors are significant is an important step.

.

## 23.921

**Improvements in Determination Of Mitigation Needs For Coral Reef Damage: The Case Of Guam**

**Mike GAWEL*[1]**

[1]Planning, Guam Environmental Protection Agency, Dededo, Guam

The study's objective is to improve definition of mitigation needs and improve planning for mitigation requirements in response to damage to coral reefs from development projects.

Experiences of regulatory agencies in addressing methods of assessing mitigation for coral reef damage on the reefs of Guam are summarized. The latest preferred method, the use of Habitat Equivalency Assessment, is discussed. Use of this quantitative mechanism has been proven and accepted in other habitats but was first used on Guam coral reefs in 2006, to address the planned expansion of the Navy Ammunition Wharf. The multi-agency approach that was used is assessed. Its prioritization for planning future mitigation on Guam and its value for application to other Micronesian coral reefs is discussed.

## 23.922

**Undersea Explorer: A Unique Symbiosis Of Tourism And Research**

**Qamar SCHUYLER*[1]**, Louise BERNSTEIN[1]

[1]Undersea Explorer, Port Douglas, Australia

Undersea Explorer is a live-aboard dive boat based in Port Douglas, Australia, that has taken a unique approach to ecotourism. Based on a vision of utilizing tourism to support research, Undersea offers a free berth space on each of its week-long trips to a research scientist. Marine tourism, particularly on coral reefs, is a vast and sustainable source of revenue. In many areas, it represents the largest single contributor to the economic value of the coral reef ecosystem. Forming partnerships between the tourism industry and research not only increases the success of the research, but also expands the audience exposed to the research, engenders a more active and engaged public, and creates informative and adventurous experiences for divers.

Undersea has been operating throughout the northern Great Barrier Reef and in the Coral Sea for the past twelve years. This has enabled researchers to gain access to sites that would not otherwise be achievable or affordable, and has allowed us to highlight areas in need of research, advance and trial management actions, and generate new and independent funds for research. Successful collaborations have included the creation of best management practices for Australia's world-renowned swim-with dwarf minke whale industry, reef shark and tiger shark research, nautilus population and genetic studies, as well as a variety of other projects. We present lessons learned from establishing and maintaining these collaborations, with the final result being a WIN-WIN-WIN-WIN interaction between research institutions, industry, management, and the general public.

## 23.924

**Guidelines For Dredging And Port Construction Around Coral Reefs**

**Thomas FOSTER*[1]**, Emily CORCORAN[2], Constantijn DOLMANS[2], Paul ERFTEMEIJER[2], Caroline FLETCHER[2], Kobe PEIRS[2], Adam SMITH[2], Hidekazu YAMAMOTO[2]

[1]PIANC Working Group 15, Singapore, Singapore, [2]PIANC Working Group 15, Belgium, Belgium

11th International Coral Reef Symposium, Fort Lauderdale, USA, 7-11 Jul 2008: Abstracts of paper and poster for presentation

Guidelines for Dredging and Port Construction Around Coral Reefs

The physical alteration of the coastal zone is one of the most immediate and visible outcomes of population growth and expanding urbanisation. A third of the world's population lives in coastal areas, which constitute just 4% of the earth's total land area. Rapid coastal development has meant increased construction of coastal infrastructure, such as urban centres, ports, airports and tourist facilities. To support such construction activities, dredging is often required to, for example, maintain ports, navigation channels, reclaim land, or mine sand for construction. With proper and prudent management, these construction and dredging activities can support sustainable economic development, but without, they represent one of a number of major threats to some of the world's most productive coastal ecosystems and the services they provide.

In September 2004, the International Navigation Association (PIANC) Environmental Commission (EnviCom) in partnership with the United Nations Environment Programme (UNEP), Central Dredging Association (CEDA) and International Association of Dredging Contractors (IADC), established a working group to produce best practice guidelines concerning environmental effects of dredging and port construction activities around shallow, warm water coral reefs and the appropriate methods for avoidance, minimization, mitigation and compensation.

The generic guidelines on dredging, material relocation and port construction around coral reefs are based upon: available scientific literature, existing local guidelines, legislation and engineering practice, supported by case studies provided by industry practitioners. The guidelines will undergo peer review by PIANC EnviCom and key user groups prior to publication in mid 2008.

The present paper presents the key findings and recommendations put forward by the guidelines with the purpose of increasing the awareness of the coral reef management and coral reef user group community to the availability and relevance of these guidelines.

## 23.925

**Scientific Monitoring And Customary Management Of Ungakum Managed Marine Area: Methods, Lessons Learned And Challenges**

**Maunoa KARO*[1]**, Tau MOROVE[1], Ryan WALKER[1], Helen PERKS[1], Fraser HARTLEY[1]

[1]PNG Marine Program, Wildlife Conservation Society, Kavieng, Papua New Guinea

Abstract: Customary marine resource management is historically strong among coastal communities within the Pacific. Papua New Guinean social tradition allows coastal communities to practice local ownership and management of coral reefs with customary management laws recognized under national law. Here, we summarize approaches undertaken by Ungakum village; a small island fishing community in north western New Ireland, Papua New Guinea (PNG). The Wildlife Conservation Society (WCS) PNG Marine Program is working in collaboration with the community to establish and maintain customary management of their coral reef. Management efforts undertaken within the community in the last two years include establishing a no-take zone ("tambu" area), conducting detailed annual ecosystem monitoring at the managed area and nearby control, and the establishment and training of a community Locally Marine Managed Area (LMMA) monitoring team. Environmental education and coral reef awareness activities in schools and the community are undertaken every six months and several villagers have been included in regional and national resource management workshops. Results from 2006 - 2007 show no significant change in fish biomass (244.8 kg/ha± 110.0 [all variance one standard deviation] to 241.3 kg/ha ±119.7), whilst the control area showed a significant decline (350.5 kg/ha ± 202.0 to 222.9 kg/ha ± 104.6). Hard coral cover showed a significant decline in the managed area (32.75 %, ± 11.76 to 25.83 % ± 8.00). Lack of awareness of the no-take zone by adjacent villages, poaching and storm damage in early 2007 are possible contributing factors to these declines. With the help of a national legal NGO, the Centre for Environmental Law and Community Ownership Rights (CELCOR), the community is developing a management plan and laws recognized by local government to protect their customary managed marine area.

## 23.926

**Incorporating Human Usage Into Conservation Planning And Management Of Coral Reefs: New Spatial And Temporal Mapping Of Use At Ningaloo Reef, North-Western Australia**

**Lynnath BECKLEY*[1]**, Claire SMALLWOOD[1], Amanda LOMBARD[2], Susan MOORE[1], Halina KOBRYN[1], Jody NIEMAN[1]

[1]Environmental Science, Murdoch University, Perth, Australia, [2]Conservation Systems, Sedgefield, South Africa

The data requirements for systematic conservation planning include appropriate spatial and temporal information about biodiversity and human use of resources. Limited work has been conducted on coral reefs in Australia (and elsewhere) to collect and combine spatially explicit and temporally grounded human usage data with biodiversity information to progress conservation planning. Ningaloo, a remote, fringing reef off north-western Australia is well known for its rich biodiversity and a Marine Park has been established in the region. However, Ningaloo has a long history of Aboriginal use of coastal resources, commercial exploitation of turtles, whales and fishes and, more recently, a proliferation of tourist and recreational usage. A project is underway to map the spatial and temporal distribution of recreational activities within the Ningaloo reef lagoon system and relate this to factors such as biodiversity, physical conditions, marine park zoning, access roads and accommodation nodes. Throughout 2007, aerial and shore-based surveys were undertaken along the 300 km length of the reef, and all recreational and boating activity in the lagoon was recorded in a geo-referenced format. Results indicate specific usage nodes and marked seasonality in use of the reef (Easter and July school holidays and the winter months). Relaxing on the beaches was the most frequently recorded activity and snorkelling, swimming, walking and fishing were also popular. During peak periods, hourly data on boat launching at Coral Bay and beach usage at favoured sites such as Turquoise Bay revealed distinct temporal patterns. The project has provided a robust data set that can be incorporated into systematic conservation planning and guide future management of the reef. Additionally, this project contributes directly to an integrated ecosystem and socio-economic model being developed for the Ningaloo region.

## 23.927

**Temporal Variation Of Fish Assemblages in Tung Ping Chau Marine Park, Hong Kong Sar, China**

**Yin Ha LAM*[1]**, Put ANG[1]

[1]Marine Science Laboraty, Department of Biology, The Chinese University of Hong Kong, Shatin, Hong Kong

This study reports results from a monitoring program (1998 – 2006) investigating the protection effects on reef fish assemblages in Tung Ping Chau Marine Park (TPCMP), Hong Kong, by temporal comparison of fish assemblages before and after the marine park designation in 2001. Underwater visual census was employed from 1998-1999, and 2002-2006 in two core areas, A Ye Wan (AYW) and A Ma Wan (AMW), where fishing activities are prohibited after 2001.

An increase in fish density was recorded in 2002-2004 (3.6 individuals/$m^2$ in AMW; 1.9 individuals/$m^2$ in AYW). This dropped to pre-protection level (2.6 individuals/$m^2$ in AMW; 1.05 individuals/$m^2$ in AYW) in 2005 and 2006. Fish diversity also increased in both areas in 2002-2004 but decreased from 2004 to 2006 in AMW. An abrupt decrease in fish diversity in AYW in 2006 was due to a serious physical disturbance to the site. Fish biomass data were also collected since 2003. However, no significant temporal difference in fish biomass (20.5g/$m^2$-2.8g/$m^2$) was found throughout 2003 to 2006 in AMW, while fish biomass decreased from 2003 (64.3g/$m^2$) to 2006 (1.72g/$m^2$) in AYW. SIMPER analysis (Primer 6) revealed the contribution of fishery target species, including *Mugil cephalus cephalus*, *Siganus canaliculatus* and *Monacanthus chinensis* to the differentiation of fish assemblage structure in the years after marine park designation. The contribution of these same species, however, decreased in 2005 and 2006 in both areas. The drop in overall fish density and in the abundance of fishery target species may be due to an increase in poaching activities observed inside the marine park in recent years. This apparently wiped out all the initial gains in fish density and diversity in the early years immediately after the marine park designation.

## 23.928

**Managing Dive Tourism in Sipadan, Sabah, Malaysia**

**Ridzwan ABDUL RAHMAN*[1]**, Zarinah WAHEED[1], Paul BASINTAL[2], Jamili NAIS[2]

[1]Borneo Marine Research Institute, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia, [2]Sabah Parks, Kota Kinabalu, Malaysia

Sipadan Island, Sabah, Malaysia is an internationally renowned SCUBA diving destination. Divers began exploring Sipadan as early as in 1984. It became more famous after Jacque Cousteau released a documentary film on his 1987 expedition about the uniqueness of its coral reefs. Dive operators capitalized on Cousteau's "rediscovery" to further promote Sipadan at local and international levels. This paper describes the development and changes that took place in Sipadan over the last two decades and the present efforts to manage the thriving SCUBA diving industry there. It discusses the rational and basis of instructing resort operators to relocate or move out of Sipadan, setting the limit/quota of divers to Sipadan and introducing and spreading divers to new dive sites near Sipadan. It also describes the scientific monitoring program introduced based on the concept of Limit of Acceptable Change to assist in the management of the coral reefs of Sipadan and to sustain the dive industry.

## 23.930

**Green Fins-Thailand: Coral Reef Conservation in The Face Of A Tourism Epidemic**

**Kanyarat KOSAVISUTTE*[1]**

[1]Green Fins Project, Phuket, Thailand

In Thailand, reefs along Andaman and Thai Gulf coast cover 160 square kilometers. Only sixteen sites are designated National Parks. Over 670 dive, snorkel tour and boat operators bring an estimated million guests to visit primary dive sites during the six month high season each year.

Currently, there are many problems contributing to reef destruction. The Government lacks infrastructure planning for the growing tourism industry and promotes reef tourism without conservation and resource management. National Parks possess insufficient human resources. Dive and tour operators lack an understanding of reef ecology and use the natural resource for business only. The popularity of reef tourism is ever increasing and this lack of management is causing devastation on the reefs of Thailand.

The Green Fins mission is to protect and conserve coral reefs by establishing and implementing environmental-friendly guidelines for divers. We actively seek out dive operators, introduce our program, educate and encourage operators to become members. We also arrange for individual members to participate in activities such as cleanups, reef monitoring, or exhibitions. Members receive certificates and materials to promote good diving practice. To renew membership, operators are assessed yearly based on Green Fins Code of Conduct criteria. We use this network to promote sustainable dive and snorkel tourism industry.

We hope that in the future, tourists will begin to ask operators whether they are Green Fins members and choose to dive with Green Fins friendly operators. In this way, the Green Fins Programe will establish a network of active conservationist divers and snorkels, spreading the word quickly and being an effective voice for positive change in the dive and snorkel tourism industries. We hope that someday, our methods will be applicable to other heavily toured nations facing similar problems.

## 23.931

**Lessons Learned and Best Practices in Coral Reef Management**

**Mark TUPPER*[1]**

[1]The WorldFish Center, Penang, Malaysia

Since the 1990s, over $320 million of Global Environment Facility (GEF) funds were invested in projects at varying action and technical levels to improve the management of coral reef, seagrass and mangrove habitats, much of which was part of a broader portfolio of over $600 million invested in coastal-marine projects overall. The dissemination of best practices based on lessons learned is a strategic priority for the GEF. The objective of this project is to formalize the experiences, outcomes and lessons learned from previous GEF projects, as well as major non-GEF initiatives involving coral reefs and associated ecosystems. The project aims to comprehensively identify, analyze, and translate lessons into good practices and information resources, and then disseminate this information globally for use in future project design and development. A total of 115 projects (65 GEF projects and 50 non-GEF projects) were examined for lessons learned and best practices. Of these, 53 projects yielded useful lessons learned and best practice information. These lessons were synthesized and used to create an online toolkit that will aid managers in decision-making by providing them with information on the successes and failures of past projects over a wide range of locations and contexts.

## 23.932

**Adaptive Management Of Crown-Of-Thorns Starfish in Sekisei Lagoon, Japan**

**Hiroyuki MATSUDA*[1]**, Takuro SHIBUNO[2], Mitsuhiro UENO[3]

[1]environment, Yokohama National University, Yokohama, Japan, [2]seikai Institute Of Fisheries Sciences, Ishigaki, Japan, [3]yaeyama Fisheries Association, Ishigaki, Japan

Coverage, community type, starfish density and other data have been observed in 104 points of Sekisei coral lagoon, Yaeyama Island, Okinawa, Japan, since 1983. Using these data, we estimated the 95% confidence interval of the number of Crown-of-Thorns starfish in Sekisei coral lagoon. The area of each survey grid is 2500$m^2$ and the area of Sekisei coral lagoon is approximately 100$km^2$. We assumed that the sighting probability is 100% and the 102 observed grid is randomly sampled. To obtain the required number of catch, we also assumed the observed rate of population increase is 50% per year. Using bootstrap method and observed data shown in Table 1, the number of starfish in 2004 was between 217,796 and 21,027. Even using the lower limit of 95%CI, the increasing number of starfish is definitely larger than the number of catch in 2003 (4437 starfish). The estimated rate of population increase is between 53 and 73% per year. We need to catch 15000 – 11370 starfish to prevent further increase of starfish in Sekisei coral lagoon. The total effort of culling starfish in 2004 is definitely short for preventing further increase of starfish.

## 23.933

**Evaluating The Success Of Four Small-Scale, Community-Based Marine Protected Areas (Mpas) in The Philippines Through Socio-Economic And Biophysical Assessment: Results From 3 Years Of Intensive Monitoring**

**Jan-Willem VAN BOCHOVE*[1]**, Shay O'FARRELL[1], Simon HARDING[1], Matthew DOGGETT[1], Claudio DE SASSI[1], Harriet MORRALL[1], Peter RAINES[1]

[1]Coral Cay Conservation, London, United Kingdom

Sogod Bay, which lies in the Visayas region of the Philippines in the Province of Southern Leyte, supports a large number of coastal villages mainly through subsistence fishing. The generally good status of the coastal resources within the bay can be partly attributed to effective governance by the Provincial Government (PGSL), which is highly supportive of local initiatives and has successfully upheld local fishery regulations.

Coral Cay Conservation, working closely with the PGSL and local coastal communities, helped to establish a small network of four MPAs within the Padre Burgos municipality in May 2005 as part of the ongoing Southern Leyte Coral Reef Conservation Project (SLCRCP). During the MPA establishment process, a number of activities were initiated with the local communities. These included environmental education and awareness programmes, participatory planning workshops and visits to well-managed, community-based MPAs in neighbouring provinces.

Monitoring of coral reef parameters such as benthic cover, motile invertebrate and reef fish abundance was conducted over three years (2005-2007) both inside and outside the MPA's. Data for reef fish abundance indicated that populations of selected fish families within the MPAs have increased since fishing was restricted or prevented. The local coastal communities have been highly supportive of the MPA initiative, with fishers reporting higher catches after one year of protection, further encouraging community involvement.

One of the main successes of the SLCRCP is the creation of a vast amount of awareness amongst local communities about the importance of securing their marine resources in order to sustain traditional livelihoods. This has resulted in neighbouring communities requesting assistance for their own coral reef management initiatives. The overall long-term objective is to establish a well managed and comprehensive network of community based MPAs within the whole of Sogod Bay.

## 23.934

**Characterizing Local Stakeholder Use And Perceptions Of Coral Reef Conditions To Develop Management Options For Southeast Florida Reefs**

**Manoj SHIVLANI*[1], Richard RUZICKA*[2]**

[1]Marine Biology and Fisheries, University of Miami, Miami, FL, [2]FL Department of Environmental Protection, Miami, FL

The Southeast Florida Coral Reef Initiative (SEFCRI) is a collaborative effort across county, state, and federal agencies, marine resource professionals, scientists, non-governmental organizations, and interested stakeholders to improve protection of coral reefs in southeast Florida. SEFCRI is addressing a variety of threat areas and developing coral reef management options for the ~105 mile northern stretch of the Florida reef tract extending from the northern border of Biscayne National Park in Miami-Dade County to the St. Lucie Inlet in Martin County. The Fishing, Diving, and Other Uses (FDOU) threat area is addressing the impacts related to fishing and diving activities. One FDOU project characterized the use patterns and perceptions of seven stakeholder groups in the study region. Using a variety of methodologies, the project received a combined total of 1,932 surveys from charter fishing operators, commercial fishers, dive operators, recreational anglers, researchers, managers, sport divers, and surfers. Use patterns showed general site fidelities based on resources targeted for consumptive user groups and proximity of access points for non-consumptive users. All user groups agreed that coral reef conditions in the SEFCRI region have declined since they first began their activities in the region, suggesting a stakeholder-wide consensus on coral reef decline in southeast Florida. Importantly, all user groups rejected maintaining the current form of management and ranked less management or property-based management as the least preferred approaches to protecting the area's coral reefs. Most favored interpretative management over other options, with some groups preferring greater enforcement. The results suggest that stakeholders are generally dissatisfied with current approaches to protect coral reefs and most would prefer an interpretative approach, buttressed in part by greater enforcement, to reverse a deteriorating trend. The results of this study will be used in combination with future FDOU projects to recommend management options for southeast Florida reefs.

## 23.935

**Knowledge Diffusion in Two Marine Protected Area Networks in The Central Visayas Region, Philippines**

**Diana M. PIETRI*[1]**, Patrick CHRISTIE[1], Alan WHITE[2]

[1]School of Marine Affairs, University of Washington, Seattle, WA, [2]Global Marine Initiative, The Nature Conservancy, Honolulu, HI

In the Philippines, community-based marine protected areas (MPAs) are a common form of coastal resource management. Unfortunately, factors such as poor management, insufficient funding, and wavering community support have compromised the success of many MPAs. In order to strengthen both the biological and social success of MPAs, organizations have begun instituting MPA networks. In the Central Visayas, Coastal Conservation and Education Foundation (a domestic NGO) and Fisheries for Improved Sustainable Harvest (a USAID-funded project) are implementing networking initiatives. Educational programs (orientations, cross visits, community monitoring of MPAs, etc.) are integral components of these projects. This paper will analyze the relationship between educational techniques, knowledge diffusion and standard measures of MPA success (such as MPA rule compliance) within and between communities in these networks. Surveys were conducted with individuals in 36 communities in the two MPA networks. Spearman correlation analysis shows that compliance has a positive correlation with diffusion and education factors such as participation in cross visits ($r=.364$, $p<0.05$) and the presence of educational programs ($r=.371$, $p< 0.05$). This suggests that educational programs may influence the overall success of an MPA. Additionally, there is a positive correlation between participation of MPA managers in cross visits and the presence of community MPA education programs ($r=.542$, $p< 0.01$). This implies that diffusion of knowledge between communities could lead to stronger education within a community itself. Training of MPA managers by the outside organizations correlates positively with the effect monitoring programs on management methods ($r=.442$, $p< 0.01$), indicating that educational programs have the potential to facilitate effective use of monitoring information. Overall, the findings of this study have implications for MPA practitioners and managers in evaluating and planning the educational components of MPA networking programs.

## 23.936

**Variable Rates Of Biodiversity Recovery in Marine Protected Areas Of The Florida Keys National Marine Sanctuary**

**Nathan LEMOINE*[1]**, Kenneth HECK, JR. [1], John VALENTINE[1]

[1]Dauphin Island Sea Lab, Dauphin Island, AL

The effectiveness of Marine Protected Areas (MPAs) as coral ecosystem restoration tools has now been extensively evaluated. Initial assessments of the efficacy of this management tool suggested that the establishment of MPAs led to increased exploited fish biomass and species richness in as little as 3-5 years; however recent studies suggest that critical methodological shortcomings existed in these initial assessments and that the effectiveness of existing MPAs has been much more variable than contemporary thinking has shown. In this study, comparisons of MPAs in the Florida Keys National Marine Sanctuary with similarly sized unprotected areas failed to show significant increases in fish density or species richness, with two exceptions, suggesting that the simple establishment of an MPA will not automatically restore reef biodiversity. MPAs in the southern FLKNMS did show signs of success, yet northern sanctuaries revealed no such response, indicating that reef landscape characteristics or location play a role in determining MPA success. It is also possible that other factors, such as age or processes acting on large spatial scales, such as larval dispersal, fragmentation and the resultant island biogeography, could largely be responsible for controlling local variability in reef fish populations, and thus should be taken into account in reserve designation. Habitat criteria have also been overlooked in many studies, despite acknowledgement that available habitat may be the driving force behind rarity and biodiversity maintenance on coral reefs (Lottery Model). Thus, ranking the relative importance of critical habitat characteristics (structural complexity vs. microhabitat diversity vs. live coral cover) is also needed for proper placement to maximize reserve efficiency.

## 23.937

**Advantages Of Direct Incentive Approaches in Marine Management Areas**

Eduard NIESTEN[1], **Heidi GJERTSEN*[1]**, Richard RICE[1]

[1]Conservation Economics Program, Conservation International, Arlington, VA

One of the most common challenges in setting up and managing marine management areas (MMAs) throughout the world is the difficulty of competing with fisheries and other marine resource sectors that offer tangible economic benefits such as employment and revenues to both governments and local stakeholders. Unless decision-makers and stakeholders face incentives that appropriately reward them for conservation, conservation will not be achieved. Existing conservation efforts around the globe take many different forms, and one way in which they differ is the directness of incentives provided under a particular type of intervention. Directness refers to the link between the benefit provided and the behavior or conservation outcome, i.e. to what degree benefits are tied directly to conservation performance. For instance, the impact on incentives is very different in the case of an alternative livelihoods project compared to a buy-out of fisheries licenses. This research effort examines the impact of different forms of incentives through a case-study based comparison of a selection of projects representing a variety of approaches. The objective of this study is to assess the effectiveness of interventions with varying types of incentives in terms of cost, sustainability, socio-economic outcomes, and conservation outcomes. Thus, the research sheds light on the relative efficacy of different approaches as a function of the directness of incentives provided, and in doing so identifies factors and enabling conditions that favor particular approaches. We conclude that more direct incentives, such as those offered by license buy-outs and explicit incentive-based conservation agreements, offer distinct advantages over indirect approaches.

## 23.938

**Macrobenthic Diversity Reaction To Human Impact At MaceiÓ Coral Reefs, Alagoas, Brazil.**

**Monica CORREIA*[1]**, Hilda SOVIERZOSKI[1]

[1]Biodiversidade & Ecologia, Universidade Federal de Alagoas, Maceió - Alagoas, Brazil

The Brazilian coral reef is an important province because it has many endemic species of corals, other invertebrates and macroalga. The fringing reefs are situated at different depths on offshore zone and some others are near the beach line that is usually visited by hundreds of people such as local collectors of sea-food, anchored boats and tourist activities. In the State of Alagoas the coral reefs are abundant and in some areas the top of the platform reef remains exposed during low tides, where different human impacts occur, principally at urban sites. This study compared the macrobenthic diversity reaction between five coral reefs on the coast of Maceió city with different human impacts. A semi-quantitative estimation of live specimens abundance were observed and has been applied to each station and consisted of an exhaustive compilation of visual records achieved during five full low-tide periods from 2005 to 2007. The 50 taxa of macrobenthic organisms observed included porifera, coral, echinodermata and macroalgae. The Bray Curtis index and UPGMA were measured for data analysis. The results showed that Jatiúca (50 spp) and Ponta Verde (50 spp) coral reefs were more similar with 0.2 for cluster analysis and the impacts were few, only collectors of sea-food. The Pajuçara (48 spp) and Amores (47 spp) coral reefs were included in the same cluster with 0.4 and 0.5, but anchored boats caused the human impact also. The different aspect observed at the Piscina Natural (13 spp) coral reef with 0.8 for cluster analysis had few species and the human impacts were caused by tourist activities and anchored boats. These facts advise for stricter control on human impacts on the coral reefs that were situated on the urban coast and prove that macrobenthic organisms can be useful data for monitoring the coral reefs.

## 23.939

**Post-Hurricane Rita Assessment Of Four Sensitive Banks in The Vicinity Of The Flower Garden Banks, Gulf Of Mexico.**

Donald DEIS[1], **Beth ZIMMER*[2]**, Leslie DUNCAN[2]

[1]PBS&J, Jacksonville, FL, [2]PBS&J, Miami, FL

Hurricane Rita, a Category 3 storm, passed over the northwestern Gulf of Mexico, in the vicinity of the Flower Garden Banks (83 km) on September 23, 2005. The 2005 hurricane season was the most active on record, fueled by record high sea-surface temperatures in the Atlantic (National Climatic Data Center 2005); with eleven tropical cyclones entering the Gulf of Mexico in 2005. Several shallow sensitive habitats within the Gulf of Mexico were closer to the path of Hurricane Rita which passed within 1.6 km of McGrail Bank, and 24 km to the west of Sonnier Bank. Hydrological models have hindcast wave heights up to 20 m acting on these banks. This may have left some bank caps exposed, even at 20-30 m depth. The implications for benthic community structure could have been catastrophic, and MMS considered it critical to characterize the banks in their post-hurricane state.

A study was performed to characterize and compare the benthic habitats of four banks and document possible effects of hurricane damage. Diver and ROV video was taken at four depth ranges to assess benthic cover to the lowest taxonomic level (20-25, 30-36.5, 45-50, 55-60m). Results show that Sonnier Bank, the only bank to the east of the storm (24km) exhibited the least live cover at all depths (~2-30%) when compared to other banks (~18-85%). Qualitative analysis of pre-hurricane video from 1996, 2002 and 2005 showed an apparent decline in Xestospongia colonies at Sonnier Bank, before the 2005 storm.

The four banks studied varied in their benthic community make up, even in close proximity. This suggests that these unique habitats are truly sensitive, since nearest neighbors may not be the source of recruitment. Relying on distant sources for biological recruitment, these habitats act as islands, possessing unique features not found elsewhere.

## 23.940

**Ecosystem-Based Management Of The Dongsha Marine National Park**

**Wei-Chien LAI*[1]**, Chang-Po CHEN[2]

[1]Dongsha Marine National Park Headquarters, Taipei, Taiwan, [2]Research Center for Biodiversity, Academia Sinica, Taipei, Taiwan

Ecosystem-based management addresses equally the importance of conservation and sustainable use of the given ecosystem. As 25 kilometer wide in diameter with a 2-kilometer-wide reef rim that encompassing an area of 500 square kilometer, Dongsha atoll is the only fully-developed atoll in the Northern South China Sea, with Dongsha Island locating on the northwestern of the lagoon. Thanks to the upwelling, the atoll is home to a variety of coral fish and other diverse marine life. However, the abundant fishery resource also leads the Dongsha Atoll to a drastic fate of damaged habitats from destructive fishery, which causes the degradation of the whole ecosystem as well as its resilience to disturbances.

Guided by the Dongsha Atoll National Park Plan, we reviewed the Great Barrier Reef Heritage's 25-year strategic plan, U.S. Florida Keys National Marine Sanctuary Management Plan, U.S. Northwestern Hawaiian Islands National Marine Sanctuary Management Plan Draft, and the associated studies done by Taiwan's researchers.

The proposed Dongsha Atoll National Park Strategic Plan Draft contains the introduction of the Dongsha Atoll ecosystem and history of the park's designation, the vision and principle of the management, and the Dongsha Atoll National Park Action Plan. The Action Plan is illustrated by 4 levels: 20 years of long term objectives, 5 years of short term objectives, 30 strategies, and 114 actions. In addition to the enforcement of reducing illegal fishery applications, the primary actions to be undertaken are sea floor mapping, infrastructure completion on the island to deal with its intrinsic shortage of fresh water and natural resource, launch of a marine station, and the establishment of the Dongsha Eco-volunteer system.

## 23.941

**Mitigating Nearshore Benthic Resources in Florida: Identifying Problems And Lessons Learned From The Past**

**Greg WARD*[1]**, Jessica CRAFT[1], Erin HAGUE[1], Angela DELANEY[1], Stacy PREKEL[1]

[1]Marine Science & Biological Research, Coastal Planning & Engineering, Boca Raton, FL

Artificial reef (AR) construction has historically focused on fisheries enhancement and, more recently, has advanced as a method to mitigate for the loss of benthic epifaunal habitat. A variety of AR designs and materials have been used with varying degrees of success; however, comparison of AR biotic assemblages is commonly made to nearby natural habitat and equivalency is determined on a relative basis. Conclusions drawn from studies are, therefore, typically relevant only on a local scale. In this study, the succession of biotic communities on ARs from two regions in Florida, USA, are compared to the low-relief, natural hardbottom habitat for which the ARs were meant to mitigate impairment. Among and between region comparisons of AR biotic assemblages are examined for common successional themes. The unique siting, materials, and physical structure of each of these ARs are discussed in relation to project "success", as dictated by the stated objectives, and also as a proxy for natural habitat. Results indicate that, while project objectives may be fulfilled, the relief and structural complexity of ARs often exceed that required to successfully mimic low relief habitat. The increased rugosity of the created habitat often does not allow for the intermittent sand scouring and smothering encountered by benthic epifauna, and can attract intermediate and large size fish not typically found on natural, low relief hardbottom. These issues are addressed here, along with suggested practices and guidance on how best to replace impacted nearshore benthic resources, for future coastal construction projects based on lessons learned from the past.

## 23.942

**Challenges in Coral Reef Management: Lessons Learnt From Education And Outreach Projects in The Mexican Caribbean**

**Sarah FRIAS-TORRES*[1]**, Maria BELLO[2], Rafael ARAUJO[3], Hernando CARDENAS[4]

[1]RSMAS-UM and MRAG Americas, St. Petersburg, FL, [2]Southeast Fisheries Science Center, NOAA-NMFS, Miami, FL, [3]Marine Biology and Fisheries, RSMAS -University of Miami, Miami, FL, [4]CIMAS, RSMAS -University of Miami, Miami, FL

The Mexican Caribbean (Mayan Riviera) has one of the fastest tourism growth rates in the world. It contains part of the Meso-American Barrier Reef. Uncontrolled tourism development threatens its coral reefs and associated habitats. We report the current pressures, challenges, successes and failures in coral reef management as obtained through two workshops organized before (Playa del Carmen, 2004) and after (Cancun, 2006) hurricane Wilma in the region. The workshops focused on conservation and sustainable use of coral reefs and associated habitats (mangroves, seagrass), and targeted managers, government officials, lawyers, tourism developers, architects, engineers, teachers and students. Testimonials provided by workshop attendees allowed to ground-truth reef management strategies on paper with reality, and how local communities perceive the increase in tourism development versus the degradation of coral reefs and associated habitats.

## 23.943

**Applying Coral Reef Impact And Ecological Function Concerns Into Research Activity Permits**

**Dave GULKO*[1]**

[1]Division of Aquatic Resources, Hawaii Dept of Land & Natural Resources, Honolulu, HI

Many coral reef management jurisdictions issue permits to allow for take of aquatic life for scientific, educational, or propagation purposes; and traditionally have evaluated permitting requests based upon species-related concerns borne out of a history of regulating fisheries in many cases. As resource trustee agencies start to focus more and more on ecosystem-based approaches towards resource management, there is increasing awareness of the need to apply such concerns into actions involving various user groups individually, and as a whole. One group that often has very direct impacts to coral reefs along a wide spectrum is the research community. While specific rules and laws vary greatly amongst jurisdictions, the impact concerns that need to be considered relative to various impact activities are relatively consistent but rarely applied to activities involving research (outside of highly regulated MPAs). In Hawaii, we are adopting a checklist-based approach towards permit review which incorporates ecosystem-based approaches including ecological function concerns and both direct and indirect habitat impacts. Issues related to bioprospecting, alien species, rare species and Species of Concern, and user conflicts are also included. The checklist approach encourages more transparency, fairness, and documentation of permitting review while providing directly for appropriate Special Conditions relative to the type and impact of the research being proposed for the type of coral reefs to be accessed. Such an approach allows for both synergistic and cumulative impacts to be considered within a permit and across permits for a designated area.

## 23.944

**The Ecological Effects Of Marine Preserves in A Grouper-Free And Diadema Rebounding System in St. Croix, Usvi**

**Alex BURPEE*[1]**, Robert HUMSTON[2], Lisa GREER[1], Dennis HUBBARD[3]

[1]Geology, Washington and Lee University, Lexington, VA, [2]Biology, Virginia Military Instiute, Lexington, VA, [3]Geology, Oberlin College, Oberlin, OH

Previous research has demonstrated that protected reefs have higher densities of parrotfish, predatory fishes, and live coral than unprotected reefs. This conclusion was drawn while assuming grouper as the dominant predator and ignoring the impacts of *Diadema antillarum* grazing. We collected data from a protected site and an unprotected site in St. Croix, an area with an imperceptible grouper population and a rebounding *Diadema* population. This biological setting in St. Croix allows us to test this theory in a different environment. Buck Island has been a marine preserve since 1961, and it is located approximately 5 km north of St. Croix. It is one of the oldest of its kind and it acts as a comparison reef against Tague Bay, an unprotected reef located on the north coast of St. Croix. Several biological indicators were monitored on both reefs to assess community composition including the densities of parrotfish, *Diadema*, and predatory fishes. The fish data were collected by means of duplicate 10-minute counts for two 10 m transects at each depth at depths of 7.5 m, 4.5 m, and 2 m. Measurements were taken from 3 different sites on each of the two reefs providing assessments that are identical in both methodology and area assessed. In a parallel study, algal cover, live coral cover, and bioerosion rates were also quantified in order to characterize the ecological and biological conditions that exist on the two reefs. Preliminary analyses have indicated that the densities of parrotfish and predatory fishes are greater on the protected reef (2,286 vs. 1,507 parrotfish). Coral data are still being analyzed. Interestingly, *Diadema* densities on the unprotected reef were significantly higher than on the protected reef (3,123 vs. 400). The difference in *Diadema* densities could reflect a competitive interaction between grazers related to reef management. The implications of this and other community dynamics on coral and algae density will be discussed.

## 23.945

**Strengthening Management Of U.s. Coral Reef Ecosystems**

**Takiora INGRAM*[1]**, Evangeline LUJAN[2]

[1]All Islands Coral Reef Secretariat, Honolulu, HI, [2]Bureau of Statistics and Plans, Government of Guam, Hagatna, Guam

Strengthening Management of U.S. Coral Reef Ecosystems

The U.S. All Islands Coral Reef Committee (AIC)[1] is a collaboration of Governor-appointed marine resource managers from state, commonwealth, territorial agencies and freely associated states (FAS), working together with federal agencies to conserve and protect coral reefs in the United States. They are responsible for managing approximately 95 percent of U.S. coral reefs.

*Objective:* This paper analyses the progress made through Local Action Strategies (LAS) to reduce threats from the adverse impacts of human activity on coral reef ecosystems implemented by members of the AIC, in partnership with NOAA's Coral Reef Conservation Program and the Department of the Interior (DOI).

*Methods*: Six main threats to coral reef ecosystems were prioritized by the AIC for implementing LAS projects: land–based sources of pollution; over fishing; recreational overuse and misuse; lack of public awareness; and climate change, coral bleaching, and disease.

Outcomes include: improvement in policies and management capacity; sharing of management experiences amongst jurisdictions; engagement of local community stakeholders; leveraging partnerships with government agencies, NGOs, academic institutions and the private sector; establishing public outreach programs; and effective coral reef research.

Key challenges include: need to strengthen local management capacity; provide additional resources for LAS projects; engage local communities and more federal agencies in LAS projects; ensure coral reef management is community based and locally driven; and link research priorities to management.

*Conclusions*

Leveraging partnerships and sharing experiences amongst jurisdictions are the main strengths of the AIC. Increased resources are needed to enable local managers to address increased threats to coral reef ecosystems.

## 23.946

**Potential Threats To Cetaceans in The Cagayan Ridge With Special Note On Populations Within The Tubbataha Reefs Natural Park (Trnp)**

**maria theresa AQUINO*[1]**

[1]tubbataha management office, puerto princesa, Philippines

The Tubbataha Reefs Natural Park (TRNP) is a significant feeding area for many cetacean populations found in the Cagayan Ridge Marine Biodiversity Conservation Corridor (MBCC). This paper reviewed several past and current studies and activities to identify threats to these populations and their habitat. By closely scrutinizing these threats, recommendations and mitigating measures were identified to assist the Tubbataha Protected Area Management Board (TPAMB) in enhancing their management policies and actions. Special attention was given to populations within the expanded boundaries of the TRNP which is currently undergoing re-nomination as a world heritage site.

Threats seen along the Ridge included major issues such as solid waste and chemical pollution, fisheries-related problems and seismic exploration activities. Although these threats were noted to emanate from outside of the TRNP boundaries, the potential impacts of these threats were nonetheless significant to the ecological stability of the TRNP. It was thus recommended that Park authorities coordinate closely with national agencies that have jurisdiction outside of the Park to work on minimizing these impacts. Furthermore, a 10-nm buffer zone around TRNP was suggested to lessen the impacts of these threats to the biodiversity within. Corollary to this, the TRNP management plan needs to be amended to include the management of the expanded area and the buffer zone.

## 23.947

**The Caribbean Marine Protected Areas Management Network And Forum: Building A Learning Community To Enhance Coral Reef Management**

**Georgina BUSTAMANTE*[1]**, Alessandra VANZELLA-KHOURI[2]

[1]Best Marine Practices, Hollywood, FL, [2]UNEP- Caribbean Environment Programme, Kingston, Jamaica

Caribbean marine protected areas (MPAs) are struggling to implement creative ways to effectively conserve coral reef resources while assisting local communities in the development of sustainable management practices.

This paper describes the lessons learned over the past 10 years by CaMPAM, a network of MPA professionals, in using a combination of training and networking tools to develop a learning community focused on MPA science and practice. From its creation by the UNEP Caribbean Environment Programme in 1997, CAMPAM has grown up, expanded its program, and increased its international recognition among the marine science and management communities. This has been achieved with the contribution of local and international partners and the support of donor agencies. However, as the Caribbean MPA management community matures, and threats from coastal development, overfishing and climate change increase, CaMPAM is challenged to find new tools to build capacity and enhance communication. A balanced combination of old traditional mentorship-apprentices schemes, exchange visits, and a training the trainers program along with more advance web based tools (databases, bogs, e-learning portals, etc.) is needed to meet this challenge. This ambitious goal can only be achieved with the contribution of government agencies, non-governmental organizations, scientists, and donors

## 23.949

**The State Of Marine Managed Areas (Mmas) To Conserve U.s. Coral Reef Ecosystems**

**Lisa WOONINCK*[1]**, Rikki GROBER-DUNSMORE[2], Mimi D'IORIO[2], Charles WAHLE[2]

[1]NMFS/MPA Center, NOAA, Santa Cruz, CA, [2]MPA Center, Santa Cruz, CA

Marine managed areas (MMAs) of all types are an increasingly common approach to coral reef conservation in U.S. waters (0-200 nm). Presently, 11% of the Pacific Islands waters and < 1% of the Caribbean waters are contained within 100 and 42 MMAs, respectively. Federal programs manage the largest proportion of MMAs in the Pacific Islands (80%). In contrast, the federal share of Caribbean MMAs is much less (10%) compared to territorial management programs (89%). The vast majority of area within coral reef MMAs allows multiple use activities (99%), such as fishing and extraction of other associated coral reef resources. Contrary to widely held perceptions, only a very small percentage of the coral reef MMA area (Pacific Islands 0.01%; Caribbean region 0.13%) is contained within no-take marine reserves or no access areas. Importantly, the use of marine zoning inside of multiple use MMAs is emerging as an effective means to spatially or temporally allocate human uses, while ensuring protection of critical coral resources. In the Caribbean, 5% of MMA area comprises seasonal no take zones. In the Pacific, no take zones within larger multiple use MMAs make up 19% of all coral reef MMA area. In general, large (median size 32 $km^2$) multiple use MMAs have several, small (median size 1 $km^2$) no-take reserves contained within portions of their boundaries. For example, spawning aggregations and other critical habitat are protected in the Tortugas Ecological Reserve (a no take zone), which is embedded within the larger multiple use Florida Keys National Marine Sanctuary, while bottom fishing is allowed in specific zones of the limited use Papahanaumokuakea Marine National Monument. Analysis of the MPA Center's national inventory of MMAs reveals important trends in the distribution, size, and management approach of MMAs to conserve coral reef ecosystems within the U.S.

## 23.950

**The Making Of The Base Maps For Coral Reef Conservation. A Case Study Of The Shiraho Area in Ishigaki Island, Okinawa, Japan**

**Rintaro SUZUKI*[1]**, Hitoshi HASEGAWA[2], Satoshi MAEKAWA[3], Kiyoshi ICHIKAWA[4], Tsuyoshi SHIBATA[5], Yoshiyuki GOTO[4]

[1]Institute for Applied Geography, Komazawa University, Tokyo, Japan, [2]Department of Geography and Environmental Studies, Kokushikan University, Tokyo, Japan, [3]WWF Japan Coral Reef Conservation & Reseach Centre, Ishigaki, Japan, [4]Komazawa University, Tokyo, Japan, [5]Naigai Map Co.,Ltd, Tokyo, Japan

The Shiraho coral reef in the east side of Ishigaki Island maintains the healthy coral reef ecosystem, which is famous for the largest colony of *Heliopora coerulea*. The local people uses the shallow lagoon to get fishery products and recently a lot of tourists visit there to enjoy the beautiful scenery. However, the coverage of corals in this area has been decreasing for various factors. This study aimed to establish of the new technique of fundamental map of the coral distribution in shallow lagoon, which can support the activity for coral reef conservation.

About the shallow water area like coral reef, because of no landmarks and underwater condition, any maps with exact benthic landscapes have not been supplied. Therefore, making a field map which shows the specific structure is the first step for the investigation. The map was made based on an aerial photo of the Geographical Survey Institute. To draft the map, the distorted aerial photo was rectified with the positional data of 60 GCP points set by DGPS and reformed to the olth photograph with resolution of 1m.

Referring to this photo, to clarify the distribution of corals in the study area, we recorded every coral species, coverage, and ranges of the same successive assemblages of species. The coverage of coral was computed from the surface area where the coral lives in three dimensions. We completed the coral distribution map with the result of the large-scale investigation and we found out the main area of Heliopora coerulea was about 26,177‡u.

The complete map can be used as not only database for coral reef survey also as positive basic information for coral conservation and management.

## 23.951

**Coral Reef-Based Tourism And The Private Boating Industry Of The Bahamas**

**Liana TALAUE-MCMANUS*[1]**, Wendy WOOD[2], Grant BROOKS[3], Garin DAVIDSON[4], Maria VILLANUEVA[1]

[1]Marine Affairs and Policy, University of Miami Rosenstiel School of Marine & Atmospheric Science, Miami, FL, [2]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [3]BoatHistoryReport.com, Windermere, FL, [4]Florida Sea Grant Boating and Waterway Management Program, University of Florida, Gainesville, FL

Both diving and private cruising represent major tourism sectors in small island states rich with coral reefs. This analysis represents an in-depth study of the latter sector, which has rarely been examined in terms of its contribution to reef-based tourism and its overall impact on coral reefs.

We studied the private boating industry in the Bahamas to assess its impacts and potential role in establishing and maintaining reef-based marine protected areas (MPAs). We estimated its economic contribution, identified boaters' travel and waste disposal patterns, and determined their knowledge of and willingness to pay for MPAs. Our sample size included respondents from 140 wintering (January-April) and 78 summer (May-July) cruising boats.

Cruisers generate about US$ 57 million in revenues, with winter cruisers accounting for 61% of total in-country expenditures in 2003. Longer-cruising winter boaters preferred Exuma followed by Abaco, and New Providence. Summer boaters chose Exuma, Cat Island , and Abaco as their top destinations. Most summer and winter boaters were repeat visitors, indicating that continued maintenance and improvement of boating destinations is imperative.

Cruisers offload a significant amount of waste at sea relative to what disposal facilities can accommodate and which can degrade the quality of reef environments. Fifty-nine percent of winter boaters and 72% of summer boaters offloaded their solid waste at marinas, while 37% of winter boaters and 20% of summer boaters did so at sea. For liquid waste, about 83% of winter boaters and 80% of summer boaters disposed at sea, and together accounted for 4% of the annual total nitrogen loading for the Bahamas. To encourage marina-based sewage disposal, a network of 12 pump-out stations may be installed for $132,000 or 2% of boating fees alone. The cruising industry can support coral reef-based MPAs financially and by adopting marina-based sewage disposal.

## 23.952

**A Baseline Socioeconomic Survey For The Community-Based Fishery Management Program Villages in American Samoa**

**Selaina TUIMAVAVE*[1,2]**

[1]DMWR, Am. Samoa Govt, Pago Pago, American Samoa, [2]DMWR, Am. Samoa Government, Pago Pago, American Samoa

The American Samoa Community-based Fishery Management Program works with ten village communities in American Samoa to implement conservation through village marine protected areas. The designation of these areas prohibit fishing communities to engage in any fishing activity in any of these areas unless authorized by the appropriate village councils. This project will determine the shift (if any) of lifestyle for these communities, how these village communities are affected and determine trends of different alternate activities these communities are engaging in. In doing this, a socioeconomic survey was conducted in the ten villages of the program on the island of Tutuila and four non-program villages in order to compare the data collected to determine any difference. According to the survey, communities are dependent on marine resources in order to fulfill their recreational time away from work and home. A small percentage of interviewees indicated a serious change in their lifestyle since the implementation of village marine protected areas. Additionally, the survey also indicated that although these communities highly depend on marine resources for subsistence and traditional purposes, a significant number of these interviewers would buy these resources from either a roadside fishermen, from the store or from off-island vendors. In conclusion, it is documented that in addition to fishing, these communities with village marine protected areas are accommodating their needs through other means like buying resources from the store. Additionally, these areas are beneficial in that they are improving the habitat quality for the communities to enjoy during openings when permitted by each village councils.

## 23.953

**Managing Reef Systems in Small Island Developing States (Sids): Case Study Of Balancing Reef Management And Tourism Development in The Bahamas**

**Kathleen SEALEY*[1,2]**, Nicolle CUSHION[1], Sherry CONSTANTINE[1]

[1]Biology, University of Miami, Miami, FL, [2]Marine and Environmental Studies Institute, College of The Bahamas, Nassau, Azerbaijan

The Bahamas is challenged with building a strong economic base for tourism throughout an island archipelago while balancing the environmental limitations of populating small islands. Although sustainable tourism is promoted throughout the Caribbean, there are few real ecological benchmarks or criteria for evaluating the long-term impact of development or the environmental soundness of a proposed development project. Reefs are particularly vulnerable to impacts of coastal development, but can rarely be managed by private entities. The Bakers Bay Golf and Ocean Club, Guana Cay, Abaco was used as a case study to understand the management and monitoring needs for a small island coastal system dominated by reef and hard bottom marine communities. The case study set out to determine best practices for 1.) Measurable ecological goals in reef protection, 2.) Tracking of information and decisions over time, and 3.) Building partnerships between ecologists, developers and government to manager user conflict over reef resource use. The case study points to the importance of having a 1) multi-year baseline data set to base adaptive management objectives, 2) the resources needed to implement assessment and monitoring, and 3) long-term economic data to put a real value on protection of reef resources.

## 23.954

**Coastal Clean-Up in Little Cayman in 2007**

**Sara KREISEL*[1]**, Diana SCIAMBI[1], Krista RICH[1], Lisa DUNNE[1], Roy DUCOTE[1], Vania COELHO[1,2]

[1]CCMI, Little Cayman, Cayman Islands, [2]Department of Natural Sciences and Mathematics, Dominican University of California, San Rafael

This study examined the annual accumulation rate of anthropogenic marine debris in the coastlines of Little Cayman. An initial clean-up was carried out in the summer of 2006 and was repeated in July 2007 to measure the rate of debris accumulation. Two undeveloped beach sites with no regular cleaning or maintenance were selected for this study; both were 200 meters long and 10 meters wide (2000 $m^2$), one is on the south (windward) side and the other is on the north (leeward) side of the island. Trash was collected from each site and separated in five categories: plastic, glass, shoes, Styrofoam, and ropes and nets. All bags were weighed and the volume was estimated. A total of 117.8 kilos or 1986.4 liters of trash was found, with plastics comprising nearly 60%, ropes and nets about 20%, and shoes 12%. By both weight and volume, there was nearly four times more garbage recovered from the windward side of Little Cayman than from the leeward side. This difference was probably due to the stronger winds and currents on the south side bringing more material to shore. Since the initial 2006 study, in which no previous clean-ups were known to have taken place in the selected sites, 56% as much weight and 73% of the volume of anthropogenic debris had re-gathered on the studied areas. Across the 32 km that makes up the coastlines of Little Cayman, we estimated 9.5 tons or 160 thousand liters of garbage accumulated over a one-year period. This type of coastal pollution is a serious issue and trash removal projects such as this one can contribute to decrease its effects on local communities.

## 23.955

**The Risk Assessment Of Soil Erosion For Better Management Of Coral Reefs in The Pacific**

**Pascal DUMAS*[1,2]**, Julia PRINTEMPS[2], Maxime FOSSEY[2]

[1]University of New Caledonia, Noumea, New Caledonia, [2]IRD, Noumea, New Caledonia

The Pacific islands that comprise nearly 25% of coral structures are increasingly subject to significant damage, the result of the increased local population and development activities on the coastal zone. Controlling pollution that could degrade these fragile ecosystems need to be able to assess the natural and human pressures developing upstream of this environment but directly affecting it. The management of coral reefs should be done through an integrated management of the coastal zone, taking into account the impacts of pollutants in watersheds. In the high islands subject to an aggressive tropical climate, sediment inputs are significant and a major cause of degradation of fringing reefs. To assess the sediment deposition into the lagoon, it is necessary to characterize the erosion process on the watersheds and to highlight the areas most affected by erosion. This paper describes the methodology implemented to map the sensitivity of soil erosion, looked at from the point of view of the potential emission of solid particles. We used the Universal Soil Loss Equation (USLE) to estimate the soil loss per unit area coming from surfacial erosion. Geographical Information System maps were derived for each of the factors involved in the USLE, including rainfall, slope steepness and length, soil erodibility, and cover. In a second step, the spatialization erosion hazard will be crossed with the degree of confinement of the marine environment in order to locate and prioritize risks of hyper-sedimentation, identifying threats of degradation of reef ecosystems. This work is being implemented on the islands of Efate in Vanuatu, Veti Levu in Fiji and Tahiti and Moorea in French Polynesia and the Grande-Terre in New Caledonia.

## 23.956

**Law Enforcement As An Effective Tool For Coral Reef Protection in Sri Lanka**

**Premathilaka BOLANDA HAKURU*[1]**

[1]Coast Conservation Department, colombo 10, Sri Lanka

This paper tries to examine the effectiveness of law enforcement as a tool to address anthropogenic coral reef management issues in Sri Lanka where the issues are triggered by short-term economical gains and they are occurring in a boarder geographical scale. Also in a country that's administrative system does not promote community based resource management initiatives. Mining coral from nearshore reefs for lime production, use of destructive fishing practices like blast fishing, uncontrolled collection of reef biota, pollution and siltation resulting from deforestation and other improper land use activities are the primary threats for Sri Lankan reefs. Considering the value of reefs for fisheries, coastal protection, tourism and biodiversity, a number of legislative measures have been taken by the government to ensure the conservation of the country' coral resources. Flora and fauna ordinance, Coast conservation act, Fisheries and aquatic resource development act and Marine Pollution Prevention Act are the important together provide an adequate legal coverage for the above mentioned issues and each agency has developed their own enforcement mechanisms. Especially enforcement capacity of the Coast conservation department has been strengthened during the last couple of years with the assistance of Asian Development Bank, Global Environmental Facility and UNDP. The results of the survey, undertaken my myself for the Coast Conservation department reveals the rate of compliance with law and regulations has been increased mainly due to the strict enforcement effort. However the uncoordinated enforcement efforts of different agencies are still to be addressed to enhance the effectiveness of reef conservation and management in Sri Lanka.

## 23.957

**Ten-Year Evolution Of Inter-Municipal Marine Protected Area (Mpa) Management in Lingayen Gulf, Northwestern Philippines**

**Severino III SALMO*[1,2]**, Kevin PACIFICO[2], Porfirio ALINO[2]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]The Marine Science Institute, Quezon City, Philippines

The lessons and experiences in the integration of community-based and local government approaches that led to the evolution of inter-municipal Marine Protected Area management arrangement in Lingayen Gulf, northwestern Philippines is characterized. From 1997 to 2002, MPAs were established and managed through community-based strategies in the municipalities of Bolinao and Anda. Subsequent efforts were made by the Local Government Units (LGU) of the municipalities of Bani and San Fernando in establishing MPAs in 2003 to 2005. Community-based approaches was effective in eliciting community participation in conducting regular management activities but was constrained by financial concerns and lacking institutional support. On the other hand, the local government-managed MPAs have more available financial resources and institutional accountability but had difficulties in engaging local communities. The success of both management approaches however was hampered by trans-municipal boundary problems, most notably encroachment and illegal fishing outside the MPAs. From 2005 to 2007 efforts on MPA networking were undertaken aiming to enhance the management effectiveness of each MPA at local and municipal-level as an entry for a gulf wide level ecosystem based management approach. Annual inter-governmental MPA Symposium served as the venue for each municipality in presenting the management status of each site and sharing the lessons learned in the management of each MPA. Initial joint patrolling and law enforcement was the main venue for joint action among municipal governments that resulted to the improvement of MPA management across sites. While the rate of improvement varies among sites, the analyses of monitoring data showed an increasing trend in coral cover and reef fish biomass. To capitalize on this initial success, the Lingayen Gulf MPA network should be formalize and develop more opportunities for cost-sharing activities as in other emergent activities around the country.

## 23.958

**Management Of Snorkeling Trails in The Andaman Sea And The Gulf Of Thailand**

**Se SONGPLOY*[1]**, Nipat SOMKLEEB[1], Nisit RUENGSAWANG[2], Jamrearn BUARUANG[1], Thamasak YEEMIN[1]

[1]Biology, Marine Biodiversity Research Group, Bangkok, Thailand, [2]Biology, Rajamankala University of Technilogy Krungthep, Bnagkok, Thailand

The Indian Ocean Tsunami incident on December 26, 2004 had caused casualties on human lives, properties and various resources on the Andaman coast of Thailand. The damaged coral reefs are required to have a recovery period with suspension of all tourism activities while the areas not affected may be further enjoyed by tourists. The coral reefs employed as tourist spots have been declining in terms of area but Thailand has targeted to increase the number of tourists who prefer diving activities. Thus it is necessary to efficiently arrange the diving activities to facilitate an increasing number of tourists with minimum impacts toward coral reefs. Department of Marine and Coastal Resources, Kasetsart University, Prince of Songkla University, and Ramkhamhaeng University jointly set up underwater trails in six provinces along the Andaman coast of Thailand to provide suitable spots for divers at the diving depths not affecting coral reefs. The present study aims to monitor the success of snorkeling trails management at Ko Daeng in Krabi Province and Ko Pu in Phuket Province.Visitors learn and understand more about nature of marine lives and processes occurring by visiting the snorkeling trails. We have prepared the route to pass interesting spots with several waterproof guides to indicate the location of 10 spots in each trail and provide further information on diversity of marine organisms that can be found in the areas. Lessons learn from the Andaman Sea were applied to Mu Koh Chang, in the Gulf of Thailand. Besides, it stimulated tourism activities in the damaged areas and generated incomes to local people and enhanced understanding and awareness on natural resource and marine life conservation. The snorkeling trail project should be considered as a tool for sustainable utilization of coral reefs in Thai waters.

## 23.959

**Marine Protected Area Report Guide And Rating System: Do Scores Equate To The Reality Of Their Biophysical Status?**

**Darwin John RAYMUNDO*[1]**

[1]Research, Coastal Conservation and Education Foundation, Inc., Cebu City, Philippines

The Marine Protected Area Report Guide and Rating System being implemented by the Coastal Conservation and Education Foundation (CCEF) and its partners in the Philippines has been utilized to assess the effectiveness of management based on several indicators of enforcement and implementation. A very useful tool for determining the management framework of an MPA, one of its points that need improvement is on how ratings can truly reflect improving or declining biophysical status of MPAs from a management standpoint.

This paper looks at the relationship between specific management criteria as rated in the MPA rating system and how this translates to the true biophysical status of MPAs. Although MPA rating per se does not show a significant correlation to live hard coral cover and fish densities, analysis of certain specific management criteria show varying correlations to these two parameters. Several recommendations are also given to further fine-tune the criteria of the rating system and improve its effectiveness.

## 23.960

**Information For The Management Of Coral Reef Based Tourism At Mu Koh Chang, Thailand**

**Niapt SOMKLEEB*[1]**

[1]Department of Biology, Ramkhamhaeng University, Bangkok, Thailand

Mu Koh Chang, a new tourism destination of Thailand, is located in the eastern part of the Gulf of Thailand. There are consisted of 52 Islands in the area which harbor approximately 16 $km^2$ of coral reefs. Three main agencies related to coral reef management in this area are as follwing: 1) Mu Koh Chang National Park, an estimated 30% of the coral reefs in this area are under responsibility of the national park. 2) DASTA (Designated Area for Sustainable Tourism Administration) Area 1, Thai Government uses this agency as a tool for sustainable tourism development in 2002. and 3) Trat Province Office, this office supported the management of coral reef in this area. In 2005, Mu Koh Chang was selected as one of the demonstration sites for the coral reef subcomponent under the UNEP/GEF/SCS Project. The significant activities would provide information concerning sustainable tourism are i) Study carrying capacity for tourists. ii) Study to determine tourist fee for coral reef management purposes iii) Socio-economic study in local communities iv) Monitoring coral reef conditions in both ecological and socio-economic aspects v) Mapping additional coral reef areas. The project would integrate all information and developed a network for management of coral reef in this area to facilitate all users for easily access the data. Establishment of coordination mechanism for coral reef based tourism and development of management plan and guideline for sustainable use of coral reef resources are also needed. This management plan and guideline for sustainable tourism based on coastal resources should be developed in the framework of coral reef demonstration site project with taking account functions of related stakeholders and linage in the network.

## 23.961

**The Effect Of The Interpretation Learning Process On Snorkeler Behavior in Coral Reefs, Thailand**

**Petchrung SUKPONG*[1]**, Suvaluck SATUMANATPAN[2]

[1]Thailand Programme, IUCN - The World Conservation Union, Bangkok, Thailand, [2]Faculty of Environment and Resources Studies, Mahidol University, Nakornprathom, Thailand

The Interpretation Learning Process is a study/project developed to help significantly reduce the damage caused by mass tourism on tropical coral reefs in Thailand and possibly, on a global basis. The Interpretation Learning Process is multimedia package included a brochure, a video cd and a guide-book designed to educate snorkelers/tour operators effectively on how they can minimize and prevent damage caused by their actions on coral reefs. The Interpretation Learning Process promotes the best practices for snorkeling coral reefs and educate them on their responsibilities for their action on nature.

A study was conducted on Similan National Park, Thailand to observe the behavior of 160 snorkelers divided into 2 separate groups – the experimental group which had undergone the Interpretation Learning Process and the control group which had not. The results of this month long study revealed a significant difference at the 0.05 alpha level between the groups. The experimental group exhibited considerable preventive behavior when swimming near coral reefs compared to the control group.

The control group was found to touch the coral reef at an average frequency of 3.31 times in 30 minutes, higher than the experimental group who were found to touch the coral reef at an average frequency of 2.56 times in 30 minutes. Factors affecting snorkeling behavior were the use of a life jacket, the Interpretation Learning Process, and the depth of the sea at which snorkeling occurred. The overall factors could be explained as having a correlation to snorkeling behavior at 32 per cent, meaning that divers who used life saving equipment, experienced the interpretation learning process, and snorkeled at a not too shallow sea level would have less damaging snorkeling behavior.

## 23.962

**Management Of Artificial Reefs For Tourism in Phuket, Thailand**

**Thamasak YEEMIN*[1]**, Se SONGPLOY[1], Sittiporn PENGSAKUN[1], Nipat SOMKLEEB[1]

[1]Department of Biology, Faculty Of Science, Ramkhamhaeng University, Bangkok, Thailand

Tourism activities on natural coral reefs are important causes for coral reef degradation, especially new scuba divers and dive students who are easily to damage corals. The special designed artificial reefs for diving in Phuket, Thailand was initiated after the Indian Ocean Tsunami incident on December 26, 2004. It had affected coral reefs along the Andaman coast while the damages varied according to the morphology of each coastal area. Therefore, the diving spots in Thailand have been reduced and deteriorated. Department of Marine and Coastal Resources and Ramkhamhaeng University have jointly conducted a study and designed the artificial reefs to increase diving spots, to reduce coral damages, to lower density of diving activities along natural coral reefs, to enhance number of visiting divers and to encourage growth and diversity of natural resources and marine organisms. Racha Yai Island was selected for establishing the special designed artificial reef in Phuket Province because it's natural coral reefs were visited by many tourists. The artificial reefs were specially designed to show Thai identity such as elephants, Thai pavilion, Thai designed signboard, and Thai traditional art arches with a pair of Thai demon. In addition, Phuket had named as "Pearl of the Andaman" therefore the large pearl oyster was also built. Diving in artificial reef areas would be a conservation tool and encourage coral reef recovery. The project monitoring program showed that the artificial reefs for diving in Phuket were interested by many foreign divers. Macrobenthic oraganisms, cryptic fauna and reef fish were found abundantly. The socioeconomic surveys revealed that the tourism sector in Phuket and its vicinity has gained direct and indirect benefits from the project. Management and maintenance of the artificial reefs for tourism are urgently required for sustainable uses.

## 23.963

**The Mpa Report Guide And Rating System: A Comprehensive Tool For Mpa Managers: New And Old**

**Agnes Corine SABONSOLIN*[1]**

[1]Research/Monitoring Team, Coastal Conservation and Education Foundation, Inc., Cebu, Philippines

In the Philippines, the total number of MPAs has increased from around 600 in 2003 (Aliño 2000) to more than 1,000 in 2007, 600 of which are from Central Visayas (Arceo unpublished). But quantity alone cannot save a degraded reef, especially with a coastline such as the Philippines'. Research in Asia has shown economic value estimates for one kilometer of a sustainably-managed reef of being able to support the annual food requirements of 2,500 people (Cesar 1996). Since a lot of these MPAs lack applied sustainable strategies in management, the MPA Report Guide and Rating Database System was initiated in 2001 by the Coastal Conservation and Education Foundation (CCE Foundation) to aid in gauging the effectiveness in achieving objectives of MPA establishment. It also serves to illustrate success in implementation of management programs and acceptance in the community.

To date, the database has almost 400 MPAs on record, 212 of which has been rated using the management rating system and more than 60 MPAs with biophysical and socio-economic data. Since then, there has been limited study using these data.

This study aims to determine if there is correlation between the biophysical and socio-economic status and the MPA Management Rating System in selected MPAs in South Cebu. MPAs with existing data are analyzed to see the effectiveness of the system in determining management, biophysical and socio-economic status of progressing MPAs as a whole. This will aid new and practicing MPA managers to develop, enhance and sustain management practices through the simple yet comprehensive MPA Report Guide and Rating System.

Biophysical data was collected using Point Intercept Transect (PIT) and Fish Visual Census (FVC) for substrate and fish data, respectively, while the MPA Report Guide was used to obtain socio-economic and management rating data.

## 23.964

**Impacts Of Tourism On Apo Island Protected Landscape And Seascape, Central Philippines**

Hilconida CALUMPONG[1], **Pablina CADIZ*[1]**, Clarissa REBOTON[1]

[1]Silliman University - Institute of Environmental and Marine Sciences, Dumaguete, Philippines

The total number of tourists and revenues as well as coral damage in Apo Island Protected Landscape and Seascape (AIPLS) were monitored from April 1999 to April 2007. Total number of tourists was 84,872 over an 8-year period grossing PhP 14,616,795 in user fees alone, 75% of which went to AIPLS for its maintenance and for livelihood. Total number of divers and snorkelers monitored for 96 months was 41,074 constituting 33% or an annual average of 3,988. No significant correlation was seen between the number of divers and coral damage on a per site basis. Pooled data showed a significant correlation (r areal damage = 0.68565; p = 0.014). The relationship between the number of divers and coral damage at present levels seems to follow a straight line with no threshold level which can be interpreted as carrying capacity. This makes the role of the Protected Area Management Board as the one that determines acceptable levels of damage very critical as they are the ones who regulate the number of divers and snorkelers allowed in the protected area daily.

## 23.965

**Reef Fish Community Of The Cagarras Archipelago: Scientific Support For A Future Marine Protected Area**

**Laís C. T. CHAVES*[1]**, Ramon NOGUCHI[2], Carlos E. L. FERREIRA[2], Cassiano MONTEIRO-NETO[2]

[1]Departamento de Oceanografia, Universidade Federal de Pernambuco, Recife, Brazil, [2]Departamento de Biologia Marinha, Universidade Federal Fluminense, Niterói, Brazil

The Cagarras Archipelago is a group of islands 5 km off the coast in the state of Rio de Janeiro (Southeastern Brazil). Fishery activities in this area are an important source of income for local fishermen. The establishment of a marine protected area is under discussion for more than a decade. Nevertheless, few efforts were done to assess its biodiversity and ecological importance. Reef fish community structure at Cagarras Archipelago was assessed to compare reef fish species distribution patterns and trophic groups accross the main islands and depth strata. Eighty-six visual strip-transects yielded 2857 fishes belonging to 107 species. Most species showed Western Atlantic distribution and many are endemic from Brazil. Among Islands there were no significant difference in richness (ANOVA, p=0.13) and abundance (ANOVA, p=0.24). Across depth strata abundance differed significantly (ANOVA, p=0.00**), where it gradually diminished towards the bottom. Shallow and medium depths presented significantly a higher richness than the bottom (ANOVA, p=0.012*). Two-way ANOSIM showed that species composition between islands, formed groups with some overlapping (R=0.597; p=0.01*) and between depths, a single group was formed (R=0.13; p=0.001**). Part of the rocky substrate is visually impoverished in retation to invertebrates, algae and benthic fishes, contrary to what was expected. The main fish trophic categories were omnivores followed by mobile invertebrate feeders, previously observed for southeastern Brazil. Surprisingly, this system presented a high diversity of reef fish species compared to other sites in the State, but there is some elements of anthropogenic impacts, such as a close sewage disposal system, destructive harvesting techniques, increasing diving activities and more. We strongly recommend the establishment of a protected area, in order to control such activities and better understand the ecological proccesses occuring in the region.

## 23.966

**Ecological Changes And Mpa Establishment in Dongsha (Pratas) Atoll**

**Ming-Shiou JENG*[1]**

[1]Academia Sinica, Taipei, Taiwan

Located in northern South China Sea, Dongsha Atoll embraces waters of approximately 300 square kilometers. In 1994, the coral coverage inside the atoll exceeded 80%, but almost all corals died in bleach due to the high seawater temperature by the 1998 El Nino. The survey conducted in 2007 indicated 10~15% coral coverage inside the atoll; the corals outside the atoll remained 40~88% coverage, which indicated less El Nino impact in the area. The survey and monitoring of 17 sites around the atoll recorded 556 species of fishes, 264 corals, 175 mollusks, 28 echinoderms, and 33 crustaceans, which also showed increasing trends of species abundance and diversity. In past decades Dongsha area severely suffered from poaching and overfishing. Many economical species are nearly extinct in the area. To ensure the sustainability of fishery resources and conserve coral reef biodiversity, Taiwanese government established Dongsha MPA, which is under management of Marine National Park Administration. All activities are prohibited for 5 years in the protected area and patrolled by the Coast Guards. The ultimate goal of this MPA is to make this atoll a living museum for conserving local coral reef biological resources and heritage.

## 23.967

**Reef Watch Monitoring And How This Kind Of Coral Reef Monitoring Supports The Objectives Of The Green Fins Programme**

**Justine DE RIOS*[1]**

[1]Green Fins, Phuket Marine Biological Center, Phuket, Thailand

The Green Fins Mission Statement is: "To protect and conserve coral reefs by establishing and implementing environmentally-friendly guidelines to promote a sustainable dive and snorkel tourism industry".

One of the activities promoted is coral reef monitoring. The Reef Watch method has proved to be very effective for busy dive operators as it is a one-dive-one-survey method that requires no special equipment other than a pencil and underwater slate. The method is simple to understand and training for instructors and dive staff can be carried out quickly either in a shop or on board a boat.

Results from Reef Watch monitoring can either be posted to the Phuket Marine Biological Center for analysis or uploaded directly into the database via a form which is found on the website www.greenfins-thailand.org

This presentation is an overview of the main components of the method and how participation in the monitoring supports the objectives of the Green Fins Programme.

Monitoring can either be done over a 10 x 10 meter square area, or throughout the dive. The following data is gathered:

Percentage coral cover & common types of coral

Numbers of invertebrate indicator species

Numbers of fish indicator species

Type and amount of damage to the reef

The method is quick, easy to learn and has proved very popular with dive operators that have implemented a programme. By participating in monitoring on a regular basis, dive operators are providing their guests with the immediate satisfaction of being part of a reef conservation project. This is an ideal way to raise coral reef awareness and understanding of threats to coral reefs, which is a main goal of the Green Fins Programme.

## 23.968

**Ecological Effects Of The Crown-Of-Thorns Starfish Removal Programme On Chumbe Island Coral Park, Zanzibar, Tanzania**

Frida LANSHAMMAR[1], **Chris MUHANDO*[2]**

[1]Conservation, Chumbe Island Coral Park, Zanzibar, Tanzania, [2]Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania

Crown-of-thorns starfish (COTS), *Acanthaster planci*, is a coral predator causing great damage to coral reefs world wide. Their preferred prey is *Acropora* sp., and during the last 50 years temporary COTS population increases, outbreaks, seems to occur more frequently putting Acropora under great stress.

This study has looked at coral mortality and recovery after the last major El Niño in 1998 related to COTS population densities in the Zanzibar archipelago. It also discusses COTS removal as a management tool for improving recovery of coral after large disturbances such as El Niño.

Benthic data from three islands on the west coast of Zanzibar (Chumbe, Bawe, and Changuu) show that the % cover of Acropora dropped between 10-15% during the El Niño in 1998, after which a slow recovery could be seen on all reefs. Since a major COTS population outbreak in 2002/2003 however the levels have dropped dramatically down to less than 5% live Acropora on all reefs except for Chumbe where the level has increased to the same as before the bleaching.

When increased densities of COTS were noticed inside the marine park on Chumbe, the management initiated a manual COTS control programme where park rangers would collect, count and measure all COTS seen inside the park in order to keep densities close to zero at all times. Since April 2004 a total of 3306 starfish have been collected inside the 0.4 km² marine park. All efforts have been recorded and each starfish has been measured and the area of the reef where it was collected recorded.

This study concludes that manual COTS removal programmes indeed can have an important positive effect on coral reef health, and that these efforts should be encouraged as a management tool for smaller marine parks with enough human resources for continuous collections.

## 23.969

**Fish Assemblages Associated With Soft Coral Communities On Guam Are Depauperate Irrespective Of Protected Status**

**Nola MEYER*[1]**, Jennifer MCILWAIN[1]

[1]Marine Laboratory, University of Guam, Mangilao, Guam

Soft corals have often been found to outcompete hard corals in reef areas subject to anthropogenic disturbances. Given the increasing levels of pollution being found in coastal waters adjacent to coral reefs, the longer-term implications of benthic community shifts needs to be investigated. Where hard coral communities are replaced by soft coral communities the overall rate of reef accretion may be reduced. Reef fish assemblages may also be affected as there are clearly major differences in the habitat templates offered by hard or soft coral communities. Perhaps surprisingly, given the significant prevalence of soft corals on Indo-Pacific reef flats, very little research has focused on whether it is (1) a suitable habitat for reef fish and (2) how different the fish communities associated with soft coral communities are from the fish communities associated with hard corals. In this study, we investigated the significance of soft coral as habitat for fish by looking at soft coral communities from 1 protected and 2 non-protected reef flats on Guam. Replicate stationary point counts, used to survey fish communities, were evenly distributed across the gradient of soft coral cover at each reef flat. The habitat was characterized by analyzing multiple photo-quadrats within each point using benthic analysis software. Relationships between habitat and fish community were assessed with various multivariate techniques, including non-metric multidimensional scaling. Percent soft coral cover had no detectable effect on fish species richness or abundance. Moreover, there were few differences among reef flats for highly targeted food fish species despite the protected status of one site. Our findings suggest that because soft coral is a marginal habitat for fish, MPA's that contain high cover of soft coral, may have reduced a capacity to support high biomass and species richness relative to areas with high hard coral cover.

## 23.970

**SCUBA Divers In The Bahamas: Perceptions And Potential Role In Coral Reef Management**

Liana MCMANUS[1], **Wendy WOOD*[2]**, Candace NACHMAN[3], Maria VILLANUEVA[1]

[1]Marine Affairs and Policy, University of Miami Rosenstiel School of Marine & Atmospheric Science, Miami, FL, [2]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [3]MRAG Americas - NOAA, Silver Spring, MD

Marine Protected Areas (MPAs) aim to conserve areas in exploited coral reef ecosystems as in popular scuba diving destinations. Many MPAs globally are 'paper' parks and do not meet their goals because of lack of funding. As part of the Bahamas Biocomplexity Project, we interviewed SCUBA divers from September 2003 to February 2004 about their willingness to pay (WTP) user fees to dive in coral reef-based protected areas. The study surveyed liveaboard divers in Bimini (n=100) and Exuma (n=202) and fly-in divers to Nassau (n=201). This study examined whether the collection of user fees from SCUBA divers was a feasible option for funding MPAs in the Bahamas.

The majority of SCUBA divers in our study sites rated the quality of the marine environment as either very pristine or fairly pristine: Bimini (75%), Exuma (70%), Nassau (68%). Most (77% in Bimini, 95% in Exuma, and 69% in Nassau) were familiar with the concept of MPAs. They were willing to pay between $2 (Bimini) and $5 (Nassau and Exuma) as a daily user fee to dive in an MPA. Because of the divers' prevalent perception that the Bahamian marine environment is pristine, their awareness of the MPA concept, and the WTP of this user group, collecting user fees appears as a viable option for funding management and enforcement of an MPA network in the Bahamas.

We estimated that about 100,000 to 145,000 divers visited the Bahamas in 2003. Of these, approximately 93% were fly-in divers. With a per capita expenditure of $1750, the SCUBA diving sector contributed about $175 to 254 M or 8-12% of 2004 tourism GDP. WTP user fees could potentially provide $1.5 to 2.2 M for conservation or less than 1% of tourism revenues, an insignificant investment to help secure the resource base of the industry.

## 23.971

**Linking Land Use And The Conservation Of A Threatened Coral Species: Using Watershed Analysis To Improve The Protection Of *acropora Palmata***

**Jeanne BROWN*[1]**, Barry DEVINE[2], Pedro NIEVES[2]

[1]SE Caribbean Program, The Nature Conservancy, Christiansted, Virgin Islands (U.S.), [2]Eastern Caribbean Center, Conservation Data Center, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

Drastic reductions in abundance and range of *Acropora palmata* due to a number of factors attributed to natural and anthropogenic causes has had serious consequences to coastal systems. The protection of this threatened coral species relies on sound management of human activities. In the U.S. Virgin Islands, where there is a high rate of development in steeply-sloped coastal watersheds, water quality in the coastal zone has been degraded by runoff from land. This study examines the impact of sedimentation on the incidence of disease and mortality in *A. palmata* relative to adjacent watersheds with various levels of development. Using watershed characteristics, such as incline, number of gullies and proximity to roads and buildings, with sediment core samples in the watershed's drainage area, the status and potential for recovery of A. palmata is linked to human activity on land. This analysis contributes to the information necessary to drive judicious decision-making and policy development of sustainable land use and protected area management.

## 23.972

**User Fees as Sustainable Financing Mechnisms for Coral Reef Marine Protected Areas**

**Steven THUR*[1]**

[1]Coral Reef Conservation Program, National Oceanic & Atmospheric Administration, Silver Spring, MD

Coral reef marine protected areas (MPAs) have proliferated globally in the past three decades. However, inadequate funding often prevents these management regimes from fulfilling their missions. Managers have become increasingly aware that successful protection of reefs is dependent not only upon an understanding of their biological and physical processes, but also their associated social and economic aspects. Unfortunately, economic values associated with MPAs and the coral reef resources they protect are rarely considered in decision-making and policy development. This study fills this information gap by 1) examining scuba divers' willingness to pay for access to quality recreational sites in the Bonaire Marine Park, Bonaire, Netherlands Antilles and 2) estimating the recreational benefits derived by those divers using the Park. The findings indicate the previous US$10 annual diver user fee could be increased substantially without an adverse effect on island tourism. The increased revenue generated from this sustainable financing mechanism would be more than sufficient to fund both current and enhanced marine park operations. In addition, the study finds that maintaining a high-quality diving experience within the Park is worth between US$56 and US$132 per diver per year. Assuming that effective Park management is preventing adverse environmental change, this information can be used in a benefit-cost analysis to clearly demonstrate the positive net benefits associated with a well-functioning Bonaire Marine Park. The findings of this study are indicative of values that may exist for other coral reef MPAs with significant tourism appeal, and illustrate how low-cost social science methods can augment existing MPA research plans.

## 23.973

**Valuation Of Coastal Ecosystem Goods And Services in East-Central, Florida**

**Brian KELLY*[1]**

[1]Dept. of Marine and Environmental Systems, Florida Institute of Technology, Melbourne, FL

Detailed analyses of market and particularly nonmarket values of ecosystem goods and services are either absent or limited for most of Florida's 35 coastal counties. This study assesses the value of coastal ecosystem goods and services in Brevard County, Florida. Brevard possesses one of the longest shorelines in Florida with major fishing and surfing economies, some associated with substantial nearshore reefs. Specific objectives include: 1) to build component value estimates for selected coastal ecosystem goods and services in Brevard County, 2) to provide a total economic value estimate of Brevard's coastal ecosystem goods and services, and 3) to identify economic and ecosystem costs from unsustainable coastal development. Economic data was gathered through an extensive literature search and from local and regional businesses and trade organizations. The primary valuation methodology deployed in the study was the value transfer technique. Preliminary results reveal that Brevard County's saltwater recreational fishing alone produces an annual market value of at least $150 million dollars and a nonmarket value of approximately $100 million. Initial estimates also show that the economic impact of surfing in the county is well over a half billion dollars per year. A substantial component of these values is associated with reef systems. These and related findings suggest that the many ecosystem goods and services provided by Florida's unique coastal habitats are undervalued and under-deployed in management arenas. Policy-makers are either unaware of or not using the non-market ecosystem service valuation methodologies available when developing critical decisions about coastal resource use, particularly given the major challenges that sea level rise poses for sustainable economic and environmental planning.

## 23.974

**The Antiquities Act And The Protection Of Coral Reefs in United States Waters**

**Frank ALCOCK*[1,2]**, Robert JOHNSON[1]

[1]Division of Social Sciences, New College of Florida, Sarasota, FL, [2]Marine Policy Institute, Mote Marine Laboratory, Sarasota

This paper explores the recent utilization of the Antiquities Act of 1906 as a management tool for the protection of coral reefs. An initial section assesses the current status of coral reef ecosystems under U.S. jurisdiction. A second section provides a historical overview of some of the legislative tools that have been used to protect coral reefs in the United States, most notably the National Marine Sanctuaries Act. A third section provides a historical overview of the Antiquities Act and its use by various administrations, noting that the Clinton Administration was the first to use the Act as a management tool for coral reefs when he used it to established the Virgin Islands Coral Reef National Monument in 2000. The Bush Administration subsequently used the Act to establish the Northwestern Hawaiian Islands National Monument in 2006 and additional designations are being contemplated for 2008. A fourth section discusses the legal and political implications of designating coral reefs as national sanctuaries vs. national monuments with a focus on the potential application of the Antiquities Act to the Gulf of Mexico region. The paper ultimately argues that the substantive impact of the Act depends largely upon (1) the specific terms outlined in specific executive orders that vary and are subject to executive discretion; and (2) enforcement of those terms. Executive discretion can engender stronger protections and expedite the process of enacting those protections but it also runs the risk of alienating some stakeholder groups to the point that enforcement becomes problematic. Carefully used, the Antiquities Act holds considerable potential to strengthen coral reef management in United States waters.

## 23.975

**A Comparison Of The Permanent Marine Protected Areas Of Bermuda To Control Sites For Anchor And Diver Damage To Hard Corals**

**Thaddeus MURDOCH*[1]**, Mike COLELLA[2], Matthew HAMMOND[1], Annie GLASSPOOL[3]

[1]BREAM: Bermuda Reef Ecosystem Assessment and Mapping Programme, Bermuda Zoological Society, Flatts Village, Bermuda, [2]Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commision, St. Petersburg, FL, [3]Bermuda Biodiversity Project, Bermuda Zoological Society, Flatts Village, Bermuda

Bermuda supports the most northerly coral reefs in the world. Local management practices treat the marine ecosystem as a highly stressed, self-sustaining entity, and are extremely conservative, with all hard and soft corals protected from extraction since 1978, across the entire Bermuda Reef Platform. In addition, a series of permanently buoyed MPA sites were established in the mid-1980s at the most frequently visited dive sites, each surrounded by a 'No fishing' radius of between 300 and 1000 metres. These MPA sites were established to reduce user conflicts between divers and fishermen, and to minimize anchor damage from boats. However, the sites also attract divers and may therefore be the focus of diving activity and diver-caused damage to corals.

The effectiveness of permanent MPA's in protecting corals from anchor and diver damage was assessed by comparing coral percent cover and species diversity at 4 existing MPAs. Since each MPA site appeared to be geomorphologically unique, each MPA was compared to two matching control sites. At each site, ten 25-m long transects were digitally photographed at 50 frames each, and analyzed for coral cover and species diversity using standard procedures. A separate one-way ANOVA was used to test for differences between each MPA and either control site, using transformed data if needed.

ANOVA and *post-hoc* tests revealed small, but statistically significant differences in mean coral cover between control sites and the MPAs, although the direction of these differences was not consistent across site groups. Mean coral species diversity, as measured by the Shannon-Weiner diversity index, peaked at the MPA in three out of four site groups.

The results do not conclusively indicate that corals are protected from or damaged by divers at MPA sites. Continued monitoring is needed to confirm that MPA sites are not declining in coral condition though time.

## 23.976

**Comparative Analysis Of Algal Cover And Coral Recruitment in Spur And Groove Reefs in Little Cayman From 2005 To 2007**

**Sara KREISEL*[1]**, Kim BALLARD[1], Diana SCIAMBI[1], Roy DUCOTE[1], Vania COELHO[1,2]

[1]CCMI, Little Cayman, Cayman Islands, [2]Natural Sciences and Math, Dominican University of California, San Rafael

An assessment of algal cover and coral recruitment in nine spur and groove reefs was conducted in July and August of 2005 through 2007 in Little Cayman, Cayman Islands. Basing our methodology on the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol, we surveyed sites 9-15 meters deep on the south (windward) and north (leeward) sides of the island in both protected (no-take marine reserves) and non-protected areas. We measured percentage cover for encrusting coralline algae, fleshy and calcareous upright macroalgae, and number of coral recruits, by throwing a 25 x 25 cm quadrat at every meter or odd meter intervals to the side of 10 m transect lines. The abundance of damselfish and *Diadema* was also assessed along 0.5 m of the transect lines. A total of 1512 quadrats and 265 transects were surveyed during the study period. Between 2005 and 2007, there was a significant decrease in mean encrusting calcareous algal cover from 19 to 9% and in mean total upright macroalgae from 44 to 39%. Fleshy upright macroalgal cover decreased from 37 to 31% but calcareous upright macroalgal cover increased from 7 to 8%. Mean number of coral recruits also decreased from 0.2 to 0.1 per quadrat. The prevalence of damselfish and *Diadema* remained statistically similar over the three-year period, averaging 1.8 and 0.2 per transect respectively. No clear differences were observed for protected and non-protected areas for any of the parameters analyzed including total upright macroalgal cover, possibly due to the fact that mainly unpalatable algae of the genera *Dictyota* and *Halimeda* were found in these reefs.

## 23.977

**Grey Reef Shark Home Range And Behavior On Pacific Coral Reefs in Relationship To Contaminants And Ecotourism**

**Phillip LOBEL*[1]**

[1]Biology, Boston University, Boston, MA

The movement patterns of the grey reef shark, *Carcharhinus amblyrhynchos*, were examined at Johnston Atoll and in Palau. The objective was to determine whether this shark species exhibited any measurable degree of local site fidelity or if they just wandered widely and haphazardly. At Johnston Atoll, the question concerned the degree of exposure to individual sharks that were found in reef habitats contaminated with PCBs, Dioxins and other containants. At Palau, the question concerned if and how far individual sharks wander beyond the boundaries of the Blue Corner marine protected area. Sharks were captured by baited hook, promptly tagged and released. Acoustic tags were banded onto a shark's caudal peduncle and tracked by strategically deployed underwater loggers. Johnston Atoll was a military base with extensive chemical and nuclear operations since the 1930's, this study was conducted from 1999 to 2003. The nation of Palau is a major scuba diver tourism destination and sharks are a key attraction, this part of the study was from 2003 to 2006. The presentation will show maps of shark movements with an analysis of diel patterns of habitat use. This research was supported by the Army Research Office, the DoD Legacy Program and the Micronesian Shark Foundation..

## 23.978

**Collaborative Watershed Planning To Protect Threatened Coral Ecosystem Resources in Coral Bay, St. John, U.s. Virgin Islands**

**Jennifer KOZLOWSKI*[1]**, Anne KITCHELL[2]

[1]Office of Ocean and Coastal Resource Management, NOAA, Silver Spring, MD, [2]Center for Watershed Protection, Ellicott City, MD

The U.S. National Oceanic and Atmospheric Administration (NOAA) Coral Reef Conservation Program works to bring together a variety of federal, territorial and non-governmental partners to advance watershed planning aimed at addressing land-based sources of pollution in priority coral reef ecosystems. A key challenge is adapting mainland watershed protection practices to tropical island environments. The Coral Bay watershed in St. John, U.S. Virgin Islands was chosen as a pilot to develop a modified watershed planning process encompassing typical obstacles: working on a shoestring budget, economic and development demands, limited space, and lack of local resources and specialized technical expertise.

The Coral Bay watershed is characterized by very steep slopes, highly erodible soils and resultant high runoff volumes. The watershed has over 10 miles of shoreline hosting a diversity of land uses, protected harbors, as well as fringing coral reefs, mangroves, sea grass beds, and salt ponds. The relatively undeveloped town of Coral Bay is fighting to retain its rural character and protect its natural resources in the face of tremendous development pressures. These factors, combined with a large percentage of dirt roads, active construction, and no existing stormwater management have led to excessive sediment loading to the Bay which is adversely impacting water quality and ecologically valuable coral ecosystem resources.

A watershed management plan was drafted that contains recommendations and implementation actions to improve planning for future development and management of stormwater, ranging from broad scale road network planning, to demonstration retrofits, to enhanced staff capacity. Targeted practical research is now necessary to determine the effectiveness and efficiency of management actions, to identify development and construction practices appropriate for island conditions, and to establish pollutant load reduction potentials and turbidity criteria. Cooperation with local academic institutions is also needed to establish engineering curriculums in support of on-island training and technical application.

## 23.979

**Creating a Community-Based Marine Protected Area**

Paul SANCHEZ NAVARRO[1], **Miguel Angel MALDONADO*[1]**

[1]Centro Ecologico Akumal, Akumal, Mexico

Akumal, Quintana Roo, Mexico

Marine protected areas in Mexico are administered by the federal government, under a centralized and consultative system. A new protection scheme based on community administration of the coral reef system is being generated in Akumal, Quintana Roo. The Community-Based Marine Management Program for Akumal's Bays, combines legal protection instruments with collaboration agreements, through committees made up of representatives from the hotels, dive shops, tour operators and local property owners, with participation of federal and municipal authorities. The process is moving toward the establishment of the first co-management agreement of a marine protected area in Mexico, with defined protection and management objectives based on aquatic tourism use, wastewater practices and sea turtle protection, and specific zoning criteria. The local, non-governmental conservation organization plays a determining role in the process. Centro Ecológico Akumal (CEA) has explored diverse alternatives for marine resource protection, with fourteen years of ecosystem research and monitoring, as well as community education. The organization's role has become one to integrate efforts in academic, educational, social, policy and economic issues related to coastal and marine management in the Akumal area. Through CEA's work, determining factors are analyzed, along with attributes of individuals and organizations, all of which allow the coastal community greater capacity to manage its natural resources. This analysis of capacities will also help adapt management policies to the particular characteristics of the community and its ecosystems. The successful use of legal instruments, best practices in marine tourism services and community participation may provide a solid alternative to traditional centralized ecosystem management.

## 23.980

**Human Uses Impacting Coral Reefs Of Puerto Rico**

**Idelfonso RUIZ-VALENTIN*[1]**, Manuel VALDES-PIZZINI[2], Michelle T. SCHARER[1], Miguel LUGO[3]

[1]Departamento de Ciencias Marinas, Universidad de Puerto Rico, Mayaguez, Lajas, Puerto Rico, [2]Departamento de Ciencias Sociales, Universidad de Puerto Rico, Mayaguez, Puerto Rico, [3]Silver Spring, Maryland, National Oceanic and Atmospheric Administration, Silver Spring, MD

The goal of this study was to identify human uses of the marine-land interface which generate activities that have direct and indirect impacts upon the coral reefs of Puerto Rico. The objectives of this project were to identify the most common human uses impacting coral reefs, identify key coral reef areas where human uses were heavily impacting the integrity of the ecosystem and recommend human use monitoring activities. A written survey and focal groups were carried out with local researchers and scientists where experts identified the most frequent threats. These were: sedimentation (13%), anchoring (11%), commercial fishing and dive tourism (6%), deforestation and waste water discharges (4%) as well as oil pollution and recreational fishing (3%). Experts identified specific reef sites and geographical regions where the aforementioned threats are most prevalent and require directed monitoring programs. This data was analyzed in a geographical information system (GIS) in order to identify priority areas for monitoring of particular threats or where conservation is a priority. One of the key problems identified by the participants of the focus groups was terrestrial erosion and subsequent sedimentation of coastal waters. The problem seems to be acute in the southwest of the island where coastal construction has dramatically increased in the last decade. General recommendations included: increased educational efforts in coral reef conservation, law enforcement, economic valuation of coral reefs, marine protected areas and community participation in management.

## 23.981

**Contaminants in Fishes From Johnston Atoll, A Us Military Base in The Pacific**

**Lisa LOBEL*[1]**, Phillip LOBEL[1]

[1]Biology, Boston University, Boston, MA

This study examined the distribution of military-industrial contaminants that entered the coral reefs offshore of Johnston Island, Pacific Ocean. This island was a major military base involved in nuclear and chemical weapons as well as being a major depot and transient airfield and harbor since the 1930's. The base was closed and abandoned in 2003. Fishes of different trophic levels were sampled from locations throughout the atoll. Contaminants of concern included heavy metals (antimony, arsenic, barium, chromium, copper, lead, mercury and zinc) and organics, Polychlorinated Biphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs), herbicide orange, dioxins and furans. Fish tissues were sampled for direct chemical analyses and PCBs were detected in damselfish embryos using immunohistochemical methods. The northwest section of the atoll was the area with the most variety of contaminants in fishes and sediments. This was near the site of the island's open burn pit and trash dump, a fire training and explosives detonation area, and the former storage site of Agent (Herbicide) Orange. An assessment of the possible ecological impacts of these contaminants on the reefs will be presented along with a discussion of issues for management. This research was supported by the Army Research Office and the DoD Legacy Program.

## 23.982

**Marine Resources Management At The Coiba National Park (Panama)**

**Juan MATÉ*[1,2]**, Angel VEGA[3], Héctor GUZMÁN[4], Daniel SUMAN[5], Darío TOVAR[4], Ricardo MONTENEGRO[6]

[1]Smithsonian Tropical Research Institute, Panamá, Panama, [2]University of Miami, Miami, [3]University of Panama, Santiago, Panama, [4]Smithsonian Tropical Research Institute, Panama, Panama, [5]University of Miami, Miami, FL, [6]Alianza para la Conservación y Desarrollo, Panama, Panama

Marine protected areas can be considered as governance tools for managing the natural and cultural resources. The Coiba National Park (CNP), a World Heritage site since 2004, is the largest marine protected area of Panama (2.700 km2). Decision-making in the CNP is characterized by shared management and represents a new governance model for protected areas in the country. The operation of the CNP artisanal fishing fleet, composed of only 47 boats, has been monitored in the field and in ports since June 2006. A baseline for population densities for lobster, conch, and shellfish not currently authorized to be extracted was also established for the CNP. Main results indicate that there is an artisanal (commercial) fishery directed to fin fish such as snappers, groupers and dolfinfish. The silky snapper (*Lutjanus peru*) fishery is harvesting pre-reproductive individuals (<40 cm in length) in shallower areas (< 40 m). The fishing effort of the fleet is below 30% and 80% of the captured fish is taken by processing plants. An estimated 596.505 lbs of fish (mostly snappers), representing $1.383.481 were taken from PNC in the last year, particularly from the North (100.352 lbs), Central (280.600 lbs), and South (117,408 lbs) regions of the park. A new management plan will be completed in the next few months. A consensus for a new fishing regulation has been made between scientists, fishermen, conservation organizations and park managers. A 1.8 km radius around islands, islets and rock outcrops of the CNP has been set as a no-take zone. This area encompasses 100% of the shallow areas of the park (<35 m), and includes 17 km2 of coral reefs, and 150.186 km2of hard bottoms, particularly rodolith beds. A close season has been agreed to protect nursery grounds for *L. peru*.

## 23.984

**Damselfish Embryo Assay: Field Measurement Of Pollution Impact**

**Lisa LOBEL*[1]**, Phillip LOBEL[1]

[1]Biology, Boston University, Boston, MA

PCB accumulation and the occurrence of embryonic abnormalities were investigated in the damselfish, *Abudefduf sordidus*, from PCB contaminated and uncontaminated sites within Johnston Atoll, Central Pacific Ocean. Developmental anomalies were assessed in damselfish embryos collected in the field during four natural spawning seasons (1996, 1998, 1999, and 2001). Laboratory incubations of abnormal embryos demonstrated that the abnormalities observed were lethal. PCBs were measured in fish tissues with mean whole body concentrations ranging from 364.6 to 138,032.5 ng/g lipid. A significant residue effect relationship was found between total PCB concentration and embryo abnormalities. This study provides baseline monitoring criteria and evaluates sediment quality benchmarks used for ecological risk assessments on coral reefs.

## 23.985

**Scaling-Up Efforts For Fisheries Management And Marine Biodiversity Conservation Through Networks Of Marine Protected Areas in Marine Corridors Within The Sulu-Sulawesi Seascape**

**Miledel Christine QUIBILAN*[1]**, Porfirio ALINO[2], Sheila VERGARA[1], Romeo TRONO[1]

[1]Conservation International Philippines, Quezon City, Philippines, [2]Marine Science Institute, University of the Philippines Diliman, Quezon City, Philippines

Information derived from local stakeholders on the state of their marine resources and use patterns and from scientific studies that elucidate more objectively key state and pressure/ threat indicators were integrated using GIS map-based analyses. Objectives for this integration were to: 1.) derive key ecological criteria relevant for MPA selection, and 2.) provide site-specific recommendations on the appropriate design (i.e. location, size and configuration) of networks of MPAs in three marine corridors within the Sulu Sulawesi Seascape. Spatially defined grids (i.e. 5 km2) and a point-scoring system was used to transform discrete data on the extent of marine habitats, diversity, distribution and abundance of corals, reef fishes, seagrasses, mangroves, fish egg and larvae and threatened marine species onto GIS maps. We elucidate the challenges and opportunities in identifying new areas for protection and the implications of expanding the size of existing no-take areas. Scientific evidence that would show the inter-connectedness of marine species, habitats, protected areas, and corridors at different spatial and temporal scales remains to be one of the fundamental gaps that need to be addressed for the purpose of guiding strategic conservation directions. An improved understanding of the science of connectivity can potentially facilitate the commitment of local governments and national policy makers to continue to work together so that synergistic benefits can be derived from cooperative conservation and fisheries management initiatives. However, the success of these initiatives will also depend on how effective coastal management is sustained in the long-term. Effective coastal management may be achieved if management responsibilities and accountabilities are clearer and defined individually, locally and cooperatively among stakeholders. In order for stakeholders to make timely decisions and actions on the ground based on current scientific knowledge and information, regular feedback and translation is crucial and to some extent, continually guided.

## 23.986

**An Automated Real-Time Meteorological And Oceanographic Monitoring System Supporting Marine Biological Research And Management On The Mesoamerican Barrier Reef**

**Thomas OPISHINSKI*[1]**

[1]Interactive Oceanographics, East Greenwich, RI

In 1997 an environmental monitoring system was established at the Smithsonian's marine research laboratory on Carrie Bow Cay (CBC) in Belize to address fundamental needs for meteorological and oceanographic measurements. Many factors including operational environment, remote location, data accessibility, power restrictions, autonomous operation, and available communications for data transfer influenced the design criteria. In many ways the design criteria established for the system by the Smithsonian in 1996 were both pioneering and vital to the long term success of the system. It was one of the earliest monitoring systems to process and transfer real-time data from a remote geographic location to a web site for public access. To our knowledge it is still the only automated system continuously monitoring oceanographic and meteorological conditions on the outer Mesoamerican barrier reef.

The system continues to provide a baseline set of data used to examine long term trends, short term and seasonal cycles, and episodic events. This data has proven invaluable to management efforts for regional organizations and research studies for both Smithsonian scientists and an increasing number of organizations worldwide. To meet expanding needs of the users, continuous efforts are taken to improve and add functionality to the environmental monitoring system and supporting web site.

This paper provides an overview of the system, samples of data offerings such as statistical weather summaries, tidal forecasts and shoreline surveys, data samples illustrating trends, extreme weather events and seasonal dependencies. A summary of biological research that has utilized the data is presented. Also included is an introduction to some of the features of the newly designed web site that provides interactive data analysis for the user, forecasting, real-time quality control of data, a harmonic tidal analysis and prediction model and an intelligent processing module designed to identify conditions favorable for coral bleaching.

## 23.987

**International Coral Reef Management Through Government-Private Cooperation**

**Michael MOLINA*[1]**, Thomas CRAVEN[2]

[1]Department of Interior, US Fish and Wildlife Service, Honolulu, HI, [2]Department of Defense, US Army Space and Missile Defense Command, Huntsville, AL

The Eniwetak Conservation Area (ECA) is an example of ecosystem-based management in a coral reef setting that is being implemented on the scale of an entire atoll lagoon islet with its surrounding reef and incorporates governmental and traditional management practices. The ECA was established at Kwajalein Atoll by the United States Government (US), the Republic of the Marshall Islands Government (RMI), and local landowners through a unique environmental process developed as a result of the Compact of Free Association between the US and the RMI. This process is embodied within a formally adopted set of environmental standards that apply the substantive protections of US environmental law to US activities in the RMI, with special focus on US Army Space and Missile Defense Command activities at Kwajalein. As a result of consultation and permitting procedures contained in the standards, a Document of Environmental Protection (DEP) was issued from the Commander, US Army Kwajalein Atoll (USAKA), permitting a proposed project to proceed on a conditional basis. Based on US Fish and Wildlife Service and National Marine Fisheries Service recommendations, the DEP required compensatory mitigation to offset anticipated project-related losses to sea turtle, seabird, and coral reef habitats. Since there was no viable opportunity to do this at the project islet, protection of these resources at a suitable nearby islet was pursued. Designation of the ECA was identified in the DEP and accomplished through issuance of a new base policy by the USAKA Commander, a signed conservation use agreement between the local Marshallese landowners and the RMI, and development of an ECA management and monitoring plan. The ECA includes an entire uninhabited islet with an intact native forest, numerous nesting seabirds, documented sea turtle nesting, and a biologically rich coral reef.

## 23.988

**Development Of A Strategy To Guide The Use Of Remotely Sensed Information in The Management Of Coral Reef Environments**

**Candace NEWMAN*[1]**

[1]Geography, University of Waterloo, Waterloo, ON, Canada

We have developed a strategy to guide the use of remotely sensed information in the management of coral reef environments in developing countries. The strategy includes development of a habitat map using satellite imagery, investigation of stakeholder receptivity to the habitat map, use of a decision-key to determine degree of suitability of habitat types to address management questions, and context-appropriate representation of data. The strategy was developed using IKONOS 4x4 m multi-spectral satellite imagery and interview data from dive operators, fishermen, and managers of Bunaken Island, Indonesia. The potential for this strategy to address coral reef management issues is wide-reaching when feedback from map-users is recognized and integrated methodically.

It is increasingly evident that specific, issue-focused maps are essential to address current and acute coral reef degradation concerns in developing nations. Moreover, it is increasingly recognized that dive operators, fishermen, and managers, who live beside these reefs, are well positioned to provide valuable information about the impacts on reefs and about context-relevant solutions. The challenge is to efficiently extract and then appropriately integrate this information with habitat-mapped data to develop context-specific management maps.

In this study, we develop a strategy to address this challenge. Over one year has been spent on Bunaken Island, Indonesia's first national marine park, gathering field data to validate the IKONOS satellite image, and gathering interview data from dive operators, fishermen, and Park managers. The strategy was developed and tested with local stakeholders and considerable feedback was acquired and used to enhance the strategy.

## 23.989

**Voluntary Standards as a Tool for Increasing the Sustainability of the Marine Recreation Industry and Improving MPA Effectiveness in Hawaii and Mesoamerica**

**Rick MACPHERSON*[1]**, Rich WILSON[1], Liz FOOTE[2]

[1]Conservation Programs, Coral Reef Alliance, San Francisco, CA, [2]Conservation Programs, Coral Reef Alliance, Wailuku, HI

Standards have a long history of improving service quality and safety in a wide range of industries. Successful businesses benefit from standards both by actively participating in the standardization process and by using standards as strategic market instruments. The Coral Reef Alliance (CORAL) recently completed a process in which marine recreation industry stakeholders in Hawaii and along the Mesoamerican Barrier Reef worked in unprecedented collaborations to develop voluntary standards that will measurably improve and sustain environmental performance in scuba diving, snorkeling, boat operations, and marine life viewing. Engaging a standards committee comprised of representatives from marine recreation, conservation NGOs, tourism industry associations, marine recreation suppliers, marine park managers and government agencies, scientists, divers, local community groups, and traditional communities, CORAL is now testing the implementation of these standards and providing technical and financial support for locally based conservation initiatives. It is expected that this process will enhance adoption of standards throughout the marine recreation industry, increase industry support for marine protected areas (MPAs), and lead to the development of extensive conservation alliances which enhance MPA effectiveness and improve the economic and environmental sustainability of marine recreation in Hawaii and Mesoamerica.

## 23.990

**"You Tell Us We Can't Eat The Fish But You Don't Tell Us Why"**

**Carlos ORMOND*[1]**, **David ZANDVLIET*[1]**

[1]Faculty of Education, Simon Fraser University, Burnaby, BC, Canada

In our attempts to establish effective reef management programs we have tended to pay particular attention on restricting human access and intervention. While successful in some areas, they have been failures in others. We argue that in order for coral reef conservation to be truly effective we must lean more on the human dimension of coral reef ecology for support.

What is needed is a much more conceded effort in integrating environmental education programs with coral reef management strategies. We are well beyond the age of discovery science that featured Darwin's The Origin of Species. We are now in an age of environmental protection as well as the United Nations Decade of Education for Sustainable Development (2005—2014), and so our practices must evolve, as do the organisms we study, to our current environment. If in the late 20th century education has proven to be an effective vehicle for social change, how then have those of us who attempt to promote environmental change misused education?

Around the world, educational programs are often classroom based with little environmental interaction. There lies a great body of research in human learning that acknowledges the positive influential affects of direct experience on learning. As well, human behavioral studies have indicated that education that occurs in local natural settings promotes environmental stewardship in an individual's own community. With that said, outdoor educational experiences offers itself as a supplement to current reef management strategies as a way to involve the local community with the potential to create ecological knowledge, and most importantly, to provide an understanding of "why they can't eat the fish".

## 23.991

**Hurricanes and corals in Southern Belize: from science to management and policy development**

**M. James CRABBE*[1]**, Edwin MARTINEZ[2], Christina GARCIA[3], Juan CHUB[4], Leonardo CASTRO[5], Jason GUY[6]

[1]Faculty of Creative Arts, Technologies & Science, University of Bedfordshire, Luton, United Kingdom, [2]Belize Regional Initiative, Earthwatch Institute, Punta Gorda Town, Belize, [3], Toledo Association for Sustainable Tourism and Empowerment (TASTE), Punta Gorda Town, Belize, [4]Toledo Institute for Development and Environment (TIDE), Punta Gorda Town, Belize, [5]Friends of Nature, Belize, Placencia, Belize, [6]Belize Department of Fisheries, Belize City, Belize

There are two major coral reef areas in Southern Belize, the Sapodilla Cayes Marine Reserve (SCMR, a World Heritage Site), and the Port Honduras Marine Reserve (PHMR). We have conducted coral surveys in both reserves, determined coral growth rates, and show here that hurricanes and severe storms have limited the recruitment and survival of massive corals in the SCMR and PHMR ($p=0.01$), similar to our earlier findings in Jamaica. From this science base we have developed a capacity building programme for local stakeholders, in collaboration with NGOs and management authorities, to inform long-term resource management decisions in Southern Belize. This has enabled stakeholders' capacity to lead, educate, and support issues regarding sustainable development, and promoted networking amongst organisations who manage marine resources, enhancing their power to collectively influence policy decisions in the country. Specific needs for the future include: enhancing and maintaining the legality of the marine parks in Belize, enforcement and the effectiveness of zoning, scientific underpinning and maintenance of coral and fish stock assessments, linking NGOs and marine parks in Belize in effective co-management and governance, and development of a shared database on the lines of that initiated by the MBRS project.

## 23.992

**The Decline Of Coral Reef Conditions Caused By Extensive Land Modification: a Case Study Of The Shiraho Area On Ishigaki Island, Okinawa, Japan**

**Hitoshi HASEGAWA*[1]**

[1]Geography, Kokushikan University, Tokyo, Japan

Okinawa, which was under the U.S. administrative authority following the World War II, was returned to Japan in 1972. Thereafter, Okinawa was incorporated in the Japanese economy under the three Okinawa Development Plans in order to rapidly accomplish the social transformation that was lacking in area of great significance for Japan. In Okinawa, several land improvement projects were performed under this special development program, followed by large-scale topographic changes accompanying large-scale deforestation and a sudden change of the land use practices. As a result, red soil outflow, overloaded runoffs from the farmlands, eutrophication, environmental perturbations of shallow-water reef ecosystems and quasi-extinction of hermatypic corals occurred.

In this study, the impacts of the development process and change of land use patterns on Ishigaki Island after 1972 were reconstituted through land use mapping. Extensive land use maps and shallow lagoon maps were generated using the combination of a variety of topographical maps and chronological aerial photographs.

The Shiraho coral reef has been gradually changing. The ratio of the sea grass bed colonizing the coral reef moat in 1972 was only 1.2%. After about 30 years (2004), the sea grass bed spread over 7.5% of the same area. The sea grass bed spread most extensively in the place adjacent to land improvement projects where large accumulation of nutrients took place. The combination of the impact of land improvement projects, the excrement of artificial manure and the runoff flow to the moat from the beef cattle breeding caused the spatial e @extension of the sea grass bed. As sea grass grows faster spreading more extensively than hermatypic corals, corals are gradually being expelled from the shallow lagoon.

## 23.993

**When Do Nearshore Mitigative Reefs Reach Functional Equivalency With The Natural Hardbottom? A Case Study For Managing Reefs Along The Central Florida Gulf Coast**

**Jessica CRAFT*[1]**, Nicole ELKO[2], Craig KRUEMPEL[1]

[1]Marine Science & Biological Research, Coastal Planning & Engineering, Boca Raton, FL, [2]Department of Environmental Management, Pinellas County, Clearwater, FL

To meet permit requirements for mitigation of impacts associated with beach renourishment activities on Sand Key, Pinellas County constructed a total of 16 artificial reefs between 1997 and 2006. Biological monitoring was conducted on three of these reefs to determine at what age mitigative artificial reefs within the study area become biologically equivalent with the surrounding natural hardbottom. The three installations were compared to two natural hardbottom sites. Each of the five sampling units consisted of six temporary transects, 10 meters in length, established at the time of data collection. A point-intercept method of assessment was conducted every 0.5 meters.

Sand and other sediment types had the highest percent cover at all sites, both natural and artificial, followed by turf algae. Excluding turf, the dominant functional groups across all sites were macroalgae, sponge, tunicate, octocoral and hydroid. Dominant species included the octocoral *Leptogorgia virgulata*, at both natural and artificial reef sites, and the sponge species *Cliona celata* at natural hardbottom sites. Mutivariate analysis using PRIMER®v6 indicated that the nearshore artificial reefs within the study area become equivalent to the surrounding natural hardbottom between two and five years after installation, and by 10 years post-installation the artificial reefs reach a community complexity which supersedes that of the natural hardbottom. This study provides a timeframe for functional equivalency that can be utilized in management applications for future nearshore artificial reef projects in the area.

## 23.994

**NMFS Species of Concern Program and Coral Reefs**

**Dwayne MEADOWS*[1]**, Marta NAMMACK[2]

[1]Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD, [2]National marine Fisheries Service, Silver Spring, MD

A “Species of Concern” is a species or vertebrate population for which there is concern or great uncertainty about its status. The program evoloved from the Endangered Species Act (ESA) candidate species list of NOAA and was created in 2004-2006. Species of Concern are not listed under the Endangered Species Act (ESA) and are not protected by the ESA. However, NMFS believes proactive conservation efforts on behalf of these species would be valuable. Hence the program funds conservation grants to states and management agencies, internally funds projects by NMFS science centers and regions, and supports and develops other partnerships and outreach to draw attention to these species in order to prevent ESA listing. I will highlight the program and opportunities in relation to the dozen or so coral reef Species of Concern.

## 23.995

**Large-Scale Characterization Of Coral Habitats By Physical Environments**

**Hiroya YAMANO*[1]**, Tsuyoshi SHIBATA[2], Tatsuo NAKAI[3], Shigeki YASUMURA[4]

[1]National Institute for Environmental Studies, Ibaraki, Japan, [2]Naigai Map Corp., Tokyo, Japan, [3]Kokushikan University, Tokyo, Japan, [4]WWF Japan, Tokyo, Japan

Nansei Shoto (Ryukyu Islands), a chain of sub-tropical islands located in the Southern end of Japan and a northern margin of the 'Coral triangle', is rich in endemic and sub-endemic fauna and flora. Nansei Shoto is recognized as one of WWF global 200 ecoregions, which is a science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats. WWF Japan initiated the project to illustrate and evaluate the biodiversity priority areas (BPAs) of the Nansei Shoto Ecoregion.

To identify coral priority areas in Nansei Shoto ecoregion, we developed a method to characterize coral habitats at a large spatial scale based on physical environments using GIS. Physical environments serve as a baseline for coral distribution and diversity. Sea surface temperatures, exposure to wave energy, and terrestrial influence were selected. The degree of exposure to wave energy was calculated based on swells and winds. Terrestrial influences were defined by distance from densely populated areas and river mouths. At points selected from reefs and coastlines selected from reef and coastline polygons of the Nansei Shoto, these factors were quantified and attributed.

## 23.996

**Conservation Action Planning in Micronesia: Learning from the past to manage for the future.**

**Trina LEBERER*[1]**

[1]Micronesia Program, The Nature Conservancy, Hagatna, Guam

Over the past two decades, The Nature Conservancy (TNC) has developed and applied the Conservation Action Planning (CAP) process to identify conservation targets, assess threats, and formulate management strategies at priority sites. TNC's Micronesia Program continues to adapt the delivery of CAP, attempting to balance the costs of supporting the work of partners in remote, vastly separated islands, and the benefit of facilitating peer-learning in cultural settings with rich oral traditions. TNC is piloting a rapid CAP process from November 2007 – May 2008, with the goal of utilizing traditional approaches to learning and management in the region, while providing a strong prioritization tool for local practitioners and communities to assist them in making decisions for managing their coral reef resources. Experienced coaches are meeting with stakeholder groups from Chuuk, Federated States of Micronesia; Majuro, Marshall Islands; Saipan, Northern Mariana Islands; and Guam at each of their sites to develop draft CAPs and initiate the process of developing management plans. Representatives from the 4 sites will then be brought together for a group workshop in Chuuk in early 2008 to share their work and learn from the experiences of their peers. Coaches will then return to island sites to work with the broader stakeholder groups to fine-tune CAPs and complete draft management plans. A set of new Micronesian CAP coaches are also "shadowing" the experienced coaches during the site visits and workshop, helping to build local self-sufficiency in strategic conservation action planning. The process is expected to result in draft management plans, including prioritized lists of high-leverage, cost-effective strategies for addressing the greatest threats to coral reef ecosystems, at 4 priority conservation sites in Micronesia.

## 23.997

**ReefBase: Information Systems Focused on Coral Reef Resources & Management**

**Moi Khim TAN*[1]**, Tupper MARK[1], Tewfik ALEXANDER[1]

[1]Natural Resources Management, The WorldFish Center, Bayan Lepas, Penang, Malaysia

ReefBase is an online information system providing quality data and GIS maps on the location, status, threats, monitoring and management of coral reef resources in over 130 countries. ReefBase serves as the central repository for the Global Coral Reef Monitoring Network (GCRMN) and ICRAN, and continues to provide valuable information services to managers, policy-makers, researchers, educators and students around the world.

ReefBase strives to improve sharing and use of information and knowledge through new projects and focused partnerships in ongoing support of research and management of coral reef resources. ReefBase allows unprecedented access to a wide range of coral reef related datasets from multiple sources on interactive maps. These datasets include the coral bleaching, Marine Protected Areas, Millennium Mapping data and many more.

The ReefBase Pacific Project is the first regionally focused project within ReefBase. ReefBase aims to improve quality and accessibility of data and information for reef fisheries and coral reef research, management, conservation, and education in the Pacific region. This project will generate worldwide web and DVD formats to maximize distribution and accessibility.

Finally, ReefBase has further expanded its utility to develop the GEF-funded knowledgebase for lessons learned and best practices in the management of coral reefs. This knowledgebase will enhance the development, implementation and outcomes of future coral reef conservation and management projects based on the distillation of the best practices available and lessons learned from previous and ongoing projects.

## 23.998

**How To Measure Success in Coral Reef Management From The Caribbean Sea And The Eastern Pacific**

**Nohora GALVIS*[1]**, Nohora GALVIS[1]

[1]Coral reefs, Corporacion Propuesta Ambiental, Bogota, Colombia

An original mathematical index was designed and applied to compare two different regions such the Caribbean Sea and the Eastern Pacific. The applicability of the index to build a Collaborative Decision Support Systems (CDSS) for adaptable management was tested by measuring perceived and objective management effectiveness in Corales del Rosario, Colombia and in Las Perlas Archipelago, Panama.

The methodology is based on a rational multicriteria model run in EXCEL spreadsheets where a combination of weights (perspectives), standardized indicators are summarized in overall assessments to support decisions about the current state of management contrasted with the perceived scenario of the ideal improved management scheme. The CDDS has been proved to be effective to be implemented by gathering data on ecological, social and economic indicators that eventually can be monitored for the selection of management zones increasing compliance and effectiveness by allowing calculus of trade-offs and spatial scenarios as foundation for enhancing public awareness by providing environmental education based on scientific information.

Contrasting results from the National Park Corales del Rosario, Colombia and from Las Perlas were found. In the first case study, the overall perceived management effectiveness remains low but it has been improved in the last six years.

## 23.999

**Comparative Analysis Of Coral Communities Found in Spur And Groove Reefs in Little Cayman From 2005 To 2007**

Kim BALLARD[1], **Sara KREISEL*[1]**, Christine GILMAN[1], Carey BATHA[1], Diana SCIAMBI[1], Roy DUCOTE[1], Vania COELHO[1,2]

[1]CCMI, Little Cayman, Cayman Islands, [2]Department of Natural Sciences and Mathematics, Dominican University of California, San Rafael

Nine spur and groove reef sites in 9-15 meters of water were surveyed in July and August of 2005 through 2007 on the south (windward) and north (leeward) sides of Little Cayman, Cayman Islands, in protected (no-take marine reserves) and non-protected areas. Live coral cover, coral diversity, diameter, height and mortality were measured using a methodology based on the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol. We measured all corals under a 10 m long transect line, and calculated live coral cover directly under the transect line. A total of 265 transects and 3343 corals were measured during the study period. Between 2005 and 2007, there was a decline in mean live coral cover from 16.8 to 14.3%, in coral mortality from 29 to 20%, diameter from 44 to 34 cm and height from 34 to 24 cm, as well as a decrease in disease prevalence from 10 to 6%, bleaching prevalence from 13 to 10%, and fish bites from 3.5 to 1.5%. Changes in the frequency of corals with sponge or tunicate overgrowth were not statistically significant, remaining around 3 and 1% respectively. *Montastraea*, *Agaricia* and *Porites* were respectively the three most abundant genera throughout the 3-year period. We found no main differences between protected and non-protected areas for any of the parameters analyzed.

## 24.1043

**Characteristics Of Seagrass Beds in Coral Reef Area And Their Restoration**

**TAKAHIKO INOUE*[1]**, SAYUKO NINOMIYA[1], TAKASHI MASUMOTO[1], YOSHIKATSU NAKANO[2], MAKOTO TSUCHIYA[2]

[1]TOKYO KYUEI CO., Ltd, 6906-10, Shiba, Japan, [2]University of the Ryukyus, JAPAN, Motobu, Japan

In Okinawa, southern Japan, well-developed coral reefs are extending, and seagrass beds composed of several seagrass species are distributed in moats. Seagrass beds are known to have important roles as the spawning and/or nursery grounds of marine fishes and invertebrates and as the feeding field of dugongs. Nevertheless, the areas of seagrass beds are reducing due to shore protection works and reclamation. Recently, the restoration of seagrass beds is being attempted. The distribution of such seagrass beds associated with coral reefs are not restricted in Okinawan waters but are widely distributed in other tropical and sub-tropical regions in the world, and therefore, techniques for the protection and/or cultivation of seagrass beds are strongly desired for their ecological importance. We have been observing seagrass beds in Okinawa. It was found that although a seagrass bed was macroscopically formed as the mixture of several coexisting species, the distributions of different species segregated according to their ecological preference on current environment and substrate type. Two component species of a seagrass bed, Cymodocea serrulata and Halodule uninervis, developed their rhizomes only near the surface of the sea bottom, and thus they could entirely be swept away by flushing currents generated by a strong typhoon. On the other hand, Thalassia hemprichii, that extends its rhizome deep into the sea bottom to settle, might not easily be swept by such strong currents. The species could form more stable meadows in areas where substrate contained large coral gravel in high proportion. T. hemprichii also formed a stable meadow in a combined community with live Montipora digitata. Based on the above findings, we introduce effective techniques, including some prospects, for seagrass bed restoration suitable to the ecological characteristics of each species.

## 24.1044

**Survival And Growth Of *acropora* Spp. in Nursery And After Transplantation At Phi Phi Island, Krabi, Thailand**

**Lalita PUTCHIM*[1]**, Nalinee THONGTHAM[1], Hansa CHANSANG[1]

[1]Department of Marine and Coastal Resources, Phuket Marine Biological Center, Phuket, Thailand

Mid-water coral nurseries have advantages particularly avoiding smothering by sediment and small fragments were used causes little effect on donor colonies. This study aims to determine survival and growth rates of coral fragments in nursery during nursing period as well as after transplanted to natural substrate. One thousand one hundred and twenty of two dominant species at Phi Phi Lae Island, *Acropora grandis* and *A. formosa*, were used as seedlings. The average size of fragments was 4.6±1.2 cm. Survival and growth rate of coral fragments were determined monthly. After 4 months in the nursery, total survival of fragments was 95.8% and 94.8% for *A. grandis* and *A. formosa* respectively. There was a significant difference of growth rate between two coral species (0.46±0.3 cm/month for *A. grandis*, 0.19±0.18 cm/month for *A. formosa*) (t-test, $p<0.05$). The results indicate that a mid-water nursery is a practical way for provide two studied species for rehabilitation in this area.

After 6 months in the nursery, fragments were transplanted to reefs which were destroyed by the tsunami in 2004 around Phi Phi Island at depth of about 8-10 meters. Survival of transplanted fragments after 8 month was 63.44% and 78.58% for *A. grandis* and *A. formosa* respectively. Growth rate were 0.41±0.32 cm/month for *A. grandis* and 0.51±0.38 cm/month for *A. formosa*. It was found that the average growth rate of fragments of both species during the first 2 months after transplantation was slower than average growth rate after 6 months. Therefore, growth rates of these fragments might continue to increase in the future and long term monitoring is needed.

## 24.1045

**Optimizing *ex Situ* nursery Culturing Conditions For Hawaiian Coral**

**Zac FORSMAN*[1]**, Cynthia HUNTER[2]

[1]Biology, University of Hawaii at Manoa, Honolulu, HI, [2]University of Hawaii at Manoa, Honolulu, HI

The effects of light, water motion, and organic nutrients (in the form of commercially available coral foods) were investigated for two species of common Hawaiian reef building coral (*Porites compressa* and *Montipora capitata*). Both species grew slightly faster under the lower flow (3.93 ± 0.4 cm s-1) conditions compared to higher flow (11.10 ± 0.7 cm s-1). *P.compressa* grew fastest in the highest light treatments, while *M.capitata* grew best in shaded treatment, exhibiting bleaching in the highest light treatments. Light and water motion interacted to affect tissue growth in both species. Higher flow resulted in less bleaching and more growth for *M.capitata* in the high light treatments most likely due to increased gas exchange reducing the effects of photoinhibition. Commercially available coral foods had no positive affect on tissue growth for either species, and significantly inhibited growth at 3 and 10 times the manufacturers' recommended doses. In addition, isogenic colony fusion was observed for 1cm2 nubbins of *Porites lobata*, *M.capitata*, and *Pocillopora meandrina*. The nubbins encrusted over glossy ceramic tiles resulting in as much as a 10-fold increase in tissue coverage in seven months. These results have implications for the ability to propagate and study corals in captivity.

## 24.1046

**Coral Reef Restoration Through The Two Stepped "Coral Gardening"concept**

**Gideon LEVY*[1]**

[1]Haifa University, Haifa, Israel

The decline of coral reefs worldwide has prompted the need for urgent development of adequate restoration methodologies. The biological, structural and functional analogies between corals and trees suggest that silviculture concepts, studied for over a century, should assist in establishing the theoretical and practical concept for the novel field of reef restoration. My research puts to test the two stepped concept of "gardening coral reefs" in which the first step is the mariculture of small coral fragments in in-situ floating nurseries, dramatically reducing the need of extracting valuable coral material from healthy reefs, and the second step is the transplantation of the nursery grown colonies into degraded reef sites. I will try to apply concepts as: ecosystem engineering, where the influence of autogenic and allogenic "engineering species" over abiotic variables and their consequent effects on biotic communities may facilitate ecological restoration; concepts learned from "silvicultural systems" to enhance biological diversity through the improvement of structural heterogeneity, species mixture, and vertical structure variation; edge effect, patch size, and perimeter-area ratio concepts well established in silviculture literature, that have dramatic impacts on community characteristics; "xenorecognition" and "allorecognition" interactions which play a dominant role in characterizing the end structure and spatial arrangement of genotypes and species in reef ecosystems. The role of the "superorganism" in enhancing resilience, reproductive properties and maintaining genetic variation. All these measures should be considered when initiative restoration approaches are to be made. In addition I will try to explore the mechanisms involved in gene expression pattern of allorecognition stress related genes, by developing a microarray from the cDNA library (established by K. O. Amar, from the IOLR) for allorecognition related genes of the model species (in the Red Sea) Stylophora pistillata through an expression chip microarray test.

## 24.1047

**In Situ Breeding Of Two Caribbean Coral Species : Acropora Palmata And A. Cervicornis**

**Claude BOUCHON*[1]**, Marie CAFFIOT[1], Yolande BOUCHON-NAVARO[1]

[1]Laboratoire de biologie marine, Université Antilles-Guyane, Pointe-à-Pitre, Guadeloupe

In the Caribbean area, the coral ecosystem undergo degradations of natural or anthropic origins threatening the most fragile coral species such as Acropora cervicornis (Lamarck, 1816) and A. palmata (Lamarck, 1816) that are key species of the coral communities of lagoons and fore reef zones. In order to explore the possibility of breeding these species, with the hope to repopulate reefs devastated areas, an experiment was conducted in the Grand Cul-de-Sac Marin of Guadeloupe, testing two techniques of in situ breeding. Hundred twenty fragments of branches of A. cervicornis and A. palmata were sampled. Sixty were hung in open water and 60 others fixed on the bottom. The follow-up of the survival and of the ponderal growth of these samples was carried out over a period of 102 days.

The rate of survival was high for the two species: 100% for Acropora cervicornis and 95% for A. palmata. The fragments of A. cervicornis presented an average weight increase of 219 % and those of Acropora palmata of 65 % over the studied period. The growth of A. cervicornis followed an exponential model whereas a linear model was better adapted to that of A. palmata. The two species did not present the same preferendum towards the tested breeding conditions. Acropora cervicornis had a better growth when suspended in open water than fixed on the sea bottom. The opposite result was obtained for A. palmata.

The obtained results, which combine a high rate of survival and a fast growth under the experimental conditions tested, are encouraging for the breeding of these two species in the natural environment with the aim of helping to repopulate devastated reef zones.

## 24.1048

**Genetic Diversity Of *acropora Intermedia* in The Aquarium**

**Naoko ISOMURA*[1,2]**, Hiromi Hannah YAMAMOTO[3]

[1]Graduate School of Engineering and Science, University of the Ryukyus, Nishihara, Japan, [2]Graduate School of Engineering and Science, University of the Ryukyus, Okinawa, Japan, [3]Okinawa Churaumi Aquarium, Okinawa, Japan

In Okinawa Churaumi Aquarium, the dominant coral species in the tanks is *Acropora intermedia*, with approximately 3000 colonies and observed spawning every year since 1998. In 1995 and 1997, before "the 1998 bleaching event", 72 coral branches of *A. intermedia* were collected locally. Since all *A. intermedia* in the aquarium have developed by growth and fragmentation for last decade from these branches, genetic diversity is suggested to be very low.

Microsatellite markers for *A. intermedia* have already been developed. In this study, (1) calculation of the genetic diversity of *A. intermedia* population in the aquarium, and (2) a search for the relationship between genotype and mating success, were conducted with the previously developed microsatellite markers.

In 2006 and 2007, cross experiments with wild *A. intermedia* individuals (WI) and aquarium individuals (AQ) were conducted in order to measure the rates of fertilization and survivorship of planulae. After DNA extraction from tissues of parent individuals used for the cross experiments and planulae, fragment analysis was conducted. In these cross experiments, fertilization and development all WI-AQ pairs were successful, while some AQ-AQ pairs did not succeed. As a result of fragment analysis, there were no identical genotypes between WI and AQ, and all non-successful genotype AQ pairs (except one pair) were shown to be the same genotype. However, no correlation between genetic similarity and rate of fertilization was shown. Furthermore allelic diversity and observed heterozygosity of AQ were lower than those of WI.

According to previous research, *A. intermedia* form normal gametes. Therefore, our results indicate that mating succession is affected by genotypes of *A. intermedia*. It is necessary to understand the genetic diversity of source populations in order to restore coral populations after localized disturbances. We suggest *A. intermedia* in the aquarium may be potential source for replenishment.

## 24.1049

**Two Deck Nursery in Nutrient Enrich Vs. Nutrient Poor Area**

**daniel YASHUNSKY*[1]**

[1]Israel Oceanographic and Limnological Research, Haifa, Israel

Evaluating the constant deterioration of Eilat's (Red Sea) coral reefs in the last four decades has resulted in controversies on both the causes and remediation acts. With regard to reef rehabilitation, the traditional approach supports the idea of eliminating major disturbances only, thus leading to natural restoration of the reef. The second approach advocates more active measures such as farming coral colonies in nurseries and then transplanting them onto denuded reef areas. This study aims to supporting this second approach for active reef restoration by providing tools for maintenance of coral colonies in underwater nurseries.

The major issues tested involve using nurseries in which corals are farmed under various nutrition regimens and depths to various transplantation needs. The two sites which were selected represented: (1) nutrient enriched (NE) site; and (2) a regular depleted nutrient reef area (DN) of Eilat. Nubbins and fragments of three corals species, Pocillopora damicornis, Acropora sp. and Stylophora pistillata were placed in each location at two different depths (2 and 8 meters) and monitored for one year. Growth rates, photosynthesis capabilities, reproductive activities and colonization of reef dwelling invertebrates were observed and collected. Results showed high survival rate of more than 80% of corals fragments at the NE site compared to less then 50% survival rate at the DN site. Similar results were obtained for nubbins survivorship. Recently collected results will be presented on the poster.

## 24.1050

**Establishment Of Midwater Coral Nurseries in Discovery Bay, Jamaica**

**Rachel D'SILVA*[1]**, Judith MENDES[1], Dale WEBBER[2], Baruch RINKEVITCH[3]

[1]Department of Life Sciences, University of the West Indies, Kingston, Jamaica, [2]Centre for Marine Sciences, University of the West Indies, Kingston, Jamaica, [3]Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa, Israel

Coral nurseries are a tool in active reef restoration that provide source material for the rehabilitation of denuded reefs. The floating mid-water coral nursery was first developed in Israel. This study describes the adaptation of the mid-water floating nursery concept to Caribbean conditions and Caribbean coral species. The three mid-water floating nurseries that we have constructed in Discovery Bay, on the north coast of Jamaica, are the first coral nurseries of this kind in the Caribbean. Each nursery is self-floating, made from 3 inch PVC pressure pipe, and can be lowered to allow for the passage of hurricane generated waves. Two nurseries (Annabell and Tinkerbell) are located on the forereef at a depth of 10m and between 14-15m off the seafloor. The third nursery is at a depth of 3m and 12m above the seafloor in the backreef. We have tested the suitability of 10 Caribbean coral species and one colonial hydroid for culturing under nursery conditions (*Porites porites, P. divaricata, P. astreoides, Madracis mirabilis, Montastraea annularis, M. cavernosa, Eusmilia fastigiata, Agaricia agaricites, Acropora cervicornis , A. palmata,* and the hydroid *Millepora complanata*). Differences in growth rate have been observed between species as well as between fore and backreef nursery locations. On the fore reef, *P. porites* polyp number increased 383.1% and *M. mirabilis* 121.3% over an 87 day period, while in the backreef, *P.porites* and *M. mirabilis* (taken from the same parent colonies as those on the forereef) showed an increase in polyp numbers of 243% and 49.3% respectively. Remarkably two species, *P. divaricata* and *M. cavernosa*, had a faster rate of growth on the nurseries than was found in their parent colonies.

## 24.1051

**Mass Culture Of *acropora* Corals From Eggs And Larvae in The Republic Of Palau**

**Makoto OMORI*[1]**, Kenji IWAO[1], Minoru TAMURA[1], Hiroki TANIGUCHI[1], Tadashi KIMURA[2]

[1]Akajima Marine Science Laboratory, Okinawa, Japan, [2]Japan Wildlife Research Center, Tokyo, Japan

The restoration techniques of coral reefs have recently draw international attention in response to the worldwide degradation of coral reefs. In this circumstance, Global Environmental Facility, the World Bank and others launched international research program, Coral Reef Targeted Research and Capacity Building for Management. The Restoration and Remediation Working Group is examining the state of restoration technique and is targeting investigations to test efficacy of a range of potential applications. The present research at Palau International Coral Reef Center (PICRC) in the Republic of Palau is being carried out since April 2006.

We successfully obtained gametes of three *Acropora* species from neighboring water. The larvae of three species were cultured respectively, and in total about 168,000 juvenile corals (polyps) attached on the ceramic substrates. They were cultured in the mid-nursery cages suspended 3m below sea surface, together with juvenile top-shell, *Trochus niloticus* or another indigenous shell to control macroalgal growth on the substrates and cages. Only 1,240 colonies were remained after l year. The average diameter of *A. tenuis* was 2.0 cm (largest 6.8 cm). This significantly high mortality was due to miss selection of the site of mid-nursery where was suffered by heavy sedimentation. In April 2007, when a second mass culture was conducted at PICRC, we moved the mid-nursery site to offshore where transparency is much better than the previous one. The cost to produce one colony after one-year culture was US$20.6 in 2007, but we expect that it will be lowered considerably in 2008, as survival rate of the colonies seem to be better than the previous year.

## 24.1052

**Coral Habitat Expansion Project Around Okinotorishima Island, Japan**

**Wataru ANDO*[1]**, Kouji WATANABE[1], Ryota NAKAMURA[2], Noboru ISHIOKA[1], Nobuo MIKAMI[3], Akito SATO[4]

[1]Fisheries Infrastructure Development Center, Chuoo-ku, Japan, [2]Fisheries Infrastructure Development Center, Zamami Village, Japan, [3]National Research Institute of Fisheries Engineering, Kamisu City, Japan, [4]Fishery Agency, Minister of Agriculture, Forestry and Fisheries of Japan, Chiyoda-ku, Japan

Okinotorishima Island is a southernmost island of Japanese territory, approximately 1,740 kilometers south-southwest from Tokyo. The island consists of coral lagoon, east-west 4km and north-south 1.7km. Around the island, coral reef is the main ecological community. However, there are only a few area with high coral cover degree. Therefore, Fisheries Agency of Japan started the Coral Habitat Expansion Project around the island from 2005. This project aims developing methods to maintenance and increase of coral ecosystem around the island. We have investigated the coral growing condition and natural environment around the island and we have carried out to develop seed production and propagation techniques.

Until now, we have almost clarified dominant species of coral, distribution area and spawning period aloud the island. In addition, we succeeded to let the coral spawning in the water tanks on the ship and larval settlement on substrate tiles. We have been breeding the juvenile corals in the water tank of land institution (Akajima Coral Hatchery Center in Okinawa: ACHC). Moreover, we were able to perform the long-distance transportation of relatively large coral colonies from Okinotorishima to ACHT for more than 50 hours. These coral colonies spawned in the tank in 2007 early summer, and we have been breeding them in the tank. We have about 10 million Acropora juvenile corals at the end of 2007 in the water tanks of ACHC.

We will report the development of coral reef restoration technologies in Okinotorishima Island.

## 24.1053

**Seed Production of *Acropora* Corals of Okinotorishima, Southernmost Island of Japan**

Ryota NAKAMURA[1], **Akira WATANUKI*[2]**, Toru AOTA[3], Michio KITANO[4], Takayasu FUJITA[1]

[1]Fisheries Infrastructure Development Center, Tokyo, Japan, [2]Alpha Hydraulic Engineering Consultants Co., Ltd., Tokyo, Japan, [3]Fudo Tetra Corporation, Ibaraki, Japan, [4]ECOH Corporation, Tokyo, Japan

The Fisheries Agency of Japan has researched and studied corals of Okinotorishima Island to develop those propagation techniques since 2006. As a part of the research project, studies on coral seed production are carried out at Akajima Coral Hatchery in Okinawa. Target species are *Acropora tenuis, A. globiceps*? and *A.* sp. Broodstock were collected at Okinotorishima in August, 2006 and May, 2007, and placed in tanks with running seawater at the hatchery for long-term rearing. In 2007, spontaneous spawning events were observed in June for *A. tenuis* and July and August for *A. globiceps*? and *A.* sp. Peaks of the spawning occurred during waning moon periods. Seed production trials were carried out with a part of the eggs spawned. The eggs and larvae were kept in still seawater tanks, changing 3/4 of the water daily. After settlement, juveniles were transferred to running seawater tanks. The numbers and rates of larvae settled on substrates in *A. tenuis*, *A. globiceps*? and *A.* sp. were ca. 110,000 and 54.1%, ca. 660 and 1.9%, and ca. 1,700 and 2.3%, and the survival rates and mean longest diameter of the juveniles of each species at 3 months after spawning were 87% and 3.4mm, 94% and 2.8mm, and 97% and 3.5mm respectively. Meanwhile, the larval settlement rates were 0.9% in *A. globiceps*? and 1.7% in *A.* sp. in an experiment with eggs spawned by wild broodstock on a research vessel at Okinotorishima in July, 2007. The low settlement rates of these two species seem to result from some nature of the species. It may be necessary to develop mass seed production methods being suitable for each species.

## 24.1054

**Plug your Reef, Recovery of Porites after extraction of cores**

**Eric MATSON*[1]**

[1]Australian Institute of Marine Science, Townsville, Australia

Long-lived, annually-banded massive corals, e.g. *Porites*, provide both valuable histories of climatic and environmental conditions on coral reefs and coral growth responses to changes in these conditions. To retrieve these records requires mechanical extraction of cores from large, healthy coral bommies. Cores are cut by forcing a rotating cutting head vertically down into the colony. Cores are typically ~50-70 mm in diameter and the holes left in the colony are commonly plugged using tapered concrete cylinders.

The living coral tissue layer occupies only the outer ~1cm of the coral with unoccupied, dead skeleton below. Anecdotal reports suggest that the living tissue layer recolonises the surface of the concrete plug rapidly and the coral suffers no long-term damage as a consequence of core extraction.

The impact of and recovery from coring was assessed in eight *Porites* bommies from the Whitsunday Islands, Great Barrier Reef, Australia. Eight recently cored corals were tracked over 30 months and each colony photographed at ~ 6-month intervals with the images including the 50mm diameter core hole, the concrete plug and the area around the plug.

Within the first 6 months all colonies had begun to recover with living tissue extending over part of the surface of the concrete plug and by 30 months two colonies had fully recovered. The plug from one colony became dislodged after ~ 6 months providing a control hole which showed little or no recovery after 30 months.

The results of this study demonstrate the importance of plugging holes after coral core extraction to ensure the ongoing health of the coral colony. The study also demonstrates that full recovery of corals from core extraction may take years rather than months.

## 24.1055

**Reduced Production Of Gametes in A.digitifera As A Result Of Transplantation To A Stressed Reef**

**Jay ANDREW*[1]**, Arius MEREP[1], Geory MEREB[2], Steven VICTOR[2]

[1]Research, Palau International Coral Reef Center, Palau, Palau, [2]Research, Palau International Coral Reef Center, Koror, Palau

Soil runoff, resulting from poor land use practices, is affecting coastal marine habitats around Babeldaob Island, Palau. To determine potential impact of sediment in the water on coral growth and reproduction, we transplanted colonies of Acropora digitifera from a site, Iou Lukes, that is far from land base sources of stress, to Airai Bay, a site that is heavily impacted by sediment. Our data show that there was no significant effect of sediment stress on growth, however, there was significant effect on reproduction. Only 14% (1 out of 7 colonies) of the corals transplanted to Airai Bay spawned. In addition we collected naturally occurring A. digitifera from Airai Bay and only 57% of the colonies spawned (4 out 7 colonies). In comparison, colonies that were collected from Iou Lukes and transplanted back all spawned (7 of 7 colonies). The spawned eggs from colonies in Iou Lukes were much healthier than eggs from colonies in Airai Bay. These data suggest that when under stress, most energy is diverted to maintenance and growth and less energy is expended on reproduction.

## 24.1056

**Status Of Coral Reef Communities And Reef Restoration Efforts At Dongsha Atoll, South China Sea**

**Tung-Yung FAN*[1]**, Chieh WEI[2], Lee-Shing FANG[3]

[1]Department of Biology, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [2]Department of Biology, National Museum of Marine Biology and Aquarium, Checheng, Taiwan, [3]Cheng Shiu University, Kaohsiung, Taiwan

In light of the World-wide decline in coral cover, there is intense interest in the potential for reef restoration to accelerate the regrowth of scleractinian corals on denuded reefs. The coral reefs surrounding Dongsha Island, South China Sea, were dominated by the branching *Acropora* spp. and massive *Porites* spp., but severe thermal bleaching resulted in mass mortality of *Acropora* spp. that created piles of coral rubble spreading over several kilometers of reef surface in 1998. In 2007, the status of coral reefs at Dongsha Atoll was assessed at 4 coastal reef and 2 lagoon sites using phototransect surveys, with the objective of assessing the current status of the reef and designing an ecologically appropriate reef restoration program. The percentage cover of turf algae and macroalgae ranged from 48.0 to 92.3% at all 6 sites, and at 4 of the sites, coral cover ranged from 14.1 to 50.6% and consisted largely of the branching coral *Porites cylindrica* and the foliaceous coral *Echinopora lamelosa*. At the 2 other sites, however, coral cover was < 3.1% and the reef was dominated by dead *Acropora* rubble with no sign of recovery. Based on the current success of *P. cylindrica* and *E. lamelosa*, we inferred that they were resistant to higher temperature, and therefore selected them for use in a reef restoration effort designed to accelerate the recovery of corals at this remote atoll. During August and October 2007, more than 100 corals from each species were transplanted to the 2 sites dominated by dead *Acropora* rubble using techniques that either attached the fragments to the reef and rubble or left them scattered over the surface. Preliminary work suggested that both techniques provided viable means to promote reef recovery. We plan to compare the techniques in a large-scale trial of a reef recovery program.

## 24.1057

**Growth-Rate And Survivorship Of *acropora Formosa* And *stylophora Pistillata* Transplants in Tun Sakaran Marine Park (Tsmp), Sabah, Malaysia.**

**Azman B.A.R.*[1]**, Nasrulhakim M.[2]

[1]Marine Ecosystem Research Centre (EKOMAR), Universiti Kebangsaan Malaysia, Selangor, Malaysia, [2]Tun Sakaran Marine Park (TSMP), Semporna, Malaysia

Branching hermatypic corals, *Acropora formosa* and *Stylophora pistillata*, were transplanted into two areas of the Ribbon reef tract in the Marine Protected Area (MPA) of Tun Sakaran Marine Park (TSMP). Sixty coral fragments were transplanted next to the parent colony. The growth-rate of these corals was measured four times between August 2006 and August 2007. The mean height of the fragments was 6.16cm (SD±3.12) ranging from 2.4-17.5cm at time of the transplantation. Average growth-rate of all surviving fragments was 0.477cm per month. Growth-rates between coral fragments, however, showed considerable variation. There was no significant difference in growth rates between sites; however a slight difference was seen between the two transplanted species. The mean survival of the coral fragments was 63.3%. The microhabitat chosen for transplantation is critical and based on the results of this study, the transplanting process is generally successful. The results suggest that the method may be used as a commendable transplanting technique in MPAs for conservation effort.

## 24.1058

**The Growth Rate Of Fragmented Acropora Formosa, A. Brueggemanni, And Euphylia Ancora in Hurun Bay Of Lampung Province-Indonesia**

**Suryadi SAPUTRA*[1]**, Endang WIDIASTUTI[2]

[1]Ministry of Marines and Fishery, Main Centre for Mariculture Development, Lampung Selatan, Indonesia, [2]Biology, University of Lampung, B. Lampung-Lampung, Indonesia

Coral reefs have been greatly traded as part of ornament fish. Since the degradation of coral reefs ecosystem in Indonesia has occurred in the last decade and if the trading corals collected from their habitat rapidly grows, then these activities would increase degradation process of the reefs. Therefore, some applicable technology for corals culture by fragmentation is necessary to be established. The study was conducted in order to determine the growth rate of transplanted coral fragments. Three different coral species were compared, two were branching corals (Acropora formosa and A. brueggemanni) and one was a massive coral (Euphyllia ancora). For Acropora species there were three treatments based on the number of branches, namely two, three or four branches with 5 replicates, for the Euphyllia there were two treatments, with either on or two polyps being transplanted, with 10 replicates. Completely randomized design was applied for this matter. After acclimatization, the fragmented corals were placed in the open water of Hurun Bay on 5-6 meter depth and observed for 150 days. The parameters of water condition were determined, and mainly they were in the normal range for the coral growth. The survival rate of A. formosa was 60%, A. brueggemanni was 80% and E. ancora was 100%. The growth rates, which were measured on their width and length, indicated the increase in width size was 0.14 – 2.02 cm/month for A. formosa and 0.11 – 0.71 cm/month for A. brueggemanni, and 0.06 – 0.43 cm/month for E. ancora, while the increase in height of each fragmented corals were 0.18 – 1.50 cm/month for A. formosa, 0.12 – 1.09 cm/month for A. brueggemanni, and 0.06 – 0.43 cm/month for E. ancora. Based on the survival and growth rates of transplanted corals fragments, we concluded that the best growth of A. formosa was 2 branches fragment, while A. brueggemanni was 4 branches fragment, and E. ancora was 2 polyps fragment.

## 24.1059

**Identifying Sediment-Tolerant Coral Taxa from LIT Data in Singapore to Aid Decision-Making in Reef Restoration Efforts**

**Karenne TUN*[1,2]**, Eugene GOH[2], Loke Ming CHOU[1], Tom FOSTER[2]

[1]Biological Sciences, National University of Singapore, Singapore, Singapore, [2]DHI Water & Environment, Singapore, Singapore

The importance and urgency of coral reef restoration has become increasing apparent, with the increasing global decline of coral reefs, especially in the biodiversity-rich Indo-Pacific region. Currently, research efforts supported through Global Environment Facility (GEF) and EU projects are aimed at identifying and testing techniques and methodologies to aid reef restoration in areas where it is most needed. Commonly, these areas are characterized by high sedimentation and turbidity, and are usually in close proximity to developed or developing coastlines. In this regard, one key question that remains to be addressed is which species/genera are tolerant to high sediment and turbidity stress, so that they can be targeted for restoration. This paper investigates the possibility of identifying sediment-tolerant taxa from extensive coral reef monitoring data of reef areas exposed to sediment stress. Our aim is to develop a list of hard coral genera with distinct or overlapping sediment tolerance ranges.

## 24.1060

**Staghorn Coral (*acropora Cervicornis*)restoration Offshore Southeast Florida Using Resilience Principles**

**Elizabeth GOERGEN*[1]**, Meaghan JOHNSON[2], David GILLIAM[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]The Nature Conservancy of the Florida Keys, Summerland Key, FL

As part of a larger project initiated by The Nature Conservancy, NCRI (Broward County, southeast Florida) is working collaboratively with Mote Marine Laboratory and Sea Life, Inc (Florida Keys) and the University of Miami (Biscayne National Park) to examine potential *Acropora cervicornis* restoration techniques along the entire Florida reef tract. Offshore SE Florida, scattered colonies and larger patches of *A. cervicornis* are present on the nearshore ridge and inner reefs. For this project 13 colonies separated by as much as 27km were identified, assessed, photographed, and tagged. Two small (<2cm) clippings were collected for genotypic analysis and 3 clippings (10cm) were collected for transplantation onto a nursery habitat from each colony. Prior to transplantation, each 10cm clipping was cut into 3cm fragments. The fragments are monitored monthly, and following a minimum of 6 months growth will be out-planted to 3 different natural reef habitats. During each monthly monitoring event images are taken, growth (linear extension) is measured, and condition (partial mortality, disease, predation, etc.) is assessed for each fragment. In September 2007, 2 colonies were tagged and 18 fragments were transplanted. In October 2007, 9 additional colonies were tagged and fragments from 3 colonies were transplanted. In December 2007, 2 colonies were tagged and fragments from the remaining 7 colonies were transplanted. The collection periods were separated due to a higher than expected September fragment mortality (56%). The SE Florida reef system was experiencing a bleaching event at this time and environmental conditions may not have been appropriate for fragment survival. Final transplantation was therefore postponed until December when conditions appeared to be more favorable. This SE Florida effort will contribute to a quantitative comparison of genotypic variation in survivorship and growth, which will provide information on within and among region potential for large-scale restoration within the Florida reef tract.

## 24.1061

**Growth And Survival Of "Pocillopora Meandrina"(antozoa) Fragments From Experimental Transplants, in Mexican Coral Reef Community**

**Juan Manuel OSEGUERA CRUZ*[1]**, Dení RODRÍGUEZ[2]

[1]Biologia Comparada, Universidad Nacional Autonoma de México, Mèxico D.F., Mexico, [2]Biología Comparada, Universidad Nacional Autonoma de México, México D.F, Mexico

The potential recovery of the reefs is defined as the ability of an individual colony or a reef system, to absorb the impacts of the environment and maintain its ability to recover and develop. With the widespread destruction of coral reefs in various parts of the world, has increased interest in the use of coral fragments transplantation as a possible tool for the rehabilitation of areas. The survival of the fragments enables species to spread their distribution and abundance locally, the pieces have the potential to survive and reproduce, forming new colonies. The objective behind this work is to conduct pilot studies and obtain relevant data to enable assess whether the fragmentation that occurs in the periphery of the growth of colonies of coral Caleta de Chon, Zihuatanejo Guerrero, Mexico, is an option to increase the coverage to restore degraded areas. Conducting two experiments we evaluated the growth and survival potential of Pocillopora meandrina, with fragments placed in 3 different depths (10, 6 and 3.5 meters) taking environmental factors (temperature, PAR and water turbulence). The coralline growth was estimate in pictures by the increment of area measured in a graduate mesh, so alternating a second experiment was carried out by taking the fragments weight. The analysis of covariance showed that the fragments of all depths equal to grow proportionately throughout the depth range, while the survival of the fragments is less than 3.5 m deep, while the 6 and 10 m survival is close to 100%.The final results of our work indicate that Pocillopora meandrina fragments are totally feasible to perform transplants to troubled areas in the communities of corals in Pacific and leave a precedent for future studies in the area.

## 24.1062

**Fish Predation On Juvenile Stony Coral, *siderastrea Siderea*, Transplanted Offshore Southeast Florida, Usa**

**Allison BROWNLEE*[1]**, Vladimir N. KOSMYNIN[2], Alison MOULDING[1], Kenneth BANKS[3], Louis FISHER[3], David GILLIAM[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]Florida Department of Environmental Protection, Tallahassee, FL, [3]Broward County Environmental Protection Department, Plantation, FL

Fish predation is not typically a cause of significant stony coral transplant mortality. However, a recent relocation study offshore southeast Florida showed significant and rapid mortality of juvenile *Siderastrea siderea* transplants due to fish predation. The original purpose of this study was to evaluate the efficacy of minimizing impacts from coastal construction activities and enhancing recovery at injured reefs by transplanting juvenile *S. siderea* colonies. In November 2007, 112 small (3-10cm diameter) *S. siderea* colonies were removed from a shallow (3-5m depth) impacted site near shore and relocated offshore to a deeper (7-10m depth) ship grounding site. During transplantation, stoplight parrotfish, *Sparisoma viride*, were observed biting the transplants, and mortality was noted. Within two weeks of transplantation, 95% of the colonies had been affected, and 57% suffered massive mortality (50-100% tissue loss). The study was repeated at an alternate grounding site, using the same methods to transplant an additional 40 colonies from the same nearshore site and 10 colonies from the grounding site itself. After one week, 100% of the nearshore colonies were affected, and 87% suffered massive mortality. Predation on the 10 local colonies was much less; only 10% suffered massive mortality. The factors related to the differential predation on the relocated nearshore colonies versus the local colonies are unknown. If resource managers require small *S. siderea* colony relocation prior to permitting coastal construction activities and/or small *S. siderea* colony relocation is to be used for enhancing reef recovery, fish predation affects on transplantation success will need to be addressed.

## 24.1063

**Successful Reef Rehabilitation Through Coral Transplantation At Hikkaduwa Marine Park, Sri Lanka**

Suki EKARATNE1, **Sithara JINENDRADASA*[2]**

[1]Zoology, University of Colombo, Colombo, Sri Lanka, [2]International Water Management Institute, Colombo, Sri Lanka

Coral transplantation with *Acropora* 'fragments' in the reef lagoon at Hikkaduwa Marine National Park , Sri Lanka, following mass coral mortality in April 1998, and monitored over 8 years, including after the tsunami event, tested eight transplantation techniques in areas that previously had live coral stands. These were cut-nubbins, horizontal untethered and tethered fragments, upright tethered fragments, branched fragments attached to rubber bases and to concrete grid-blocks, branched fragments in sand and shaded/exposed fragments, where transplantation success was assessed using Anova on monthly linear growth, branching and survival.

Transplanted cut-nubbins grew at 0.30±0.027mm.day$^{-1}$ with branching by the first month of transplantation, but suffered 100% loss due to fish cropping. Horizontal untethered fragments incremented at 0.05±0.016mm.day$^{-1}$ with 60% mortality and drupellid colonization, branching commenced at one month. Horizontal tethered fragments incremented at 0.01±0.046mm.day$^{-1}$ with 47% mortality and light attachment within a month. Upright tethered fragments showed negative growth (-0.36±0.100mm.day$^{-1}$). Branched fragments attached to rubber mat-base grew at 0.03±0.011mm.day$^{-1}$, without any mortality. Branched fragments attached to concrete grid-blocks grew at 0.08±0.010mm.day$^{-1}$ showing alternating slower and faster growth periods, and without any mortality. Branched fragment in sand showed 0.2±0.040mm.day$^{-1}$ growth and no mortality, but their basal regions became buried with sediment deposition. Shaded and exposed fragments grew at 0.07±0.100mm.day$^{-1}$ and 0.03±0.054mm.day$^{-1}$, respectively, with no mortality.

Since transplantation of branched fragments onto concrete grid-blocks yielded best long-term results, 4' by 4' areas transplanted by this method were monitored over 8 years and proved successful, attracting a variety of fish, with no loss even from the forces of the tsunami. Sediment accumulation, common with degraded reefs, passed into holes of its gridded design. Transplanted fragments, being placed horizontally, also withstood cropping pressure.

## 24.1064

**Comparison Of Fish Assemblages Between Mitigation Boulder Reef And Neighboring Natural Hardbottom in Broward County, Florida, Usa**

**Jessica FREEMAN*[1,2]**, T. Patrick QUINN[1,3], Lance K. B. JORDAN[1,2], Kirk KILFOYLE[1,2], Richard SPIELER[1,4]

[1]Oceanographic Center, Nova Southeastern University, Dania Beach, FL, [2]National Coral Reef Institute, Dania Beach, [3]Biological Resources Division, Broward County Environmental Protection Department, Plantation, [4]National Coral Reef Institute / Guy Harvey Research Institute, Dania Beach

A beach renourishment project was initiated in May 2005 and completed in February 2006 to restore 11.1 km of shoreline in Broward County, Florida, USA. For mitigation of predicted nearshore hardbottom burial, a boulder reef totaling 3.6 ha was deployed in 2003. To examine the replacement value of the mitigation relative to fishes, this study compared fish assemblages on boulder reef to those on adjacent natural hardbottom. Twenty-five natural hardbottom sites and twenty-five boulder reef sites were surveyed six times between March 2005 and August 2007. Two non-destructive visual census methods, a transect count (30 m long x 2 m wide x 1 m high) and a 20 minute rover diver count (approximately 30 m x 30 m), were conducted at each site to assess abundance and species richness. On transect counts 7,117 fishes of 96 species were counted on natural hardbottom, while 11,769 fishes of 119 species were counted on boulder reef. Across both survey types, a total of 271 species was recorded. Significant differences among reef fish assemblages were found in both abundance and species richness ($p<0.05$, ANOVA). Similarly, an MDS plot of Bray-Curtis similarity indices indicated differences between natural hardbottom and boulder reef within all individual years. Natural hardbottom exhibited higher densities of newly settled (<2 cm TL) *Haemulon* spp., while boulder reef showed higher densities of early juvenile (2-5 cm TL) *Haemulon* spp. Boulder reef also demonstrated a higher abundance of fishes greater than 5 cm and piscivorous fishes in general. While boulder reef may provide a suitable habitat for many fishes, it does not mimic natural hardbottom associated fish assemblages, nor does it provide a similar nursery habitat for juvenile fishes.

## 24.1065

**Differences in fish communities on artificial reefs of different age in the United Arab Emirates**

**Paolo USSEGLIO*[1]**, Andrew BAUMAN[1], John BURT[2,3]

[1]International Network on Water, Environment and Health, Dubai, United Arab Emirates, [2]Natural Science and Public health, Zayed University, Dubai, United Arab Emirates, [3]Biological Sciences, University of Windsor, Windsor, Canada

Artificial reefs are being increasingly promoted as a means to mitigate environmental impacts and to enhance fisheries yield. Assessments of artificial reefs typically occur shortly after deployment. However, changes in benthic communities over longer time scales may affect associated fish assemblages. These changes may be perceived as positive or negative depending on management goals. The purpose of this study was to compare fish communities associated with 4 large artificial reefs ranging in age from 2 to 35 years. Fish communities differed significantly on artificial reefs of different age, with older reefs having higher overall species diversity and abundance. Abundance of herbivores was negatively correlated with age, while facultative coral dwelling species were positively correlated with age. Intermediate age reefs (5-25 years) showed assemblages similar to each other, but distinct to very young (2 years) and very old (35 years) artificial reefs. Results suggest that artificial reefs of different age have distinct fish communities, and that assessments of artificial reefs should occur over longer timescales.

## 24.1066

**Effects Of Status And Density Of A Threatened Coral Species, Acropora Cervicornis, On Coral Reef Fish Recruitment: Implications For Fisheries Management**

**R. L. GONZALEZ-MARRERO*[1]**, P. M. YOSHIOKA[2]

[1]Biology, University of Puerto Rico, San Juan, Puerto Rico, [2]Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico

Acropora cervicornis is a Caribbean coral listed as "threatened" (2006) under the U.S. Endangered Species Act. This coral is an important reef builder and its physical structure is unique among Caribbean corals. Since A. cervicornis is structurally complex (highly branching) and often occurs in large monospecific patches, many scientists hypothesize that this coral species is an important habitat for coral reef fish recruitment. Therefore, its recent demise could result in a significant reduction in the abundance and diversity of coral reef fish assemblages. To study the effects of coral condition (i.e. alive/dead) and density on fish recruitment, 5, 20 or 35 live or dead coral fragments were uniformly arranged in a grid at 8cm intervals. Each fragment was approximately 15cm in length with 3 branches. Fish abundance was estimated at 2-4 week intervals for 5 months. In most sampling intervals, no significant differences were found between equal densities of live and dead fragments. However, fish recruitment was significantly lower in both the live and dead low density treatments. For example, in May, the Student-Newman-Keuls test indicated significantly lower recruitment in both low density treatments compared to the live high density treatment ($p < 0.05$). Preliminary results show that structural complexity is the major factor affecting fish recruitment. This highlights the importance of coral density as a key factor for fisheries management.

## 24.1067

**Growth Of Newly Settled Reef Corals At The Mpa Corals' Coast-Northeastern Brazil.**

**Barbara PINHEIRO*[1]**, **Mauro MAIDA*[2]**

[1]Oceanografia, UFPE, Recife, Brazil, [2]Oceanografia, UFPE, Recife -PE, Brazil

Studies related to the settlement and recruitment of corals has been of great importance for the understanding and elucidation of the diverse operating factors that contribute for the initial structure of a reef community. This study was carried out at the biggest marine protected area in Brazil created to preserve the coastal coral reefs, one of the most threatened ecosystems in this country. We aimed, through the use of artificial substratum confectioned with ceramics tiles vertically guided, to determine the patterns of settlement, mortality rate and growth of corals recruits on the Ilha da Barra reef (a No-Take zone at this MPA). The plates were distributed around one of the Ilha da Barra's pools in August of 2004. Monthly, through out the year of 2005, and in January of 2006, tiles were collected and analyzed in laboratory. The presence of newly settle corals, was investigated as well as theirs growth, position and survival. These plates were kept in tanks with proper aeration and constant circulation during analysis and subsequently returned to the sea. The coral settlement apparently was dominated by brooder species and occurred preferentially during the summer, and was found a density of 12.2 recruit/m2. The absence of edge effect confirmed that inclination and positioning of the plates provided good light intensity distribution. It was observed a mean growth rate of 11.27(4.30SD) mm and 20.42(8.97SD) mm in diameter for *Siderastrea stellata* and *Favia gravida* respectively, both Brazilian endemic coral species. The difference between growth rates was attributed to the taxonomic variation of these species. This was the first study to examine the growth rate of newly settle corals in Brazil

## 24.1068

**Differential Post-Recruitment Survival Of Corals On Neighboring Artificial And Natural Reefs: Implications For Reef Restoration**

**Shimrit PERKOL-FINKEL*[1]**, Yehuda BENAYAHU[1]

[1]Zoology, Tel Aviv University, Tel Aviv, Israel

Understanding the processes that shape artificial reef (AR) communities is critical if these are to be used for reef restoration purposes. A study of the post-recruitment survival of coral colonies transplanted onto a mature AR and its adjacent natural reef (NR) was carried out in Eilat (Red Sea) in order to test the hypothesis that differences in benthic communities between adjacent ARs and NRs are derived from differential survival processes. Transplanted miniature coral colonies were monitored in situ on both reef types. It was found that the survival of miniature colonies of the soft coral Dendronephthya hemprichi on a 10-year-old AR was nearly double that of those transplanted onto the NR. Similarly, survival of nubbins of the stony coral Pocillopora damicornis on the AR was over three-fold greater than on the NR. We suggest that the observed differential survival resulted from the unique suites of environmental conditions at the two habitats, mainly in terms of sedimentation load and current velocities. The suggest that in order to construct an AR for restoration purposes, it must offer similar environmental conditions to those offered by the natural surrounding in order to avoid differential post-recruitment survival.

## 24.1069

**Settlement Behavior Of *acropora Palmata* Planulae: Effects Of Biofilm Age And Crustose Coralline Algal Cover**

**Patrick ERWIN*[1]**, Alina SZMANT[1]

[1]Center for Marine Science, University of North Carolina Wilmington, Wilmington, NC

The impacts of persistent declines in coral cover may be compounded by concomitant reductions in coral recruitment to areas of high coral mortality. Understanding the factors that influence planula behavior and settlement choice are integral steps to reef preservation and restoration. Both crustose coralline algae (CCA) and microbial biofilms have been shown to play a role in coral larval settlement. A time series experiment was conducted by pre-conditioning ceramic tiles in reef waters for 0, 2, 4, 6, 8, and 9 weeks and determining settlement rates of *Acropora palmata* at each time point. Following settlement assays, digital photographs were taken of each tile to quantify CCA cover. Tile surfaces were then swabbed to sample microbial biofilms for genetic characterization. Larvae of *A. palmata* clearly preferred to settle on the underside of tiles as conditioned in the field (78%), compared to tile tops (8%) or Petri dish surface (14%),. Larvae showed no preference for surface texture. Larval settlement rates varied significantly among time treatments (ANOVA, $p<0.001$), with low settlement (11%) on unconditioned tiles, moderate settlement (46%, 49%) on tiles conditioned for 4- and 6-weeks, and high settlement (87%, 84%) on tiles conditioned for 8- and 9-weeks. CCA cover on settlement tiles increased with longer pre-conditioning times (ANOVA, $p<0.001$); however, variation within treatments was large. CCA cover was positively correlated with larval settlement (Linear Regression, $p<0.05$), but only explained 16.3% of the variation in settlement rates, suggesting additional cues were responsible for most of the settlement. Terminal restriction fragment length polymorphism (t-RFLP) analysis, a sensitive DNA fingerprinting technique, is being used to compare biofilm species richness and diversity across treatments and assess correlations between biofilm composition and larvae settlement rates.

## 24.1070

**Does Substrate Conditioning Enhance Larval Settlement in Corals? A Closer Look At A Singapore Study.**

**Beverly GOH*[1]**, **Co Sin LEE*[2]**

[1]Natural Sciences & Science Education, National Institute of Education, Nanyang Technological University, Singapore, Singapore, [2]Tropical Marine Science Institute, National University of Singapore, Singapore, Singapore

Reef rehabilitation studies have shown that marine biofilms play an important role in coral larval settlement. Biofilms are formed when substrata are immersed in seawater over a period of time in a process of conditioning. This study investigated the settlement of *Pocillopora damicornis* larvae on concrete tiles which had been conditioned in seawater over different time durations. The objective was to determine if increasing durations of tile conditioning increased the density of larval settlement on the tiles. Newly planulated larvae were exposed to tiles that had been conditioned in running seawater for one, two, four, six and eight weeks, with unconditioned tiles used as controls. Results indicated that larval settlement decreased with increasing duration of tile conditioning. Two-way ANOVA on larval settlement density indicated no significant interaction between the duration of tile conditioning and the preferred settlement surface on the tile. Tukey's post hoc test revealed no significant differences in larval settlement densities in treatments and controls, but significant differences in the choice of settlement surfaces preferred by larvae. Larvae preferred to settle on the sides of the tiles, compared to the top and bottom surfaces. A concurrent experiment examined sediment accumulation on tiles during conditioning in seawater over the same treatment durations. Sediment accumulation increased with increasing duration of tile conditioning, particularly on the top surfaces. Regression analysis conducted on the weight of sediment accumulated and the density of settled larvae indicated a negative and significant correlation between the two variables. Sediment accumulation on biofilm layers growing on underwater substrata likely affects the suitability of these surfaces for larval settlement and recruitment. This factor must be taken into account when designing artificial surfaces to enhance coral larval settlement for reef rehabilitation.

## 24.1071

**Reef Rehabilitation And Natural Recovery: Does Transplantation Of Coral Fragments Increase Natural Recruitment?**

**Sebastian FERSE*[1]**

[1]ZMT Bremen, Bremen, Germany

The potential of degraded coral reef areas to recover, provided chronic stressors are removed, depends to a large part on the natural recruitment of coral larvae. One argument for the use of coral transplants in reef rehabilitation is that it may lead to an increase in coral recruitment in the surrounding area, either directly through gametes subsequently released by brooding transplants, or indirectly through processes of facilitation and attraction. In this study, fragments of brooding and spawning coral species were transplanted in combination with artificial structures at three locations in North Sulawesi, Indonesia. Combinations of one brooding and one spawning species (*Pocillopora verrucosa*/*Acropora yongei* and *P. verrucosa*/*Acropora formosa*) were used at two sites, and one brooding species (*Acropora brueggemanni*) was transplanted at the third site. At each site, natural recruitment rates in the plots were assessed using settlement plates exchanged every three months, and compared to rates in a rubble plot and a plot with artificial structures alone. No significant differences in the numbers of recruits could be detected between the three treatments at all three locations, with the exception of the final measurement. Here, an increase in the total number of recruits indicated an annual spawning event at all three locations, and numbers of recruits were highest in the plots containing transplants at two sites. Identification of the recruits to family level revealed a higher percentage of Acroporids in the transplant plots than in the other plots at spawning times, while the percentage of Pocilloporids was lowest in the transplant plots. These results indicate that transplantation of Acroporids may facilitate the recruitment of other Acroporid, while discouraging recruitment of Pocilloporids. No larval seeding by the brooding *P. verrucosa* could be shown during the time-frame of this experiment.

## 24.1073

**Post-Settlement Development Of The Scleractinian Corals *acropora Palmata, Montastrea Faveolata* And *diploria Strigosa***

**Abel VALDIVIA*[1,2]**, Margaret W. MILLER[3], Benjamin MASON[4], Dana E. WILLIAMS[1,2], Lyza JOHNSTON[4]

[1]Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Southeast Fisheries Science Center, National Oceanographic and Atmospheric Administration, Miami, [3]Southeast Fisheries Science Center, National Oceanographic and Atmospheric Administration, Miami, FL, [4]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

Early life history, specifically the post-settlement phase, of broadcasting scleractinian corals has been poorly treated in the literature due to the difficulty of following small settled spat. Here we present a time photo-series of early post-settlement development for three broadcasting species, *Acropora palmata*, *Montastrea faveolata* and *Diploria strigosa*. Larvae were settled onto different natural and artificial substrata in a closed seawater aquarium (outdoor shaded environment and temperature controlled at 26-27oC), in order to document morphological differences among species. Predation and sedimentation were excluded from the system. Within one week post-settlement, two cultured strains of zooxanthellae and natural reef substrates were introduced as a source of endosymbionts. After one week post settlement, premature basal plate formation with six salient initial septa was observed in all three species even for those polyps without visible zooxanthellae. In the second week, a few polyps from *A. palmata* budded while polyps from *M. faveolata* started budding on the fourth week. In the fourth week, the average diameter size of *A. palmata* was the highest at 1091.7 microns (± 66.0 SE) followed by *D. strigosa* at 681.3 microns (± 29.6 SE) while *M. faveolata* was the smallest at 576.7 microns (± 27.7 SE). At the tenth week, survivorship of *M. faveolata* polyps, settled on marble tiles, was higher (95%) than those polyps settled on natural rubble (22 %). After 17 weeks, calices of the three species were growing more in height, than in diameter. Clearly, morphological differences were present including size, septa shape, and tentacle development among species. Understanding and distinguishing early-stage growth and survivorship and their controlling factors in broadcasting corals could provide crucial insights to develop strategies for restoration and effective management of these species.

## 24.1074

**Coral Recruitment in Sediment-Stressed Reefs: Effect Of Reef Zone And Substrate Inclination**

**Jani TANZIL*[1]**, Loke Ming CHOU[1], Peter TODD[1]

[1]Department of Biological Sciences, National University of Singapore, Singapore, Singapore

Approximately 60% of Singapore's coral reefs have been lost through foreshore reclamation. A monitoring programme initiated in 1987 indicated declining live coral cover with increasing depth and over time. Hermatypic corals generally do not occur deeper than 6m due to high sediment loads (5–45mg cm-2 day-1 in 1994) and resultant low visibility (0–5m). In March 2005, 288 20cm×20cm terracotta tiles were deployed for 6 months in order to investigate optimal conditions for enhancing coral recruitment. Recruitment was measured at 3 different reef zones, i.e. reef flat (1.5–3.5m depth), crest (4–6m), and slope (6.5–8m), and 4 different settlement plate inclinations, i.e. 0o (horizontal), 30o, 60o and 90o (vertical). Results revealed that recruitment on tiles deployed at the reef flat was highest, followed by that deployed at the reef crest and slope. Results also revealed that at all reef zones, tiles inclined at 60o and 90o had significantly higher recruit counts than those at 0o and 30o. Recruits on the flat and crest tiles were predominantly Pocillopora damicornis and Acroporids, with few representatives from other taxonomic groups. However, sizes of recruits (based on P. damicornis) on slope tiles were generally smaller (~0.2cm diameter) than those on flat or crest tiles (~1cm diameter); this could be due to either differential rates in mortality and/or growth of the recruits at the different reef zones.

## 24.1075

**Distribution and Recruitment of the Black-lipped Pearl Oyster, *Pinctada margaritifera*, at Midway Atoll, Northwestern Hawaiian Islands**

**Kristin MCCULLY*[1]**, Donald POTTS[1]

[1]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, Santa Cruz, CA

The black-lipped pearl oyster, *Pinctada margaritifera*, is considered a potential indicator of the "health" of reef lagoons. It occurs throughout the Hawaiian Archipelago, including Midway Atoll near the northern end of the chain. This species experienced intense commercial exploitation at neighboring Pearl and Hermes Atoll in 1927-1929 and has not recovered to pre-exploitation levels. Although *P. margaritifera* exists at Midway Atoll, there are no reports of it ever being the subject of a commercial industry. Adults are rare at Midway, but we observed recruitment of juveniles onto a variety of substrates at four locations inside the lagoon in 2007. We are continuing studies on adult distribution, growth rate, and temporal and spatial patterns of spawning and recruitment in order to extend knowledge of the biology of *P. margaritifera*, enhance understanding of its use as an indicator of environmental change, and provide a pilot restoration study at Midway that will assist the U.S. Fish and Wildlife Service's goal of restoring *P. margaritifera* at Pearl and Hermes Atoll.

## 24.1076

**Herbivore Effects On Coral And Algal Population Dynamics**

**Sarah DAVIES*[1]**, Peter VIZE[1]

[1]Biological Sciences, University of Calgary, Calgary, AB, Canada

Regime shifts from coral to algal dominated communities have been well documented and herbivores have been shown to participate in these ecological shifts in community structure. Throughout the Caribbean, coral degradation is increasing and algal dominated communities are becoming more common. Competition and overgrowth by algal species appear to negatively affect coral recruitment success. Several preliminary studies indicate that increasing herbivore density facilitates an increase in coral growth.

Our project aims to test the effects of herbivores on recruitment and survival of scleractinian corals at the Flower Garden Banks National Marine Sanctuary (FGBNMS), Gulf of Mexico. A controlled environment has been constructed on a sand patch at a depth of 23 m. It consists of a galvanized steel platform measuring 6 x 6 m. Nine large fiberglass bins have been attached to this platform, each of which contains one of three herbivore treatments (*Diadema antillarum, Cerithium litteratum,* no herbivores). Artificial tiles are used as settlement substrates within each bin and high-resolution photography will monitor long-term recruitment and survival patterns of all settling organisms.

Coral recruitment fluctuations can have profound repercussions on the management of corals reefs. Low recruitment rates being observed on Caribbean reefs will likely result in slow reef recovery after natural or anthropogenic disturbances. Promoting recruitment has been suggested as a solution to reduce the long-term decline of coral communities and gaining baseline knowledge about coral population maintenance is essential to reef longevity.

## 24.1077

**Effect Of Herbivore Exclusion On The Survivorship Of Hatchery Reared Acropora Tenuis Spats**

**Maria Vanessa BARIA*[1]**, James GUEST[2], Porfirio ALIÑO[1], Andrew HEYWARD[3]

[1]The Marine Science Institute, University of the Philippines, Quezon City, Philippines, [2]School of Biology, Newcastle University, NE1 7RU, United Kingdom, [3]Australian Institute of Marine Science, Crawley, Australia

Post-settlement mortality is one of the critical stages in the life a coral, however little is known about the effect of herbivory on post-settlement survivorship of coral spat. Herbivorous fish may affect coral spat survival in two ways, mortality may increase if small spat are grazed accidentally or mortality may be reduced if herbivores prevent spat being overgrown or killed by macroalgae and other benthic biota. This study was conducted to understand the mechanisms affecting the survival of one-month old coral spats of *Acropora tenuis* specifically the influence of grazers and algal density at two depths, 4 and 9 m. Larvae of *A. tenuis* were reared in the hatchery facility at Bolinao Marine Laboratory in north-western Philippines as part of work to develop low cost coral larval rearing for reef restoration. Settled spat were placed on the reef approximately 40 days after settlement in three treatments, caged, open sided cage and no cage. Although the density of turf algae was higher in the cage treatment, survivorship of coral spats was significantly lower in the uncaged set-ups at both shallow and deep sites after 3 months (4.72 and 10.5% respectively). Higher survivorship was observed in cages at 9 than 4 m deep (33% and 17% respectively). It is likely that accidental grazing of algae on the uncaged settlement plates contributed the to lower survivorship, although shading may also have played a role. Further research is needed to see if survivorship in cages decreases at a later stage due to overgrowth by other biota and whether survivorship is enhanced if spat are settled on substrata with rough surfaces (to provide possible refuge from grazers). The results of this study are relevant to reef restoration studies that aim to use larval rearing and outplanting of coral spat.

## 24.1078

**Considerations For Experimental Transplantations Of Diadema Antillarum**

**Aaron ADAMS*[1]**, Erich BARTELS[2], Robert MILLER[3], John EBERSOLE[4], Cory WALTER[2], Ken LEBER[5]

[1]Mote Marine Laboratory, Pineland, FL, [2]Mote Marine Laboratory, Summerland, FL, [3]University of California Santa Barbara, Santa Barbara, CA, [4]University of Massachusetts Boston, Boston, MA, [5]Mote Marine Laboratory, Sarasota, FL

Diadema antillarum experienced a Caribbean-wide mass mortality in 1983-84. Recent localized recovery has been documented throughout the Caribbean, with reduced algal cover and increased coral recruitment. However, even within locations, Diadema density is extremely patchy. The combination of patchy distribution, potential for recovery, and Diadema's importance as a key herbivore, has prompted some to recommend Diadema transplantation as a potential reef restoration tool. Recent experiments, however, suggest caution must be used when considering transplantation as a viable method for Diadema stock enhancement and/or restoration.

Recent research in the Caribbean showed positive density-dependence whereby juvenile Diadema survival was greater in areas of high adult densities. This approach was expanded in the upper Florida Keys, where a grid of 30, 1m2 live-rock reefs was constructed on open sand bottom. Two transplant experiments showed similar results. In experiment 1, reefs were stocked with 0, 1, and 4 adult urchins to reflect estimated post-die-off, present, and pre-die-off densities in the upper Florida Keys, and 0 or 3 juveniles. Loss of transplanted Diadema was 100% when the reefs were surveyed 100 days later. In the second experiment, 3 (20 reefs) or 4 (9 reefs) (one reef received no urchins) adult Diadema were transplanted to each reef, and reefs were monitored routinely over an 137 day period. Initial loss of urchins was gradual, with loss rate increasing after 27 days (abundance declined by 37%). By 137d, loss was 92%. Since juveniles generally do not migrate, their loss was likely due to predation. Loss of adults may have been due to combined emigration and predation (evidence of predation was observed in experiment 2). Relatively high natural mortality rates, lack of retention of transplanted individuals in other research, and the high loss during these experiments indicates additional research is needed before transplantation is used as a restoration tool.

## 24.1079

**The Effectiveness of Macroalgal Reduction and *Diadema antillarum* Addition in Maintaining Algal Turfs and Facilitating Coral Recovery**

**David BURDICK*[1]**

[1]Guam Coastal Management Program, Hagatna, Guam

The effectiveness of macroalgal reduction and *Diadema antillarum* addition in maintaining algal turfs and facilitating coral recovery was investigated between June 2002 and July 2003. Two treatments, one involving the manual reduction of macroalgae (A), and the second involving macroalgal reduction followed by the addition of *D. antillarum* (B), were each performed on a set of three replicate patch reefs (4-8m2) off the island of Eleuthera, The Bahamas. Macroalgal cover was reduced to <2% immediately after macroalgal reduction, but neither treatment was effective at preventing macroalgal re-growth. The only slight increase in macroalgal cover observed on Treatment B reefs between 0 and 12 mo, compared to the greater increases on Treatment A and the control reefs suggests that Treatment B may have had some effect at inhibiting increases in macroalgal cover. Coral cover increased by more than 50% immediately after macroalgal reduction, indicating that a significant amount of live coral had been covered by macroalgae. No significant change in coral cover was detected for either treatment or the control between 0 mo and 12 mo, however. Juvenile coral surveys conducted before and immediately after macroalgal reduction revealed that approximately two-thirds of the total juvenile coral population of each reef had been covered by the thick macroalgal canopy comprised mainly of *Microdictyon marinum*. The failure of the combined treatment of macroalgal reduction and *D. antillarum* addition in maintaining algal turfs and facilitating coral recovery was likely due to poor D. antillarum survivorship. The results suggest that the effectiveness of reef restoration efforts involving translocated or lab-reared *D. antillarum* may be limited on some reefs, and may require multiple re-stocking efforts if they are to be successful in maintaining algal turfs and facilitating coral recovery.

## 24.1080

**Herbivory To The Rescue? Can Diadema Stimulate Grazing By Reef Fishes?**

**Brad BALDWIN*[1]**, John WINKOWSKI[2], Gabe SATALOFF[3]

[1]Biology, St. Lawrence University, canton, NY, [2]Biology, St. Lawrence University, Canton, NY, [3]Biology, College of Charleston, Charleston, SC

Data on 7 inshore patch reefs around the island of San Salvador, Bahamas, confirm macroalgal dominance. Abundance of herbivorous reef fish was indirectly correlated with macroalgal cover and directly correlated that of coral. Parrotfish, surgeonfish, and certain other fish were significantly more abundant, and showed higher feeding activity in experimental plots cleared of fleshy macroalgae. Few Diadema are found on San Salvador reefs but those transplanted to and caged on a patch reef (from inshore populations) had significant grazing effects on macroalgae. Apparent preference of Diadema for bare or turf substrate (inshore habitats) rather than substrate covered with fleshy macroalgae (reefs) may not play as large a role in regulating natural distribution since experiments did not indicate that Diadema favors either of these substrates. As an alternative explanation, experiments on Diadema transplanted onto reefs suggest that high mortality may currently restrict natural populations of Diadema to inshore habitats. Although we had hoped to transplant Diadema onto patch reefs as a way to graze back macroalgae and stimulate additional grazing by herbivorous fishes, high mortality on Diadema will apparently limit this reef restoration approach.

## 24.1081

**Effects Of Herbivorous Sea Urchins On Reef Algae: Algal Biomass Responses To Caging Experiments**

**Lindsey PRECHT*[1]**

[1]Sciences, American Heritage School, Miami Lakes, FL

On a shallow, hard-bottom reef area in the Florida Keys, four cages were deployed for one week (seven day intervals). Pre-measured (50 g) assays of the macroalgae, *Laurencia obtusa* were placed in each cage. The mesh cages served to keep natural reef herbivores out of the experiment while providing a refuge from predation for the urchins released within each cage. Cage #1 (treatment #1), had no sea urchins; this cage served as the control for the experiment. In Cage #2 (treatment #2), two *Diadema antillarum* were released. In Cage #3 (treatment #3), two *Echinometra viridis* were released. In Cage #4 (treatment #4), one *Diadema* and one *Echinometra* were released. All urchins used in the study were approximately the same size (test diameter). At the end of each week, the cages were opened and the remaining macroalgae within each cage was removed and quantified. These one-week experiments were repeated for six weeks. The difference in macroalgal biomass, represented by the remaining assay, was then subtracted from the original assay amount. This calculation represents the total amount of algal assay consumed by the sea urchins. By combining *Diadema* and *Echinometra* in a treatment resulted in the consumption of the most macroalgae, this was followed by the *Diadema* only treatment. The *Echinometra* only treatment consumed the least macroalgae. Based on the amount of algae consumed in these caging experiments, there is tremendous potential of using these urchin species as a tool for use in reef restoration projects in south Florida.

## 24.1082

**Longterm Monitoring And Overview Of Coral Propagation In Indonesia**

**Ofri JOHAN*[1]**, Dr. SUHARSONO[2], Dedi SOEDHARMA[3]

[1]Ministry of Marine and Fisheries, Research Center for Aquaculture, Jakarta Selatan, Indonesia, [2]Indonesian Institute of Science, Research Center for Oceanography, Jakarta, Indonesia, [3]Bogor Agriculture University, Marine and Fisheries Faculty, Bogor, Indonesia

Coral propagation has been carried out since 1999 on Pari Island, Seribu Islands, Indonesia and since that time propagation has been done by several institutions in Indonesia. This study focuses on coral propagation using fragmentation on artificial substrates placed on either the leeward or windward sides of Pari Island, and in a lagoon area. The purpose of the study was to assess the success of transplantation by measuring growth and mortality, attachment to the substrate and the increase in the number of axial corallites after adaptation to a new environment. Coral growth was recorded for 6 months post-transplantation for Acropora donei, A. acuminata, and A. formosa on both sides of the island, and further monitoring was carried out for 8 years on the leeward side. The Factorial-Completely Randomized method was used to analyse the results. The research results showed that A. acuminata and A. formosa prefer a leeward location, while A. donei prefers a windward location. The lagoon station had a higher mortality of A. formosa (93.3%) and A. acuminata (86.7%) than at other stations due to low visibility and the coral was bite by fish. A. acuminata (0.42 cm/mo) had a higher linear growth rate than A. formosa (0.37 cm/mo) and A. donei (0.15 cm/mo), because A. acuminata and A. formosa have arborescent growth form which was free from turf algae competition. Attachment to various substrates and the increase in axial corallites was higher in A. donei than A. acuminata and A. formosa. Monitoring after 4 years showed that Drupella sp. appeared to be eating A. formosa, but not A. acuminata. Monitoring undertaken after 7 years discovered broken Acropora formosa on the substrate and after 8 year most of A. acuminata was dead due to impacted by Drupella sp.

## 24.1083

**Coral Transplantation At Pari Island, Indonesia: A Case Study For Biodiversity Protection And Reef Conservation Combined With Higher Education**

Harry PALM[1], **Hawis MADDUPPA*[2]**, Beginer SUBHAN[2], Meutia SAMIRA ISMET[2], Dolorosa BRIA[3]

[1]Heinrich-Heine-University Duesseldorf, Duesseldorf, Germany, [2]Marine Science and Technology, Bogor Agricultural University (IPB), Bogor, Indonesia, [3]Sekolah Tinggi Ilmu & Teknologi Kelautan Nusantara, Kupang, Indonesia

The island has been negatively affected, besides bomb fishing, by high pollution level, over fishing, and human activities, such as commercial algae culture. Wastewater resulting from algae processing and all kind of anthropogenic waste from the 600 inhabitants is directly released into the lagoon. Coral transplantation is one of the methods to protect the coral reefs. There have been several reasons stated to transplant living corals. This methodology can accelerate reef recovery, replace corals that have been killed by sewage or other pollutants, or aid the recovery of reefs influenced by destructive fishing (e.g. dynamite) or coral quarrying. A weak human resource development in Indonesian universities and the lack of law enforcement results in an urgent need to involve the island community to protect their coastal reefs. Coral transplantation can serve such purposes by rehabilitating destructive reef areas, providing potential alternative income for local people (labour, ornamental trade) and by serving as a platform for students and education activities. The transplantation was carried out under water with the help of SCUBA. For coral transplantation iron sticks with a concrete base where prepared and fixed by hand into the rubble ground at the two sites. A total of 17 coral genera were placed into the coral garden sites. For documentation of the new habitat by the reef fish community, both transplantation sites were monitored by using the stationary visual census method. Sampling site 1 showed an increase in fish species from 2 to 14 belonging to 5 families within 7 month. Site 2 showed a constantly increasing diversity from 2 to 27 species belonging to 7 families in 19 month.

## 24.1084

**Coral Reefs Conservation Program Of Puhawang Island of Lampung Province Indonesia. Was There Any Community Benefit?**

**Endang WIDIASTUTI*[1]**, Pamuji LESTARI[2]

[1]Biology, University of Lampung, Bandar LAmpung-LAMPUNG, Indonesia, [2]Directorate Small Islands Affairs, Ministry of MArine and Fishery, Jakarta Pusat, Indonesia

Coral reefs degradation has occurred in many places throughout the Indonesia archipelago, one which was in Puhawang Island of Lampung Province sited in N: 05o40'54" and S: 105o13'56" . Therefore, the coral reefs conservation program had been introduced by the Ministry of Marines and Fishery, such as establishing the grouper culture followed with artificial reefs in year 2001 and 2002, then once again in year 2006 for another artificial reefs transplanted with the life corals. The study then was conducted to evaluate the existing coral reefs condition and to monitor the program activity, in year 2004, 2006, and 2007. The coral reefs condition was determined based on life-forms method using Line Intercept Transect in two different depths, 5 and 10 meters. The coral reefs were indeed had been preserved since the establishing of the program, it showed that the coral reefs had been protected since then. The incentive which obtained from the grouper culture has sustained the coral reefs conservation by the local community, in which then it affected the coral reefs recovery from degradation. However, the recruitment of the corals in the previous implanted artificial reefs (for the last 5 years) monitored from 2004 – 2006 was considerably slow; it covered 50.42% of the total artificial reefs area, 38.75% of was covered by hard corals and 11.67% was sponges/tunicates. We conclude then that the coral reefs conservation by establishing the grouper culture was able to give community benefits and the implementation of artificial reefs would be considered to improve the coral conservation.

## 24.1085

**Vieques Island Coral Reef Restoration Demonstration Project, Vieques Island, Puerto Rico**

**Diane E. WEHNER*[1]**, William F. PRECHT[2], R. Steve DIAL[3], Lisamarie CARRUBBA[4], Kevin D. KIRSCH[5]

[1]Office of Response and Restoration, NOAA/NOS, Highlands, NJ, [2]Battelle Memorial Institute, West Palm Beach, FL, [3]Dial Cordy and Associates Inc., Wilmington, NC, [4]Protected Resources Division, NOAA/NMFS, Lajas, Puerto Rico, [5]Office of Response and Restoration, NOAA/NOS, St. Petersburg, FL

The Vieques Island Coral Reef Restoration Demonstration Project is an outgrowth of the National Oceanic and Atmospheric Administration's (NOAA's) efforts, as a natural resource trustee, to help facilitate the cleanup, protection and restoration of the coastal resources of Vieques Island, Puerto Rico. The Navy began using Vieques Island in the early 1940s for naval gunfire and support and air to ground ordnance training. The Navy is now investigating areas it previously occupied to determine the extent of any potential contamination and to remove any unexploded ordnance (UXO) and ordnance related debris. To date, these activities have focused primarily on land but future efforts will investigate the magnitude and extent of ordnance and debris underwater and the potential impacts removal of these items may have on coral reefs. The Vieques Island Coral Reef Restoration Demonstration Project is designed to evaluate the success of various types of artificial reef structures to restore coral reefs. The design is based on addressing many aspects of reef function, not just charismatic species such as hard corals, and involves the integration of both natural and artificial structures into the natural reef ecosystem. The artificial reef structures were placed off the coast of Vieques Island during August 2007. The settlement of corals, survival of coral transplants, and use of the structures by other sessile and mobile reef organisms will be monitored quarterly for a two year period.

## 24.1086

**The Coral Transplantation Experiment Contributes A Tool For Rehabilitation Of Degraded Coral Reefs In Ha Long Bay Natural World Heritage Site, Vietnam**

**Nguyen QUAN*[1]**

[1]Marine Biodiversity and Conservation, Institute of Marine Environment and Resources, Hai Phong, Vietnam

The coral reefs in Ha Long Bay have suffered from several sources of damage such as the coral bleaching event of 1998, as well as destructive fishing practices. To addess some of these problems an experiment coral transplantation works was carried out with the total area of transplanted reefs covered 400m2. The substrates used for coral transplantation were made from cement, metal and PVC tubes. The results of this experiment after one year of operation (January 2005 to December 2005) indicated that low cost techniques of coral transplantation have contributed to coral reef restoration in Ha Long Bay. The survival rate of coral colonies at transplanted sites reached 85-90% and the branching coral, Acropora spp,performed very well in all the substrate types. No significant differences were found in the survival rates of coral colonies among substrates. There were significant changes in reef fish species indicators within and outside transplanted reefs. For example, most juvenile cryptic species such as Chaetodon octofasciatus and Cephalopholis boenack were more abundant in transplanted reefs compared with natural reef sites. The outcomes of this work have increased public involvement, with local organization taking part in conservation of coral reefs in recent years.

## 24.1087

**The Accidental Reef – Creative Reef Restoration in Land Scarce Singapore**

**Eugene GOH*[1]**, Loke Ming CHOU[2], Karenne TUN[2], Tom FOSTER[3]

[1]DHI Water & Environment (S) Pte Ltd, Singapore, Singapore, [2]Biological Sciences, National University of Singapore, Singapore, Singapore, [3]DHI Water & Environment, Singapore, Singapore

Singapore's limited extent of coral reefs (<50km2 presently) are among some of the most impacted in the world. Sixty percent of its natural reefs have been lost to coastal reclamation. Acute and chronic impacts arising mainly from intense coastal development continue to shrink the remaining areas both vertically and horizontally. This has prompted many to question the ability of the remaining reefs in Singapore to survive, and the possibility of damaged reefs to recover in the long term should the current trend persist. Many past and present remediation projects executed by various agencies and institutions have helped to address this decline. However, these attempts remain small in scale, isolated and pale in comparison to the scale of historical and current spatial reef reduction. Nevertheless, recent improvements in monitoring and management of coastal development projects have provided a glimmer of hope. As part of these management efforts, research and investigations into artificially created reef environments along granite rock revetments of a reclaimed offshore island revealed that given suitable environmental conditions, reef communities can establish and develop on such artificial substrate without active restoration interventions. Within an 8-year span, some of the sites surveyed are starting to resemble healthier adjacent natural reefs in both coral cover and diversity. This paper presents the findings and recommends how such artificial structures can creatively help to broaden restoration efforts in Singapore while reclamation and coastal development critical to the island's overall economic growth continue.

## 24.1088

**Promoting Eco-Friendly Port Construction Way in Japan**

Norikazu MAEKOUCHI[1], **Shunpei IWAMURA*[2]**, Takashi ANO[1], Megumi OOGI[1], Syuichi TSUDA[1], Kazuki KURITA[3], Yasuo SHIMAKURA[4]

[1]Okinawa General Bureau, Cabinet office, Naha City, Japan, [2]ECOH Corporation, Taito-ku, Japan, [3]Okinawa General Bureau, Cabinet office, Miyakojima City, Japan, [4]Okinawa General Bureau, Cabinet office, Ishigaki Sity, Japan

We have performed various projects since 1977 to promote eco-friendly port construction. Those carried out up to and including 2004 were reported by Akakura et al. (2006); Proc. 10th Int. Coral Reef Symposium, Naha.

In addition to the past undertakings, this report deals with a summary of the Coral Investigation Guidelines at Ports in Okinawa (hereinafter, referred to as the guideline), a unified guide for coral investigation, and the outline of some coral monitoring projects based on the guideline.

The contents of the guideline consist of the gist of two investigations: coral assemblage distribution around the ports, and research and development of coral restoration technology. The former is intended to explore the relationships between an increase or decline in coral distribution around the ports and environmental changes. The latter is intended to develop and promote reef restoration technology. Investigations conducted at Naha Port, Hirara Port and Ishigaki Port in Okinawa Prefecture are also shown as examples, where coral distribution around the ports was surveyed. The guideline suggests that wide-area surveys on corals be conducted every five years, so that the accumulation of data from the continued monitoring can afford a year-based analysis of coral distribution. Reef restoration projects performed include coral transplant at Hirara Port. Coral assemblages growing in an area of a planned breakwater extension are being transplanted. In Ishigaki Port, a transplant project is also underway in conjunction with the removal of existing breakwaters. We transplant corals naturally colonizing on the breakwaters onto the mounds of nearby existing port facilities. At Naha Port, we are striving for continuous development of reef restoration technology. All these endeavours were planned and carried out based on the guideline.

## 24.1089

**Determining Thermal Stress To Hindcast Coral Bleaching Risk At A Restored Reef.**

**Zaidy KHAN*[1,2]**

[1]Communites and Coast, Foundation of the People of the South Pacific International, Suva, Fiji, [2]Institute of Marine Resoucres, Univeristy of the South Pacific, Suva, Fiji

Simple, low- cost techniques were used to restore a portion of the reef which was subsequently degraded by possible bleaching events, at Moturiki, Fiji Islands. Staghorn (*Acropora* spp) coral transplants suffered 100% mortality by August 2006 after 12 months post transplantation. Two thirds of the transplants were dead in May, 9 months after transplantation. Natural coral communities on neighboring patch reefs suffered minor bleaching and were able to recover 3 months after prior bleaching. The possibility of thermal stress was determined by using three indices: sea surface temperature anomalies, degree heating days, and heating rate, to hindcast coral bleaching risk at the restored reef.

The temperature data showed that SST anomalies over the summer period were $1^0$C above long term averages throughout the 2005-6 summer period and $2.5^0$C and $3.0^0$C above average in the following April and May, respectively. These above average anomalies correlate with a bleaching event that most likely caused the high mortality in transplant corals. The temperature logger data indicate that out of 120 days over summer and autumn, 56 days had temperatures $2^0$C above the long term average temperature giving a total of 176 DHD over this period. Cumulative thermal stress after degree heating days persisted for three more weeks before it started to cool in June.

The death of the coral transplants during the abnormally high SST period suggests that coral reefs that have experienced previous bleaching events are likely to experience further bleaching events.

## 24.1090

**Benefits Of Reef Rehabilitation – Experiences From The Gulf Of Mannar, Southeastern India**

**Edward JK PATTERSON*[1]**, G. MATHEWS[1], Jamila PATTERSON[1], Dan WILHELMSSON[2], Jerker TAMELANDER[3], Olof LINDEN[4]

[1]Suganthi Devadason Marine Research Institute, Tuticorin, India, [2]Stockholm University, Stockholm, Sweden, [3]IUCN Global Marine Programme, Dar es salaam, Tanzania, [4]International Maritime Organization, World Maritime University, Malmo, Sweden

Over 1 sq.km of coral reefs has been rehabilitated through coral transplantation in the Gulf of Mannar (GoM) since 2002. The overall survival of the rehabilitated corals is 85-90% and the annual growth varied between 9.0 – 13.5 cm for branching corals (*Acropora intermedia*, *A. cytherea*, *A. nobilis*, *A. formosa*, *Montipora foliosa*) and 1.5-2.0 cm for non-branching corals (*Favia* sp., *Turbinaria* sp. *Porites* sp.). The precision in techniques (fragmentation and fixing), fragment size, substrate and species selection, and regular monitoring are key factors for the success. The successfully rehabilitated coral areas in GoM serve as donor sites for further rehabilitation and a source of new recruits through asexual and sexual reproduction, which expands the live coral cover in the area. To some extent this could also help in conserving / enhancing the endangered and threatened coral species. The abundance of fauna and flora associated with the artificial substrates enhance the biomass and stability in the rehabilitated sites. However, reef rehabilitation should only be considered as a management tool in repairing limited damaged reef areas and as a mean to enhance / assist natural recovery in the heavily degraded reef areas.

## 24.1091

**The Role Of Resorts On Coral Reef Restoration And Monitoring in The Maldives**

**Robert J. TOMASETTI*[1]**, Abdul Azeez A. HAKEEM[1]

[1]Banyan Tree Marine Lab, Vabbinfaru Island, Maldives

The Maldives is a tropical nation of low-lying coral atolls in the Indian Ocean and has the most to lose from global warming. Changing weather patterns over the last 15 years have increased beach erosion on many Maldivian islands. The 1998 global El Niño killed 70-90% of all corals in the central Maldives. The Maldives rely on coral reefs for island formation, barriers to waves and beach erosion, for fishing, and for tourism. The Maldivian model of coral reef management includes using resorts, as long-term leaseholders of islands, as stewards of coral reef resources surrounding resort islands. There are nearly 100 resort islands in the Maldives, with 50 more being built during the next three years. The resort at the forefront of coral reef management in the Maldives is the Banyan Tree, winning the President of Maldives Green Resort Award twice for its conservation efforts and one of the only resorts employing resident marine biologists for long-term conservation and research. The Banyan Tree Marine Lab focuses its efforts on coral reef research, education and capacity building in marine conservation, and global warming and sea level rise. The lab employs five full-time staff for coral reef monitoring, restoration, and research on two adjacent islands in North Malé Atoll. Humanitarian projects include environmental education and community outreach. Conservation projects performed by the lab include engaging guests and school children for reef monitoring and restoration, sea turtle conservation, coral transplantation, artificial electric reefs, monitoring bleaching events, and beach erosion monitoring and mitigation. The lab hosts international scientists, with past research conducted on electric reef structures, sea turtle satellite tracking, monitoring of reef sharks and dolphins, coral heat shock proteins, coral spawning and recruitment, *Acropora* spp. systematics, mass fish mortality and harmful algal blooms, bryozoans, beach movement, physical oceanography of atolls, and invertebrate assessments.

## 24.1092

**Lessons Learned On Demonstration Sites For Coral Reef Restoration in Thailand**

**Thamasak YEEMIN*[1]**, Makamas SUTTHACHEEP[1], Nipat SOMKLEEB[1], Chaiyaporn LOCHAYA[1], Nisit RUENGSAWANG[2]

[1]Department of Biology, Faculty Of Science, Ramkhamhaeng University, Bangkok, Thailand, [2]Biology, Rajamangkala University of Technology Krungthep, Bangkok, Thailand

There are numerous documentations of coral reef restoration methods in the last decade. The objective of this paper is to provide lessons learned on demonstration sites for coral reef restoration in Krabi Province, the Andaman Sea and Mu Koh Chang, the Gulf of Thailand. The demonstration sites for coral reef restoration were carried out in limited demonstration areas where they can be easily controlled and managed for the benefit of ecotourism, education, raising public awareness, ecosystem restoration and research. Local communities, government agencies, private sector and NGOs have participated actively in the planning and implementation processes for their direct and indirect benefits from the projects. Natural coral fragments were used in order to increase the survival of natural coral fragments that might otherwise have had low survival because they were susceptible to being buried. Several coral reef restoration methods showed at the demonstration sites such as; i) additional substrates for coral recruitment by using clusters of cylindrical concretes lay in a triangle model; ii) attaching branching *Acropora* spp. with screws to designed PVC pipe frames in the coral nursery area; iii) additional substrates for coral recruitment and attaching coral fragments by using clusters of concrete blocks fused in horizontal and vertical directions; and iv) attaching branching fragments to dead branching corals by means of plastic straps. We suggest that government agencies, tourism businessmen and local communities encourage and strengthen collaborative management of the demonstration sites for coral reef restoration in order to develop key features of long-term successful management systems.

## 24.1093

**Rehabilitation Reef Habitat With Coral Transplantation To Increase Resilience Of Reef Habitat And Community Economic**

Hery YUSAMANDRA[1], **Hery YUSAMANDRA*[1]**, Hery YUSAMANDRA[2]

[1]-, Reef Check Indonesia Foundation, Denpasar, Indonesia, [2]-, Hayati Lestari Foundation, Padang, Indonesia

The activity to rehabilitate coral reef have been done in Sungai Pisang village on West Sumatera Province since 2005. Location selected are coral reef habitat which has damage after mass bleaching event in 1997 and destroyed area as consequence of destructive fishing activity using cyanide and bomb by fisherman around there. Objective of this activity are to rehabilitate reef habitat which has damage by coral transplantation and increasing public awareness by creating artificial reef garden with local community in Sungai Pisang village. Method used is by farming the fragment coral on "small-ball" concrect substrat. Corals fragment is glued to substrate by using special glue from cement powder. After one month that substrat planting to the three type of permanent substrat are build from concrect artificial reef, iron plate and coral rubble. Corals species that collected based on dominant species around location are *Acropora* spp., *Millepora* sp., *Pocillopora* spp., *Euphyllia glabrescent*, *Galaxea fasciata* and *Seriatopora* sp. The artificial reef building and corals cultivation rack had been laying down in two depths that are 6-9 meters and 10-12 meters. Based on the research shown that growth of coral in depth 6-9 meters better than 10-12 meters. Life survival rate of coral fragment in depth 6-9 meters equal to 80.5% while in depth 10-12 meters equal to 65%. Expected, in the future this technique can be replicate to another area that suitable as coral rehabilitation site because this technique are not expensive and easy to apply by community. In the long term it can help increase diversity of the reef habitat become more resilience and also increase resilience of community economics with alternative livelihood by ecotourism activity.

## 24.1094

**Reef Restoration at Laughing Bird Caye National Park, Belize, Central America**

**Lisa CARNE*[1]**

[1]Independent, Placencia, Belize

Laughing Bird Caye National Park (LBCNP) has been re-seeded with 20 Elkhorn coral (*Acropora palmata*) fragments transplanted from naturally recurring stands in Gladden Spit and the Silk Cayes Marine Reserve (GSSCMR). Elkhorn coral was prevalent at LBCNP until 1997/98. LBCNP is a World Heritage Site located approximately 12 miles east of Placencia, in Southern Belize, Central America. GSSCMR is an additional 10 miles to the east, on the outer barrier reef. All fragments demonstrated new tissue growth within 2-4 weeks of placement; many have already grown onto their new substrate. This methodology establishes a restorative technique for decimated *A. palmata* populations in Belize, and can be utilized in response to future hurricane events, ship groundings and/or anchor damage. It is estimated that this coral's abundance has been reduced by 98% Caribbean-wide, in the last three decades. All of the *Acroporid spp.* found in the Caribbean were recently listed as "Threatened" under the Endangered Species Act in the US.

Elkhorn coral is known to be fast growing (5-6 inches per year) in ideal conditions. Elkhorn coral is structurally important, providing protection to fragile cayes during storms, allows reef growth to keep pace with changing sea levels and provides essential habitat for over 100's species of fish and invertebrates, including the commercially important spiny lobster, *Panulirus argus*. No other Caribbean reef building coral species are able to fulfill these essential ecosystem functions. Mapping has begun for this species in Southern Belize and should be continued nationwide, to establish sources of *A. palmata* transplants in the event of future hurricanes or ship groundings.

The potential long-term conservation and economic benefits are enormous as both the tourism and fishing industry rely on the health of Belize's marine eco-system.

## 24.1095

**Characteristics Of Seagrass Beds in Coral Reef Area And Their Restoration**

**Takahiko INOUE*[1]**, Sayuko NINOMIYA[1], Takashi MASUMOTO[1], Yoshikatsu NAKANO[2], Makoto TSUCHIYA[2]

[1]TOKYO KYUEI CO., Ltd, Kawaguchi, Japan, [2]University of the Ryukyus, JAPAN, Nishihara, Japan

In Okinawa, southern Japan, well-developed coral reefs are extending, and seagrass beds composed of several seagrass species are distributed in moats. Seagrass beds are known to have important roles as the spawning and/or nursery grounds of marine fishes and invertebrates and as the feeding field of dugongs. Nevertheless, the areas of seagrass beds are reducing due to shore protection works and reclamation. Recently, the restoration of seagrass beds is being attempted. The distribution of such seagrass beds associated with coral reefs are not restricted in Okinawan waters but are widely distributed in other tropical and sub-tropical regions in the world, and therefore, techniques for the protection and/or cultivation of seagrass beds are strongly desired for their ecological importance. We have been observing seagrass beds in Okinawa. It was found that although a seagrass bed was macroscopically formed as the mixture of several coexisting species, the distributions of different species segregated according to their ecological preference on current environment and substrate type. Two component species of a seagrass bed, Cymodocea serrulata and Halodule uninervis, developed their rhizomes only near the surface of the sea bottom, and thus they could entirely be swept away by flushing currents generated by a strong typhoon. On the other hand, Thalassia hemprichii, that extends its rhizome deep into the sea bottom to settle, might not easily be swept by such strong currents. The species could form more stable meadows in areas where substrate contained large coral gravel in high proportion. T. hemprichii also formed a stable meadow in a combined community with live Montipora digitata. Based on the above findings, we introduce effective techniques, including some prospects, for seagrass bed restoration suitable to the ecological characteristics of each species.

## 24.1096

**Changes in Fish Assemblages At A Ship Grounding Site Following Restoration in The Florida Keys National Marine Sanctuary: The Wellwood Coral Restoration Project**

**Christy PATTENGILL-SEMMENS*[1]**, Joseph CAVANAUGH[1]

[1]Reef Environmental Education Foundation (REEF), Key Largo, FL

Between 2002 and 2007, the Reef Environmental Education Foundation (REEF) conducted monitoring on the fish assemblages of a coral reef restoration area near Key Largo, Florida. The *M/V Wellwood*, a 122-meter freighter ran aground in 1984 on Molasses Reef. The ship impacted the reef's upper forereef and remained aground for 12 days. The grounding destroyed 1,285 square meters of living corals and injured 644 square meters of coral reef framework. In 2002, limestone reef modules were placed in the injured area to provide substrate for new coral colonization. Monitoring included the restoration modules and contiguous low profile hardbottom areas adjacent to and in between the modules. Nearby reference sites were also surveyed to include areas that were closest in proximity to the grounding area while remaining undamaged and unrestored. For each monitoring effort, a team of Advanced Assessment Team REEF Experts conducted Roving Diver Technique visual surveys to document fish diversity and relative abundance. Belt transect surveys were also conducted to document size frequency shifts and more quantitative shifts in density of key taxa. Baseline surveys were conducted prior to and immediately following the installation of the restoration modules. Changes in fish assemblages over five years of monitoring will be presented.

## 24.1097

**Monitoring The Recovery Of A Coral Reef Following Restoration After A Large Vessel Grounding**

**Joe SCHITTONE*[1]**

[1]National Marine Sanctuary Program, NOAA, Silver Spring, MD

This presentation provides the results of the monitoring of a coral reef injured by the M/V *Maitland* vessel grounding incident of October 25, 1989. This grounding occurred in the Florida Keys National Marine Sanctuary. The National Marine Sanctuary Program (NMSP), within NOAA, is responsible for the assessment, restoration and monitoring of the injured reef. NMSP's monitoring program tracks patterns of biological recovery, determines the success of restoration measures, and assesses the resiliency of sites over time. The restoration area was composed of both cement and limestone rock components. To evaluate success, reference habitat adjacent to the restoration site are concurrently monitored to compare the condition of restored reef areas with natural coral reef areas unimpacted by the vessel grounding. Restoration was completed in July 1995, and monitoring of both areas occurred in the summers of 2004, 2005, and 2007. This report presents the results of all three monitoring events. Populations were monitored in all years of three Orders of coral: Gorgonacea, Anthoathecata and Scleractinia. In 2004, all three Order densities were significantly higher in the Restored than the Reference areas; they remained so for Scleractinia during all three monitoring events. Regarding Scleractinia, besides overall densities, populations of some individual species were further analyzed. Results in all years indicated a higher proportion of smaller size-class members of one Scleractinian species at the restored area. In addition, biodiversity indices were calculated. For all years biodiversity indices were higher in the Restoration site. Finally, within the restored area, the Order and Genera-specific patterns of corals on the limestone rocks versus the cement portion of the restoration was unexpected and surprising.

## 24.1098

**Unreported Small Vessel Grounding Damage To Corals Threatens Reef Resilience, A Case Study From The Florida Keys And Addressed in Current U.s. Legislation**

**Steven LUTZ*[1]**

[1]Public Policy Office, Marine Conservation Biology Institute, Washington, DC

For thousands of years coral reefs have survived natural impacts, such as storms, diseases and predation. What they cannot withstand is the combination of these natural impacts with the effects of climate change and severe or repeated anthropogenic damage, such as overfishing, sedimentation, excess nutrients, and vessel impacts. To increase coral reef resilience, it is imperative that all anthropogenic threats are reduced.

The unique threat of unreported boat grounding damage to shallow corals is discussed through the following: 1) a case study from the Florida Keys, where this threat has been found to be widespread and especially significant in highly tourist-visited areas; and 2) how this threat is addressed in recent U.S. legislation regarding the Reauthorization of the Coral Reef Conservation Act, including liability provision for damaging corals and the identification of reefs at risk from vessel groundings.

## 24.1099

**Growth Rates And Natural Recovery Of Injured Giant Barrel Sponges, *xestospongia Muta*.**

**Brian K. WALKER*[1]**, David S. GILLIAM[1], Stephanie SAELENS[1], Daniel P. FAHY[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL

The giant barrel sponge, *Xestospongia muta*, is a conspicuous, common component of the Southeast Florida reef system. Colonies reach sizes greater than 1m in height and provide substantial habitat for commensals which promotes reef biological diversity. Because of their size and abundance, *X. muta* colonies are frequently injured during permitted marine construction activities (e.g. dredge projects, submarine cables, and fishing) and un-permitted events (e.g. vessel anchoring and vessel groundings). Currently, there is limited knowledge of their growth and capacity to recover from injury. In late 2002, areas within the Middle and Outer reefs offshore Southeast Florida (Broward County) were injured by cables dragged from a tug boat during dredging operations. Injuries included shearing which removed large portions of the colonies, leaving base tissue intact, and complete removal. In early 2003, 2-3 months after the injury event, an assessment of 482 colonies within the injury areas demonstrated that 93% were recovering. In 2006, 3 years post-injury, 90% of 117 monitored colonies were alive and continued to show signs of recovery. Estimated growth rates (colony height) of the 104 surviving colonies ranged from 0.7cm to 6.0cm yr-1 with a mean of 2.78cm yr-1 ± 0.11 SE. Estimated recovery rates (increase in colony height) appeared to be dependent upon initial colony size and injury area location. Colonies injured within the Outer Reef (further offshore and deeper) had significantly greater recovery rates (12.4cm ± 0.44 SE) than colonies injured within the Middle Reef (9.7cm ± 0.97 SE). While *X. muta* recovery appears to be successful in terms of its regenerative capacity, future research will include a controlled study to determine detailed growth rates and recovery success for different injury and restoration scenarios and apply estimates of total long-term ecosystem recovery potential for restorative practicality and cost efficiency.

## 24.1100

**Proceedings in Shipgroundings Impact Events At Coral Reefs in The National Park Sistema Arrecifal Veracruzano, Veracruz, Mexico**

Gabriela NAVA MARTÍNEZ[1], **Miguel GARCIA*[2,3]**

[1]Oceanus, A.C., Chetumal, Quintana Roo, Mexico, [2]Oceanus, A.C., Chetumal, Quintana roo, Mexico, [3]MBRS Project, Belize City, Belize

Few areas have designed programs and have trained field personnel on the techniques to evaluate and properly managed the high variety of anthropogenic impacts on the reef. Due to this need, in México, some efforts have started at the national protected areas and NGO´s to generate and to establish the adequate methods for management of shipgroundings and restoration techniques with positive results.

Oceanus, A.C. and the National Park Sistema Arrecifal Veracruzano carried on a first workshop in Veracruz to determine the proceedings on coral reef impacts by shipgroundings in the National Park. The training brought together the different public institutions tradionally involved on these accidents and the technical staff and specialists that evaluate the sites. The workshop included some training in evaluation following national and international procedures as those given by Gulko in 2006, as well as some recommendations to evaluate the need of a restoration program and methods to help on restoring and maintenance of the biological community.

The participation included fishermen, navy officials, law officials, biologists, national park staff, coastal police and administrators involved. The results included a proposal of the guide of procedures in Shipgrounding Impact Events, describing the activities and responsible of each step, as well as the contact information, a technical committee was establish to support the decisions in each case and proposal for research and capabilities needs for the committee and the personal involved.

## 24.1101

**The Impact Of Biorock To Growth Rate And Survival Rate Of Coal Transplant In Tanjung Lesung, West Java, Indonesia**

**Neviaty ZAMANI*[1]**, Ramadian BACHTIAR[1], Hawis MADDUPA[1]

[1]Marine Science and Technologi, Bogor Agriculture University, Bogor, Indonesia

Biorock is one of coral reef rehabilitation technique, wich have been develop world wide. This methods is relatively easy and cheap to applaid for coral reef rehabilitation. There is an argumentation among the scientist that, the biorock can make the growth rate of coral transplan faster than without biorock. It is also an argument that the biorock can reduce the mortality of coral transplant. Some studies show the phenomena that the growth and mortality of coral transplant in biorock is better than in location without biorock. However there is also other study, which have the result in vise versa. The question is the better result of growth and survival rate because of biorock, or rather than the impact of location surrounding the biorock. This study is trying to investigat the impact of biorock to the growth and survival rate of coral transplant in one year monitoring. The sample have been taken every month for the period of 12 months monitoring activities. The activities was started in February 2007 and ending in January 2008. Initial result shows that the growth rate in biorock is faster than in non biorock for the first 3 month. The survival rate is not significant different between biorock and non biorock coral transplant.

Key word: *Biorock, coral transplant*

## 24.1102

**Biological Consequences of Quick Fixes in Reef Restoration**

**Andrew TAYLOR*[1]**

[1]School of Marine and Tropical Biology, James Cook University, Townsville, Australia

Restoration projects can run the risk of simply transforming one degraded habitat into another anthropogenically altered habitat. While aesthetically different and possibly of higher socio-economic value, the new state of alteration may or may not have any added ecosystem function.

Electro-mineral accretion has been used in many restoration and artificial reef projects as both a means to secure scleractinian coral transplants to substrate and to promote growth. The applied electric current induces accretion of calcium carbonate onto a metal structure, and is assumed to have a positive effect on growth (linear extension) of attached corals. Previous research regarding this process has dealt with quantity rather than quality of attached corals. This study attempts to determine if the higher skeletal growth rates experienced by the coral are at the expense of a trade-off with some other aspect of their life history – such as reproductive ability or fitness.

The capacity for restoration efforts on the surrounding reef is governed by the viability of the transplants. In this study the functional biology of transplants under electro-mineral accretion conditions are examined to ascertain if the corals growing on such structures are biologically viable and contribute to restoration efforts. Species specific comparisons of fecundity, tissue thickness, polyp density, and skeletal density were done on Acroporid and Pocilloporid corals growing under electro-mineral accretion treatments and under natural conditions in a field site in Lombok, Indonesia.

## 24.1103

**Effects Of An Electrical Field On Growth, Chlorophyll And Zooxanthellae Of Transplanted Acropora Yongei And A. Pulchra Fragments**

**Sascha B.C. ROMATZKI*[1]**, Neviaty P. ZAMANI[2], Esther M. BORELL[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [2]Department of Marine Science and Technology, Bogor Agricultural University, Bogor, Indonesia

The mineral accretion method is an alternative reef restoration method using the principle of electrolyses to precipitate minerals from seawater in form of limestone as settlement and transplantation substrate on conductive metal rags. Previous observations indicated, that the hereby-used electric field has positive side effects on corals transplanted to these structures.

Here we examined the responses on growth, chlorophyll concentration and number of Zooxanthellae of two transplanted *Acropora* species on charged iron frames on different height levels from the ground. Results were compared with those of a similar, uncharged control frame and the donor colonies. The field experiment was carried out on Pulau Gangga, North Sulawesi, Indonesia at a depth of 5 to 7 meters from April to December 2006.

Mean average length increase of *A. yongei* was significantly bigger on the control frames (4,15mm/month) and the donor colonies (5,64 mm/month) compared to those of the charged frames (3,21mm/month). Similar observations were made for the number of Zooxanthellae whereas photometrical analyses of chlorophyll a and c concentration showed significantly increased rates on electrical charged structures. *A. pulchra* showed growth rates without significant differences between the charged and the control structure (mean average 4,55 and 5,34 mm/month) but rates were significantly lower than those of the donor colony (8,0 mm/month). Chlorophyll concentrations and Zooxanthellae number had no significant differences between treatments and donor in *A. pulchra*, although chlorophyll concentrations were slightly higher and numbers of Zooxanthellae were lower on structures compared to the donor colony.

The results indicate that an electrical field slows down *A. yongei* growth rates, but it seems to increase the chlorophyll concentration. *A. pulchra* fragments showed no significant response to the electrical field, but the species is sensitive to fragmentation and transplantation stress.

## 24.1104

**Biorock Corals – Backtracking The Notion Of Enhanced Growth And Prosperity**

**Esther M. BORELL*[1]**, Sascha B.C. ROMATZKI[1], Sebastian FERSE[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany

Seawater electrolysis has been promoted as a mechanism to enhance growth and health of coral transplants growing on a cathode (biorock corals) but evidence supporting these claims remains largely anecdotal. This study investigates the effect of seawater hydrolysis on the maximum potential quantum yield ($F_v/F_m$), zooxanthellae densities, chlorophyll content and growth rates of the congeneric species *Acropora yongei* and *A. pulchra.*

Coral fragments of each species were transplanted to a depth of 5 m and grown on either 1) an iron cathode, 2) bamboo within the electric field, or 3) bamboo outside the electric field. $F_v/F_m$ of dark adapted *A. yongei* between 10:00-11:00 h after a treatment period of 4 months was significantly higher inside and outside the electric field than on the cathode, which coincided with significantly higher zooxanthellae densities in corals inside and outside the electric field compared to corals on the cathode. By contrast there was no effect of treatment on Fv/Fm of *A. pulchra* but zooxanthellae densities were significantly higher in corals on the cathode than inside and outside the electric field.

Chlorophyll a + $c_2$ concentrations of both species were lowest inside the electric field.

Both species exhibited significantly higher growth rates within the electric field than on the cathode or outside the electric field.

Since calcification is linked to zooxanthellae photosynthesis the low growth rates, low $F_v/F_m$ and concurrent low zooxanthellae densities of *A. yongei* grown on a cathode indicate that electrochemical processes through seawater hydrolysis may adversely effect important physiological processes in some coral species leading to reduced growth and health. Although growth was electrically stimulated in both species, the results of this study provide no support for the proposed physiological benefits of biorock corals over corals transplanted onto other artificial substrates.

## 24.1105

**Electrical Enhancement Of Coral Growth in Tobago**

**Lee Ann BEDDOE*[1]**, John AGARD[1], Dawn PHILLIP[1]

[1]Life Sciences, The University of the West Indies, St. Augustine, Trinidad and Tobago

It has been hypothesized that low direct current increases calcium carbonate deposition in some corals, resulting in increased growth. The validity of this claim has been disputed because of weaknesses in the experimental design of previous studies.

In this study, phase one developed and tested the experimental design while phases 2 and 3 were larger field experiments in Tobago. Electrically conductive racks, called Buoyancy Test Racks (BRTs), small enough to carry individual coral fragments, served as the cathode while a titanium coated iron mesh (Biorock®) was used as the anode. Forty electrically charged coral nubbins were attached to the BRTs and the exact number of nubbins with no electricity acted as control. The BRTs allowed the measurement of the growth of individual nubbins via the Buoyant Weighing Technique.

Phase 2, using *Porites porites* and *Acropora cervicornis,* showed that growth was initially negative in both the electrical treatments and controls during an apparent settling down period of about 6 weeks, after which growth rates in the electrified treatment only started to increase. Unacceptable mortality in the control resulted in the premature termination of the experiment.

Results from the Paired T-test for phase 3 using *Millepora sp.* showed that in 4 weeks there was a significant increase in air weight growth of 5.69g (P=0.0397) for treated corals and a significant decrease in weight of -0.71g (P=0.0000) for control. Within 26 weeks the mean growth change for the treated corals was 20.44g (P=0.0000) and -1.05g (P=0.0000) for the control.

Preliminary results indicate that the enhanced growth for one coral species (*Millepora sp.*) supports the hypothesis. However, at least another six months is required in order to make a more definitive conclusion. This technology has the potential to restore reefs that are adversely affected by environmental change.

## 24.1106

**The Influence Of Substrates On The Settlement, Survival, And Growth Rates Of Juvenile Coral Of *acropora Humilis***

**Siriwan USSAVAUSCHARIYAKUL*[1]**, Suchana CHAVANICH[2], Voranop VIYAKARN[2]

[1]Environmental Science (Interdisciplinary), Graduate school, Chulalongkorn University, Bangkok, Thailand, [2]Department of Marine Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Mineral accretion generated by electric current recently is used as a method for accelerating coral growth and survival. This technique allows limestone to accumulate on substrates and may help corals in reducing energy for coral calcification. In this study, we investigated whether there were differences on growth and survival of coral, *Acropora humilis*, between substrates that had mineral accretion and substrates that did not have. The experiments were done in a hatchery. Three difference types of substrates were used (steel plate encrusted with limestone, aluminum plate, and tile with coralline algae). In the experiments, the settlements of larvae on differences substrates were conducted, and the survival and growth of juvenile corals were monitored for 5 months. The results showed that the tile with coralline algae had the highest number of settling larvae (63.2% ± 2.69) followed by steel plate encrusted with limestone (23.5% ± 2.18), and aluminum plate (9.4% ± 3.33) respectively. In addition, there were differences on the survival and growth rates of juvenile corals on difference types of substrates. Unlike the settlement rate, high survival rates of juvenile corals occurred on the aluminum plates (74.8% ± 6.4) compared to encrusted steel plate (66.1% ± 8.74), and tile with coralline algae (31.1% ± 1.76). The results from the growth rates also showed that juvenile corals on aluminum plate had the highest relative growth rate (31.6% /month), followed by encrusted steel plate (24.7% /month), and tile with coralline algae (15% /month). When comparing between months, juvenile corals on aluminum plate and encrusted steel plate had the highest relative growth rate during the 4th and 5th month (34.2% and 24.8%, respectively) while corals on the tile with coralline algae had the highest relative growth rate during the 2nd and 3rd month (33.3%).

## 24.1107

**Artificial Reef Materials As Mitigation For Natural Reef Impacts: Comparison Of Benthic And Fish Assemblages On Artificial And Adjacent Natural Reefs in Miami-Dade County, Florida**

**Sara THANNER*[1]**, Stephen BLAIR[1]

[1]Department of Environmental Resources Management, Miami-Dade County, Miami, FL

The Bal Harbour Artificial Reef was constructed in May of 1999 with 176 prefabricated modules and 8,000 tons of limerock boulders as mitigation for natural reef impacts sustained during a beach renourishment project. A long-term monitoring program was developed to evaluate the effectiveness of these artificial reef materials as mitigation for natural reef impacts. Benthic and fish assemblages on the modules, boulders, and two adjacent natural reefs were monitored and compared. The natural reef areas showed stable fish and benthic populations with consistent levels of similarity and abundance throughout the period of comparison. The benthic assemblages on the artificial reef materials have shown significant changes over time, with increasing density and diversity of benthic organisms, and increasing similarity to the natural reef areas. The density and diversity of the benthic assemblages on the artificial reef materials appear to be stabilizing. Fish assemblage comparisons, on the other hand, showed distinct differences on the different artificial reef materials as well as between those of the artificial and natural reefs. Differences in the physical characteristics between natural and artificial reef materials (i.e., shape, relief, cryptic space, etc) have and will continue to affect the extent to which the reefs can become similar.

## 24.1108

**Restoring An Artificial "Enhancement": Baseline Data To Assess Strategy Effectiveness And Future Mitigation**

**Danielle MORLEY*[1,2]**, Robin SHERMAN[3], Lance JORDAN[1,2], Richard SPIELER[1,4]

[1]Oceanographic Center, Nova Southeastern University, Dania Beach, FL, [2]National Coral Reef Institute, Dania Beach, [3]Farquhar College of Arts and Sciences, Nova Southeastern University, Ft. Lauderdale, FL, [4]National Coral Reef Institute / Guy Harvey Research Institute, Dania Beach

In 1967, Broward County, Florida resource managers initiated a project to construct an artificial reef to enhance recreational fishing using waste vehicle tires. An estimated two million unballasted tires were deployed in bundles approximately 1.8km offshore in 21m of water on sandy substrate separating the Middle and Outer reef tracts, running parallel to the coast. Over time, bindings on the tire bundles failed and they became mobile with normal currents and high energy storms. The tires have apparently moved extensively, traveling kilometers from their original location to beaches and deeper waters offshore. It has also been reported that loose tires have physically damaged benthic reef fauna on the natural reef. Due to this damage, a large-scale removal plan of the tires has been initiated. To assess damage and evaluate effectiveness of tire removal, an examination of existing biota was accomplished. Live corals were absent on the Middle reef edge, buried by tires but were present on the tires themselves. When compared to the impacted Middle reef edge (tires present), adjacent natural reef control sites (tires absent) exhibited significantly lower fish abundance and species richness. Removal of the tires will directly reduce the abundance of fishes and affect the corals in the area. Future studies will evaluate the loss of these resources relative to the gain in reduced impact to the natural reef.

## 24.1109

**Comparison Of The Benthic And Fish Assemblages On Three Types Of Artificial Reef Modules**

**Sara THANNER*[1]**, Stephen BLAIR[1], Timothy MCINTOSH[1]

[1]Department of Environmental Resources Management, Miami-Dade County, Miami, FL

In 1988, offshore dredging for a beach renourishment project in Miami-Dade County, Florida caused extensive damage to the second reef tract off of Sunny Isles Beach. In an effort to restore and mitigate for the damage, the Sunny Isles Reef Restoration Project began in August of 1991. Three different types of artificial reef modules, “Dome”, “M-2”, and “Reef-Replacement”, were placed on the reef where the damaged occurred. The goal of the restoration was to provide a basis for the biological recovery of the impacted hard bottom, while minimizing the enhancement effects (e.g. over representation of a specific community component) of the restoration modules used. The development of the benthic and fish assemblages on the modules was monitored for the initial four years following deployment. Monitoring efforts in 2003 sought to re-assess the modules to determine the extent of change that had occurred since 1995. Species diversity and density on each module type, similarity between the modules and the surrounding natural reef, and possible enhancement effects of the modules were evaluated. The reassessment indicated the diversity and density of benthic and fish assemblages increased on all module types. The Dome and Reef-Replacement modules had the greatest similarity (Bray-Curtis Index) with the surrounding reef at 49% and 48%, respectively for benthic assemblages, and 21% and 15% respectively for the fish assemblages. Enhancement effects were observed in the fish assemblages near the modules due to their greater relief and extensive void space, particularly on the M modules. Dome and Reef Replacement modules were considered the more appropriate mitigation as they developed biotic communities more comparable to the natural reefs, had the lowest profiles and incorporate natural substrate (lime rock) in their design. Exactly how similar these artificial habitats will become relative to the natural reefs requires additional monitoring efforts.

## 24.1110

**Effects Of A Novel Invertebrate Substrate On Fish Assemblages Associated With Concrete Modules**

**Judy ROBINSON*[1]**, Lance ROBINSON[2], Brian BUSKIRK[1], Richard SPIELER[1]

[1]Marine Biology, Nova Southeastern University Oceanographic Center, Dania Beach, FL, [2]Nova Southeastern University Oceanographic Center, Dania Beach, FL

Most coral reef restoration efforts have concentrated on limited target organisms, e.g. returning coral populations, usually by transplant, or fish populations, by providing artificial refuge. Normally these restoration efforts do not make specific attempts to increase the non-coral invertebrate assemblages which provide an important forage base for the majority of coral reef fishes. We hypothesized addition of a substrate for invertebrate recruitment to concrete artificial reefs would provide a forage source for fish, and potentially create a more natural assemblage of fish and invertebrates. Thirty-two commercial concrete reef modules (Reefballs®) were deployed with one of four treatments: 1) with invertebrate substrate (3M High Pro Stripping Pads) and internal fish refuge (concrete blocks), 2) with only invertebrate substrate, 3) with only internal refuge and, 4) without added substrate or refuge (control). During a 2-year period (2005-2007), fish counts were performed quarterly by divers on SCUBA. Twenty-nine families and 112 species of fish were identified. An apparent preferential selection of treatment type was noted for several species. Larger reef fish such as *Gymnothorax miliaris*, *Gymnothorax vicinus*, and *Lachnolaimus maximus* associated with treatments that offered internal refuge (blocks). In addition, there were often more *Balistes capriscus*, *Acanthurus chirurgus*, *Lutjanus synagris* and *Haemulon melanurum*, on these modules. No significant difference (GLM) was found between treatments with internal refuge with or without substrate; however, the combination of internal refuge and invertebrate substrate showed the highest abundance for these species. In contrast, *Stegastes partitus* and *Thalassoma bifasciatum* were significantly more abundant on modules with invertebrate substrates than on block alone or control. This study provides insight into the effects of invertebrate refuge on fish assemblages, highlights the value of artificial substrate design in the establishment of a diverse fish community, and ultimately may provide a unique method for enhancing coral reef restoration efforts.

## 24.1111

**A Pre-Designed Artificial Reef Planted With Corlas As A Tool To Attract Fish & Relieve Diving Pressure Off Natural Reef**

**Omer POLAK*[1,2]**, Fuad AL-HORANI[3], Yaron PITKOVSKI[4], Nadav SHASHAR[1,4]

[1]Ben-Gurion University, Beer Sheva, Israel, [2]Interuniversity Institute for Marine Sciences, Eilat, Israel, [3]Marine Science Station, Aqaba, Jordan, [4]Ben-Gurion University, Eilat Campus, Eilat, Israel

In recent years there has been sporadic use of coral transplantation on Artificial Reefs (AR). ARs are used for the fishing industry and to some extent in tourism. AR location, design, and biodiversity may increase attractiveness to divers and thus enhance visitation frequency or length of stay. To try and relieve pressure off the nearby MPA and assess divers' attractiveness a pre-designed AR (4x4x4 m) was deployed in Eilat, Red Sea. The study followed divers' behavior inside and outside the MPA and compared a similar sized reef knoll to the AR before deployment, after deployment and following coral transplantation. Concurrently, fish count was visually censused during all phases of the deployment and compared to diving behavior. Initial results suggest that the AR, at all phases mentioned, attract divers of different experience level similarly to the adjacent knoll. However, possibly due to its small size, it did not significantly alter diving behavior to nearby MPA. The introduction of transplanted corals has increased species richness significantly by ~30% within matter of days, but did not change divers' behavior. The use of an actively transplanted AR was effective for increasing fish biodiversity but less effective for changing diving behavior. Increase of AR size as well as increased community involvement, may increase visiting time and generate a change in diving behavior. It is apparent that Diving Aggregating Device (DAD) has different needs than the familiar Fish Aggregating Devices (FAD).

Supported by the USAID- MERC program

## 24.1112

**Coral Recruitment On Reef Ball Structures At The Benete Bay, Sumbawa Island, Indonesia**

**Imam BACHTIAR*[1]**, Windy PRAYOGO[2]

[1]Biology Education, Universitas Mataram, Mataram, Indonesia, [2]Environment, PT Newmont Nusa Tenggara, Mataram, Indonesia

Reef ball structure is a popular artificial reef that has been invested in many countries. Publication on its efficacy in promoting coral recruitment however remains lack of study or publication. This present study is aimed to examine the pattern of coral recruitment on reef ball structure at the Benete Bay of Sumbawa Island, Indonesia. Thirty big size reef-balls were censuses after three years of deployment. All of these structures were deployed on a sandy bottom location in a sheltered bay. The results show that nearly all coral colonies grow on the vertical surface and upper side of the reef balls. Recruit number varies among depths, between 1-69 colonies per unit reef balls. Most recruits are belonging to the Family Acroporidae, which contribute about 76% to the whole recruitment. Branching acroporid is the most abundant colonies (55%). Pocilloporidae and Faviidae both contribute about 9% to the total recruitment, while Poritidae contributes about 3%. Other coral families only has <1% contribution. The size of coral colonies growing on the reef balls vary between 5-290 mm. Among the Acropora colonies 50% are small size (diameter < 50 mm). The number of recruit on the ball is very low at 10 meter depth (1-5 colonies per ball) that is likely to be affected by sedimentation. Taxon of recruits does not proportionately reflect taxon abundance on adjacent natural reef.

## 24.1113

**A Step-By-Step Guide For Grassroots Efforts To Reef Rehabilitation**

**Todd BARBER*[1]**, Jason KRUMHOLZ[2], John C. WALCH[3], Catherine JADOT, PHD[4], Lee E. HARRIS, PH.D., P.E.[5], Tom MAHER[6]

[1]Coral Team, Reef Ball Foundation, Inc., Greenville, NC, [2]URI Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, [3]Coral Team, Reef Ball Foundation, Inc., Phoenix, AZ, [4]Marine Biology & Oceanography, UNIVERSITY OF LIEGE, Brussels, Belgium, [5]Ocean Engineering, Florida Institute of Technology, Melbourne, FL, [6]Marine Habitats, Inc., Tallahassee, FL

Over the past ten years, the Reef Ball Foundation's Coral Team has conducted reef rehabilitation projects in over 55 countries comprising over 4,000 projects. This manual aims to codify the process developed by the organization that has lead to successful rehabilitations. Suitable for all reef types, there are additional specific chapters dealing with coral reef rehabilitation and detailing the propagation and planting techniques developed by the organization to work on Reef Ball designed artificial reefs utilizing volunteer or grassroots efforts instead of relying only on professionals. Appendixes detail the sources of all materials used in the process, discuss red mangrove rehabilitation techniques and offer ample images for non-English speaker comprehension. Steps cover the entire rehabilitation process; goal setting, resources, damage assessment, site selection, permitting, substrate selection/creation, coral rescue, coral propagation, coral planting, and monitoring.

## 24.1114

**Coral Reef Restoration: Standardized Module Intervention And Monitoring Program in Mexico, Preliminary Results**

**Kirk KILFOYLE*[1,2]**, Marcos A. RANGEL[3], Richard E. DODGE[1,2], Richard E. SPIELER[1,2]

[1]National Coral Reef Institute, Dania Beach, FL, [2]Nova Southeastern University Oceanographic Center, Dania Beach, [3]Parque Nacional Sistema Arrecifal Veracruzano, Veracruz, Mexico

Coral Reef Restoration: Standardized Module Intervention and Monitoring Program in Mexico, Preliminary Results

A hypothesis-driven ecological experiment involving standardized modules (SMs) has been initiated at two sites along the coast of Quintana Roo, Mexico. The purpose is to bridge gaps in our understanding of coral reef restoration by applying select treatments (artificial substrate pads, coral transplants, settlement plates, and controls) to SMs. As of September 2007, 2 of 6 planned bi-annual monitoring trips have been completed. Divers conducted non-destructive visual counts of fishes (abundance, species, and size class), coral recruitment surveys, substrate pad collections, and digital imaging of quadrat survey areas and transplanted corals for settlement and growth analyses. Additionally, transects were established on nearby natural reef (NR) at both sites for comparison with SMs using identical methods. Statistical analysis (ANOVA) of initial results indicate no difference ($p>0.05$) in abundance or species richness of fishes among treatments at both sites in March 2007, and NR had higher species richness than SMs ($p<0.05$). In March, Puerto Morelos SMs had greater abundance and species richness than Akumal, and there were no differences detected on NR between sites. In September there was still no difference among treatments at Puerto Morelos; however, SMs had higher abundance and species richness than NR. Comparisons of March to September in Puerto Morelos demonstrated a predicted increase in abundance and species richness on SMs over time. Coral recruitment on Puerto Morelos SMs averaged 13 recruits/SM, and there was no difference detected in coral recruits/$m^2$ among treatments. Of the three coral species transplanted to SMs, *Porites astreoides* and *Agaricia agaricites* both have had 100% survival, while *Montastrea annularis* has 95%; resulting in 98% survival overall. Further work will involve analysis of settlement plates, invertebrate community composition on substrate pads, coral transplant growth rates, and areal coverage by competing species.

## 24.1115

**Distress On Hard Coral Communities On Artificial Reefs: A Case-Study From Ecoreefs Rehabilitation Site At Bunaken National Park, Indonesia**

**Estradivari ESTRADIVARI*[1]**, Tries Blandine RAZAK[2]

[1]Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, [2]The Indonesian Coral Reef Foundation, Melbourne, Australia

Hard coral communities are threaten to various kinds of stressors that are challenging their resilience. This paper gives an overview of distress symptoms on artificial modules, including abundance and distribution with respect to species groups and depths. In total, 138 modules at four depth ranges were surveyed between May-June 2006. Macroscopic field observation attributed to distress symptoms such as white syndromes (WS), bleaching, algae infection, sponge infection and unknown sources were counted from studied modules, including their wide and length sizes. Results showed that distress colonies were widespread among EcoReefs modules and occurred at all depths with the exception of WS and sponge infection at the shallower waters. A total of 415 distress colonies were recorded from 5626 surveyed coral colonies. Total distress colonies increased with depth and the highest prevalence occurred at the deepest row of modules (8-10 m deep) with an average of 0.83±1.44 infected colonies/module. Despite their widespread distribution, the mean abundance of distress corals was very low. Unidentified syndrome category with 196 infected colonies was the highest in occurrence at an average of 1.43±2.15 infected colonies per module, followed by algae infection (0.43±0.79 colonies/module), sponge infection (0.43±1.17 colonies/module), white syndromes (0.41±0.87 colonies/module) and bleaching was the least at an average of 0.29±0.72 bleached colonies per module. The highest abundance of distress corals were found between 3–7 cm of geometrical mean size, these sizes were also in accordance with the highest amount of dead coral with algae and healthy colonies found on the surveyed modules. Pocilloporidae and Acroporidae were the two major families influenced by distress and found growing on the modules. This suggests that the faster growing corals are more susceptible to coral distress.

## 24.1116

**A Newly Established Coral Reef Ecosystem At The Northern Tip Of The Gulf Of Aqaba -Jordan**

**Salim AL-MOGHRABI*[1]**, Khaled SOKHNY[2]

[1]Aqaba Special Economic Zone Authority, Aqaba, Jordan, [2]Environmental Center for Arab Towns, Dubai, United Arab Emirates

The coastal area of Jordan extends over 27Km at the northeastern tip of the Gulf of Aqaba, where fascinating coral reefs of the fringing type thrive and flourish as the most northern latitudinal limit of reefs distribution, worldwide. Jordan's northern-most third tip of the Gulf is characterized by featureless sandy seabed. This very limited coast is Jordan's only maritime access and it is currently home to many users adding to the natural stress exerted over corals.

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) and the Aqaba Special Economic Zone Authority (ASEZA) funded the establishment of an artificial reef in August 2004. It is composed of two hundred blocks, ranging in height from 1-4m, caste according to 12 different design structures and deployed over 40000m2 of the sandy area from 9-22 m depth. Two days after blocks deployment fish started laying their eggs over the blocks. Two soft corals (Anthelia glauca and Xenia umbellata) colonized the structures less than two months after deployment, while it took the hard coral larvae about a year before they were first noticed. Underwater cleanup dives were realized along the coastal area and orphan coral colonies growing over the garbage were collected, fixed to PVC substrate and buoyant weight. The adopted coral saplings were transplanted to the artificial reef site and fixed over the blocks. The artificial reef provided a proper foraging ground, a safe shelter and an appropriate spawning place. Nowadays, hundreds of fish, soft and hard corals, and other species inhabit the artificial reef structures creating a new coral reef ecosystem at the northern tip of the Gulf of Aqaba.

## 24.1117

**The Coral Trays, a Simple Method to Create Large Sustainable Artificial Reefs**

**Thomas LE BERRE*[1]**, Cedric GUIGNARD[1]

[1]Seamarc Pvt. Ltd., Male', Maldives

Transplantation has been widely used to artificially propagate corals. A simple, cost effective technique, the coral trays, is used to propagate the corals rescued from coastal development areas. The present technique, based on very workable protected metallic rebars is very versatile. It has been successful in relatively large scale experiments (>500 m2) in a shallow sandy reef flat on the exposed and lee side of the island of Landaa Giraavaru for recreational activities and aesthetics. The success of the technique is mostly owed to a good water flow and decreased effects of sedimentation. The height from the sea bed makes abrasion less than for other types of structures. The structure also enables relatively high densities of transplants decreasing the predation pressure. Ease of deployment and rapidity of transplanting are enabling operational advantages.

Applications of such sustainable artificial reefs further needs to be developed and the monitoring process is an integral part of the reef development as the initial stock is used to always develop new structures from "cultured" fragments. Self sustainability is achieved after a short time. The process already involves local communities and could provide alternative livelihoods in the rural parts of the Maldives.

Compared with the sandy reef flat nearby, they are the location of high fish biodiversity and abundance, providing shelter to large array of fish life from pipefish and blennies to snappers and angelfishes. Prospective development of large reefs are similar to those include sediment creation and erosion control. It would favorably replace dead coral rock structures in wide use, increasing biodiversity and overall resilience of the system, and be used for the restoration of damaged or dredged areas.

## 24.1118

**Reef Ball Pilot Project in Hastings, Barbados**

**Andre MILLER*[1]**, David GILL[1], James BLADES[1]

[1]Barbados Marine Trust, St. Michael, Barbados

Reef Balls are artificial reef structures designed to create new or enhance existing reef habitats. They consist of a long-lasting marine concrete mix which allows for growth of benthic biota such as corals and a suitable habitat for fish.

Previous observations suggest that they can also serve as fish recruiting devices, but much debate exists as to whether an increased presence of fish at reef ball locations is a result of direct recruitment or population redistribution (i.e. aggregation vs. production).

The Barbados Marine Trust in 2004 deployed 30 Reef Balls off the South Coast of Barbados in a sandy channel located between two patch reefs. The pilot project sought to determine the propriety of reef balls for Barbados' reefs, and to ascertain its effect on fish abundance, distribution and diversity at the test site and its reef environs.

The Bohnsack and Bannerot Fish Census Method (1986) was employed which involves a survey of all fish observed within a water column 15m in diameter over a ten (10) minute period. This was executed several times over an 18-month period. Three neighbouring control sites (two reef sites, one sand site) were designated to be compared and contrasted against the experimental reef ball site.

The overall observation findings indicate that the placement of the artificial reef structures into the barren location has resulted in an increase in both the abundance and diversity of fish within the same location – initially due to redistribution, but subsequently from direct recruitment. The reefs balls have also demonstrated marked stability in unstable water conditions (after the passage of Hurricane Ivan), proving that they can maintain high structural integrity in such conditions and thus can be used as shoreline defense mechanisms or for reef rejuvenation in high energy environs.

## 24.1119

**Benthic Colonization And Ecological Successional Patterns On A Planned Nearshore Artificial Reef (Ar) System in Broward County, Se Florida**

**Adrienne CARTER*[1]**, Stacy PREKEL[1]

[1]Marine Science & Biological Research, Coastal Planning & Engineering, Inc., Boca Raton, FL

Nearshore marginal reefs are frequently impacted from beach restoration activities. Beach nourishment, in particular, can impact nearshore hardbottom through burial and subsequent habitat degradation. In response to increased beach nourishment activities, reef restoration projects have increased immensely over the last decade. In Southeast Florida, the deployment of artificial reefs (ARs) as mitigation for nearshore habitat loss has become routine. To determine the success of ARs as appropriate nearshore habitat replacement, long-term AR colonization studies are essential to evaluate ecological processes and succession rates in shallow marine environments. This paper reports on a four-year study of the development, seasonal recruitment and ecological succession rates of macrobenthic communities on a mitigative AR system located in Broward County, Florida. Pioneering organisms and community composition were evaluated via the Coastal Planning & Engineering, Inc. Benthic Environmental Assessment for Marginal Reef (BEAMR) method. Benthic communities were sampled at 9-, 12-, 18-, 24-, 36- and 48-month post-construction. By use of multivariate analyses both spatial and temporal fluctuations of colonizing organisms were assessed, as well successional stages of contemporary organisms. Preliminary results indicate a typical colonization pattern in which biotic cover and diversity increased on the AR system progressively from 9 to 48 months post-construction. Results also indicate that equilibrium was not attained by functional groups due to frequent physical disturbances.

## 24.1120

**Coral Resistance To Hurricane Impacts On The Erojacks Artificial Reef, Dania Beach, Florida**

**Deron BAUER*[1]**, Joshua FEINGOLD[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania Beach, FL

In 1967 thousands of concrete hexapods (each 1.4m tall) were deployed in a linear pile perpendicular to the Dania Beach, Florida shoreline forming the Erojacks artificial reef. This structure begins approximately 50m from shore in 3m depth and extends 380m out to a natural coral community (7m maximum depth). On 25 August 2005 Hurricane Katrina made landfall 6.5km south of the study site as a Category 1 storm, and two months later (23 October) Hurricane Wilma passed 60km north of the study site as a Category 2 storm. Prior to their passage, the shallow (3-4m depth) near-shore segment (first 90m) of the Erojacks artificial reef had been surveyed for the abundance and size of scleractinian coral using 21 randomly located 2m wide belt transects oriented perpendicular to the main axis of the reef. Sampling was repeated following the passage of the hurricanes and results were compared using a paired, 2-sample for means t-Test. There was a significant difference in coral colony number ($p < 0.001$, $n=21$) and surface area ($p = 0.003$, $n=21$). The initial survey documented 771 coral colonies with a combined surface area of 17.9m2. After the hurricanes, 818 colonies were observed with a combined surface area of 18.0m2. The predominant corals on the artificial reef were small (~5cm2), encrusting colonies of *Siderastrea siderea* and *Siderastrea radians*, with 9 other scleractinian coral species present. Thus, despite exposure to waves, sedimentation and turbidity generated by wind speeds up to 177km/hr, the coral community on the shallow portion of the Erojacks artificial reef experienced a significant increase in colony counts and surface area. However, since the post-hurricane survey was performed by the same but more experienced observers than the one prior to the storms, it is possible that these increases could have been due to technique improvement.

## 24.1121

**Recruitment Of Corals On Standardized Artificial Substrata At Two Indo-West Pacific Locations**

**Iris Salud BOLLOZOS*[1]**, Ronald VILLANUEVA[1], Alasdair EDWARDS[2]

[1]University of the Philippines - Marine Science Institute, Quezon City, Philippines, [2]School of Biology, Newcastle University, Newcastle upon Tyne, United Kingdom

A study on the long-term efficacy and cost-effectiveness of restoration interventions is being conducted simultaneously at an anthropogenically disturbed site (Malilnep) near Bolinao, Philippines and a relatively undisturbed site (Lukes) near Koror, Palau. To facilitate long-term comparisons between the outcomes of various restoration interventions against natural recovery, without the confounding effects of highly variable reef substrates, "pallet balls" were used to provide a standardized substratum. One of the main objectives is to study natural recovery processes at locations with markedly differing recovery potential (reef resilience), and compare the long–term efficacy of restoration interventions against natural recovery using a suite of key indicator processes and standardized substrata. Pallet balls were deployed in 3-7 m deep sandy areas at the two study sites, 42 in the Philippines and 24 in Palau. Coral recruitment to both 10 x 10 cm settlement tiles and to the surface of the pallet balls is being monitored at both sites. Initial results showed 4.5 recruits per tile at Malilnep with 53% pocilloporids, 31% poritids and 9% acroporids, and 29 recruits per tile at Lukes with 49% acroporids, 9% pocilloporids and 1% poritids. By contrast, at Malilnep there were 12-279 (mean = 49.0, SE = 8.9) 'visible' recruits per pallet ball about 6 months after deployment, whereas at Lukes there were only 26-55 (mean = 37.9, SE = 2.1) 'visible' recruits per pallet ball about 11 months after deployment. A range of indicators such as coral growth and survival, fish abundance and species composition, fish grazing rates, and algal growth are being monitored on both the pallet balls and adjacent reef.

## 24.1122

**Coral Recruitment And Community Development: The Broward County Artificial Reef Compared To Adjacent Hardbottom Areas, Four Years Post-Deployment.**

**Andrew HANNES*[1,2]**, **Lauren FLOYD*[1]**

[1]Marine Science and Biological Research, Coastal Planning and Engineering, Boca Raton, FL, [2]Marine Science and Biological Research, Coastal Planning and Engineering, Boca Raton

Artificial reefs have been utilized as a tool for reef conservation, rehabilitation and mitigation. The success of artificial reefs is measured by their ability to mimic the natural hardbottom environments which they are intended to replace. Despite the numerous artificial reef studies, there are few comparative studies between artificial and natural reefs. This study examines recruitment and subsequent development of coral communities on an artificial reef, and compares them to adjacent natural hardbottom in Broward County, Florida, USA. Mitigation reefs constructed of limestone boulders were deployed in 2003 to mitigate for potential impacts resulting from the Broward County Beach Nourishment Project. The artificial reefs and adjacent natural hardbottom were evaluated using Benthic Environmental Assessment for Marginal Reef (BEAMR) method. We compare artificial to natural hardbottom coral communities by examining abundance, diversity and size distribution over time. After four years of monitoring, the octocoral abundance and average size increased on the artificial reef, but are still less than those found on natural hardbottom. Octocoral diversity was similar in both habitats, but genera were more evenly distributed on the natural hardbottom. Scleractinian abundance, diversity and average size on the artificial reef was nearly equal to those on the nearshore hardbottom four years post-deployment. The natural hardbottom community was dominated by *Siderastrea siderea*, while the species on the artificial reef were more evenly distributed. This study presents the data from each of the seven monitoring events and discusses the variables contributing to coral recruitment and community composition on artificial reefs.

## 24.1123

**Macrobenthic Epifauna Related To Some Artificial Reef Environments From The Pernambuco Littoral, Brazil**

Simone LIRA[1], **Fernanda AMARAL*[1]**, Cristiane FARRAPEIRA[1], Carla RAMOS[1], Kyllderes LIMA[1]

[1]Biologia, Universidade Federal Rural de Pernambuco, Recife, Brazil

The state of Pernambuco, Brazil, has approximately 100 shipwrecks, highly diverse artificial reef environments that are frequently visited by tourists from all over the world. The study area consisted of four of these wreckages: Servemar X located 7.5 mi from Boa Viagem Beach, Recife; Pirapama, Taurus and Vapor de Baixo, all 5 mi from the Port of Recife; all of them at approximately 23 deep. Organisms were observed, photographed, and collected with the aim of surveying the macrobenthic epifauna of the localities cited, in a total of 32 scuba dives carried out between December 2005 and October 2007. The organisms were collected with the aid of a hammer, chisel, and diving knife, and conditioned in plastic vessels and bags, fixed in 4% formaldehyde or 70% alcohol, and selected and separated into functional groups and morphospecies with the aid of a stereomicroscope; subaquatic observations were recorded on PVC plaques. Organisms were classified into the lowest taxonomic level possible. The epifauna distributed around the shipwrecks comprised 123 species from the following phyla: Porifera, Cnidaria, Annelida, Mollusca, Arthropoda, Bryozoa, Echinodermata, and Protochordata. A high species richness was found, especially in Pirapama, which had the largest number of species. The nature of the artificial substrates was not correlated with the species richness found in the wreckages and a clear spatial distribution was verified for the fauna, which was related with several abiotic (luminosity, sedimentation, and marine currents) and biotic (competition, symbiosis) factors. Three new occurrences were recorded for Brazil (*Patinella radiata*, *Watersipora subtorquata*, and *Zoobotryon verticillatum*) and 18 for Pernambuco State (11 species of Bryozoa, six of Ascidiacea, and one of Cirripedia).

## 24.1124

**Is The Scale Of Your Coral Problem Resulting in Project Paralysis? Unusual Partners May Be The Solution**

**William NUCKOLS III*[1]**

[1]W.H. Nuckols Consulting, Annapolis, MD

In the 1970's an artificial tire reef project of massive scale was placed in between the second and third reef lines 2 km off the beaches in Ft. Lauderdale. As many as two million tires were used during an artificial reef project that proposed to compliment the adjacent living coral habitat. But good intentions resulted in an ecological disaster, as the tires migrated toward land, denuding and smothering the middle reef. Mobilized by hurricanes and other large storms, a central pile of 700,000 tires now covers over 34 acres of seafloor. Coral resource managers had been unable to tackle the problem, due to a lack of experience with large scale salvage projects and tire abatement efforts, and a lack of the tens of millions of dollars estimated for the coral restoration. However in 2006 hopes that the failed artificial reef could be removed were renewed. Coming to the table with a wide range of skills, legal authorities and funding capabilities, a team began examining how a solution to a 30-year old problem could be implemented, even with an almost complete lack of funding for the effort. Military salvage assets, coral biologists and tire abatement experts formed a team than spans three levels of government. While the overall goal is the restoration of the reef, each agency comes to the project with its own authority and resources. It is noteworthy that some key partners have no connection to coral restoration at all, yet their contribution to the effort is crucial. Cooperation and utilization of existing resources by similar teams is likely to become the dominant path to solutions for of many of our yet unsolved large scale restoration problems.

## 25.1125

**In Hot Water: Rising Ocean Temperatures and Coral Reefs**

**Lillian O'CONNELL*[1]**

[1]University of Central Florida, Coral Springs, FL

This paper seeks to define a relationship between global sea surface temperature increases and the declining health of coral reefs worldwide. The author believes that the most pressing of the numerous threats to coral reefs is in fact rising ocean temperatures, a direct result of anthropogenic global climate change. The author begins with an overview of the life of a coral reef and the increasing number of threats to them that can cause coral bleaching, a potentially fatal reaction to stress. Using past El Nino cycle information, the author establishes a relationship between sea surface temperature increases and coral bleaching. The author explains that bleaching caused by coral disease is easy to distinguish from bleaching for other reasons. Using ArcGIS mapping software, the author displays point data for 10,000 charted coral reefs to compare reefs bleached for various reasons. The author follows by demonstrating the economic and intrinsic value of coral reefs. Current policy is evaluated, and the author expresses the difficulty in protecting them because of the large number of threats they face as well as their inability to be isolated. The author concludes that the only policies that will help protect and preserve coral reefs must be policies that fight global climate change.

## 25.1126

**Effects Of Climate Change On Coral Reefs**

**Adekunle OKE*[1]**,

[1]environmental Protection And Agricultural Food Production, Stuttgart, Germany

Climate is changing - this is a known fact, its impacts are enormous and devastating on factually everything on earth, in which coral reefs of the world are not an exception. The climate change which has been attributed to human activities over the years due to the increase in the emission rate of greenhouse gases (especially CO2) has profound effects on the global temperature; this in turn has catastrophic impacts on coral reefs.

Coral reefs remain most biologically diverse ecosystems on Earth, providing habitat to nearly 25 percent of marine species. These also provide economic benefits through tourism and fisheries. Nevertheless, it has been estimated that human activities including development in coastal areas, fishing, and pollution have contributed to a global loss of over 10 percent of these valuable ecosystems. An additional 15 percent have been lost due to warming of the surface ocean, and climate change will further contribute to coral reef degradation in the decades ahead resulted into the coral bleaching , non recovery as well as limitation to the growth of the coral due to changes in ocean chemistry, and also environmental stress.

There should be better practice to reduce or stabilize the concentrations of the greenhouse gases in the upper atmosphere, this will reduce the impacts on the environment and will also result into the preservation of the coral reefs.

## 25.1127

**Ocean Warming -The Seasonal And Long-Term Variation Of The Mixed Layer Depth in The Coral Sea And Its Impact On The Great Barrier Reef**

**Jasmine JAFFRÉS*[1]**

[1]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia

The present study investigates the seasonal and long-term variability and trends of the mixed layer depth (MLD) within the Coral Sea, including the Queensland continental shelf on its western border, and discusses impacts of future shallowing of the MLD on the Great Barrier Reef (GBR). MLD data reviewed in this study is derived from conductivity-temperature-depth (CTD) profiles collected by other research teams from various ship cruises and from output obtained from several ocean general circulation models. A distinct seasonality in the mixed layer depth was found throughout the Coral Sea, but was generally more pronounced in higher latitudes as a result of greater seasonality in sea surface temperature (SST) and wind stress. Austral winter MLDs, which tend to be much deeper than summer MLDs throughout the Coral Sea, display a shallowing trend over the last two decades, whereas the average summer MLD remains relatively constant. The trend towards a shallower MLD could have dire consequences for the GBR as SST is expected to increase more rapidly within a shallow mixed layer, thus likely resulting in more severe and more frequent coral bleaching events. Further CTD profiling is required throughout the entire Coral Sea in order to accurately determine the long-term trends in the mixed layer depth.

## 25.1128

**Temperature Dependant Respiration Rate Increase Measured By In-Situ Underwater Respirometer**

**Yutaka TATEDA*[1]**, Yuri MASUMITSU[2], Kenji IWAO[3], Minoru TAMURA[3]

[1]Environmental Science Research Laboratory, CRIEPI, Abiko Chiba, Japan, [2]Tokyo College of Medico-Pharmaco Technology, Tokyo, Japan, [3]Akajima Marine Science Laboratory, Zamami, Japan

Using underwater instrument composed of plastic chamber with water exchange pump, data logger, sensors of light, DO, salinity, temperature and turbidity, respiration change of coral under filed environment condition was measured in coral reef at Okinawa, Japan. The production and respiration rates of several corals estimated by this underwater instrument indicated that preliminary estimated respiration of coral in reef lagoon was high during summer high temperature. Under assumption that temperature dependant respiration is limiting factor of coral survival under the condition of water temperature anomaly, high productive symbiotic algae will be necessary to resist stress of high water temperature causing bleaching in the future global warming condition.

## 25.1129

**High *symbiodinium* Diversity At High-Latitude Reef Sites – A Means Of Survival in The Face Of Climate Change?</i>**

Laura WICKS[1], Eugenia SAMPAYO[2], Jonathan GARDNER[1], Ove HOEGH-GULDBERG[3], **Simon DAVY*[1]**

[1]School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand, [2]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [3]Centre for Marine Studies, University of Queensland, Brisbane, New Zealand

Little is known about *Symbiodinium* diversity of high latitude corals systems. These systems seasonally undergo significant variations in temperature and light, and gaining insights into symbiont diversity may help us understand how coral-algal associations can persist in marginal environments. To investigate this, the most common coral species were sampled from 5-15 m at two high-latitude sites in the South Pacific. In total 5 and 12 host species were examined from the Kermadec Islands (29°S) and Lord Howe Island (31°S) respectively. Symbiont diversity was characterized using PCR and Denaturing Gradient Gel Electrophoresis (DGGE) of the ITS2 region. Most corals associated with clade-C *Symbiodinium* and symbiont diversity within specific hosts largely overlapped with that of tropical regions. However, previously unreported sub-cladal symbiont types were also identified, some of which were highly divergent from those occurring on nearby tropical locations. Multiple sub-cladal symbiont types were found between colonies of the same coral species (i.e. *Acropora cuneata* and *Pocillopora damicornis*) and varied both in relation to depth or location, suggesting the presence of environmentally-specialised symbionts. In conclusion, the common occurrence of multiple symbiont types within a single host species may represent an adaptive strategy to survive under the variable environmental conditions occurring at high latitude sites. Furthermore, the overlap between symbionts in this marginal environment and those previously studied in tropical reefs may provide an avenue for corals to extend their range margins, and limit the impacts of climate change.

## 25.1130

**Gis Modeling And Mitigation Of Coral Reef Damage**

**Richard SNOW*[1]**, Mary SNOW[1]

[1]Applied Aviation Sciences, Embry-Riddle Aeronautical University, Daytona Beach, FL

In addition to supplying food and shelter for marine flora and fauna, coral reefs provide natural barriers as well as tourism and fishing income for coastal communities. However, a global inventory of Earth's coral reefs estimates that nearly 60% are at risk, and 90% of all living reefs have been damaged by coral bleaching. Regionally, the occurrence of coral bleaching will be the highest in the Caribbean and could take place on an annual basis over the course of the next 30-50 years. The objective of this study is to demonstrate that an efficient instrument for conducting surveys and inventories of coral reefs to assess those ecosystems at higher risk and develop mitigation strategies is through the use of a Geographic Information System (GIS). Efficient monitoring requires the assessment of various coastal data baselines and the evaluation of subsequent alterations in spatial patterns. While monitoring involves real-time components, among the most powerful tools of a GIS are its modeling capabilities, which allow simulation of various climate change scenarios. Relevant aspects include changes in coastal land use, wetlands, and shoreline configuration. Using Caribbean coral reef examples, the results of this research reveal that GIS techniques and applications play an integral role in defending coral reefs from climate change and other threats. Planners and politicians require the ability to analyze risks, assess impacts, and consider alternatives based on input from researchers across diverse disciplines. GIS provides the collective tool that integrates multifaceted data and transforms it into a meaningful medium for informed decision-making.

## 25.1131

**Climate Change Leads: Linking Environmental Analysis To Decision Support**

Alessandra SCORE[1], **Eric MIELBRECHT*[2]**, Dan WAGNER[3]

[1]South Florida Program, World Wildlife Fund, Key Largo, FL, [2]Emerald Coast Environmental Consulting, Washington, DC, [3]Florida Institute of Technology, Melbourne, FL

Climate Change LEADS: Linking Environmental Analysis to Decision Support is an interdisciplinary initiative that is bringing together scientists, natural resource managers and decision-makers at the local, state and federal levels, with a full range of stakeholders to analyze coral resilience to climate change and transform these findings into effective management strategies. Florida's stakeholders and decision-makers urgently need targeted research, clear communications, and powerful tools to better understand the likely impacts of climate change and coral bleaching so they may develop and implement successful management and mitigation initiatives. This project is synthesizing existing and emerging scientific data to identify resilient populations of coral and uncover the key environmental factors that confer this resilience. All relevant coral bleaching and water quality data for the Florida Keys is being obtained and transferred into a GIS framework to identify patterns in bleaching occurrence and recovery with respect to environmental variables such as water quality. These results are being used to create a tool that will help guide management decisions to better sustain the resilience of this ecosystem as climate change stresses increase. By involving the community and user groups directly in the design and implementation of the project and working closely with local partners such as the Florida Reef Resilience Program (FRRP), the Florida Keys National Marine Sanctuary, the Florida Department of Environmental Protection, the Nature Conservancy, and a various Universities , WWF has established a critically-important process for information to flow between scientists, stakeholders and managers in the region.

## 25.1132

**The Heterogeneity Of Temperature Change And Coral Bleaching During Temperature Abnormally Warm In Summer 2007**

**Tung-Yung FAN*[1]**, Bing-Je WU[2], Lee-Shing FANG[3]

[1]Department of Biology, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [2]National Museum of Marine Biology and Aquarium, Pingtung, Taiwan, [3]Cheng Shiu University, Pingtung, Taiwan

The sea surface temperature in the tropical West-Pacific surrounding Taiwan was abnormally warm in summer 2007 and caused mass coral bleaching. To test the hypothesis that temperature and coral bleaching might be different at various sites, the seawater temperature change and coral bleaching were examined in shallow water (< 10m) of coral reefs at 9 sites around southern Taiwan and Dongsha island in South China Sea. Censuses completed over 4 months time frame identified three broad patterns of variation in seawater temperature and coral bleaching (defined as Type I - III). Type I bleaching occurring at 6 sites where the seawater temperature exceeded 30°C and the percentage of coral bleached ranged from 29-60%. Type II bleaching occurred at 2 sites with the temperature higher than 30°C, but the percentage of coral bleached was lower than 5%. Type III bleaching occurred at 1 site with the temperature lower than 30°C and corals did not bleach. The three patterns of variation in seawater and coral bleaching was caused by different effects of geography, as well as upwelling- and typhoon-induced temperature decreasing. The striking spatial variation in seawater temperature and the extent of mass coral bleaching acted together to create large patches of reef affected by bleaching that were interspersed with areas that appear relatively unaffected by bleaching. This pattern may have ecological importance as it suggests that the healthy patches might be capable of functioning as refugia for coral reefs affected by global warming.

## 25.1133

**Rising Sea Level and Increased Turbidity on Fringing Coral Reefs**

**Michael FIELD*[1]**, Andrea OGSTON[2], Ann GIBBS[1]

[1]Pacific Science Center, U.S. Geological Survey, Santa Cruz, CA, [2]School of Oceanography, University of Washington, Seattle, WA

Relative sea level is predicted to rise 2.2 to 4.4 mm/y and perhaps more this century. We hypothesize that even small increases in sea level will increase wave energy on adjacent reef flats and shorelines. This in turn will significantly increase turbidity on some coral reefs by increased resuspension of sediment in shallow reef areas, and increased erosion of fine sediment from adjacent coastal plains and deltaic deposits.

Sedimentation and suspended sediment are leading contributors to reef degradation, and our studies in Hawaii indicate that sea-level rise has a strong potential to increase suspended sediment concentrations (turbidity) on fringing coral reefs through increases in both wave resuspension and wave erosion. Results from a well-studied fringing reef flat (Molokai, HI) show that sediment is resuspended daily, and levels of suspended sediment concentrations are primarily related to wind velocity, resulting waves, and water depth (tide stage). Both the duration and magnitude of suspension events may increase with even small increases in sea level over fringing reefs due to enhanced bottom stresses. Given a rise of 10 cm in the next couple of decades, wave bottom stresses will be higher and critical water depths will be reached earlier during rising tides and be maintained longer during falling tides, resulting in longer and more intense turbidity conditions.

Increases in water depth of even 10 cm over reef crests may also increase wave energy on adjacent shorelines, many of which are only thin sandy veneers capping older deposits of alluvium. Waves at higher water levels within the tidal cycle have increased capability to erode friable, unprotected deposits in low-lying areas over prolonged time periods. The fine-sediment component of these deposits is susceptible to advection seaward and deposition on the reef, potentially increasing the levels of suspended sediment.

## 25.1134

**Coral Protection Under The U.s. Endangered Species Act**

**Miyoko SAKASHITA*[1]**, **Brendan CUMMINGS*[2]**, **Andrea TREECE*[1]**, **Shaye WOLF*[1]**

[1]Center for Biological Diversity, San Francisco, CA, [2]Center for Biological Diversity, Joshua Tree, CA

Two coral species, elkhorn coral (*Acropora palmata*) and staghorn coral (*A. cervicornis*), were recently protected as "threatened" under the United States Endangered Species Act (ESA). Once the primary reef-building corals of Florida and the Caribbean, these species have suffered an 80-98% decline in just 30 years. These corals face significant threats from changing environmental conditions because of human-induced global warming and pollution. In 2008, "critical habitat" will be designated for elkhorn and staghorn corals, as required by the ESA. Using the case study of the corals, we examine the protections that the ESA provides, including the listing process, critical habitat designation, and recovery planning. We discuss how the ESA's statutory prohibitions against "jeopardy" and "adverse modification" of critical habitat for listed species might apply to greenhouse-gas-generating actions of U.S. federal agencies. The ESA remains highly relevant to species preservation in a changing climate, providing mechanisms to address both mitigation (reducing greenhouse gas emissions) and adaptation (ecosystem management).

## 25.1135

**Species Specific Responses To Experimental Bleaching Of Corals**

**Deborah VIVIAN*[1]**, Susan YEE[1], Sarah KELL[1], Cheryl MCGILL[1], Mace BARRON[1]

[1]Gulf Ecology Division, US EPA, Gulf Breeze, FL

The combined effects of temperature and solar radiation on six species of reef-building corals were examined using a laboratory coral exposure system. *Diploria clivosa*, *Montastraea faveolata*, *Siderastrea siderea*, *Siderastrea radians*, *Stephanocoenia intersepts*, and *Porites astreoides* were first exposed for 10 days to two temperatures (26 or 31oC) and three solar radiation doses (ultraviolet radiation (UVA) at 13.7, 68, and 84 W•d/m2). Corals were then monitored for a 40 day recovery period. A pulse amplitude modulation (PAM) fluorometer was used to monitor changes in photosystem II efficiency (ΔFv/Fm) during the exposure period. Weekly observations and PAM measurements were conducted during the recovery period to assess changes in bleaching and health. After recovery, pigment, zooxanthellae, and protein concentrations were analyzed to determine recovery rates of corals. During initial exposure, species responded differently to the combined effects of temperature and solar radiation with *P. astreoides* showing the greatest decline in Fv/Fm over time and *S. siderea* showing the least change in Fv/Fm. Most species responded similarly to temperature showing a decrease in Fv/Fm in the 31oC treatments. However, species response to light was significantly different ($p = 0.038$), with *S. intersepts* showing the greatest response to high radiation and *S. siderea* the weakest. Highest mortalities were observed in *S. intersepts* and *M. faveolata* (22%) exposed to the highest solar radiation at the end of exposure. Changes in Fv/Fm showed poor recovery for only *S. intersepts* and *M. faveolata* exposed to high solar radiation. Recovery rates based on pigment, zooxanthellae, and protein concentrations were variable among species and treatments. Responses to combined effects of solar radiation and temperature are species specific for both experimental bleaching and recovery.

## 25.1136

**Making The Loss Of Coral Reefs A Personal Matter**

**John WARE*[1]**

[1]SeaServices, Inc., Gaithersburg, MD

The primary objective of this study is to focus attention on coral-reef problems at the individual level in order to increase public awareness and involvement with climate change issues. A secondary objective is to demonstrate the utility of a simplified "reefs-in-the-greenhouse" model for predicting the effects of climate change on coral reefs.

The unique feature of this study is that it relates reef loss and survival on a per capita basis so that these issues become a personal matter. The abstract allegation: "Coral reefs are dying and that $CO_2$ emissions are a major cause", does not allow the average person to relate his/her actions to real-world effects. My alternative conceptualization: "Reducing your future $CO_2$ emissions can save N $m^2$ of coral reefs" permits individuals to assess how their activities relate to the very real threats to reefs.

$CO_2$ emissions are used as a surrogate for all the ills that humanity has imposed on coral reefs because, in addition to direct temperature and acidification effects, $CO_2$ emissions correlate with many other negative impacts on reefs. That is, people who emit large quantities of $CO_2$ also tend to be indirectly responsible for other reef problems (e.g., overfishing, pollution, and sediment loading).

Focusing on the United States, but with global implications, I couple a simplified model of climate change with a unique simultaneous simulation of more than 1000 reef types to draw conclusions with regard to reef survivability under various $CO_2$ emissions scenarios. The reef types cover a broad spectrum of temperature environments, bleaching/mortality thresholds, resilience/recovery, and adaptation potentials. The model has been calibrated using observed warming and present reef status.

Although the future of reefs is not bright, reducing future warming coupled with coral adaptation potential, even on the scale of 100 years, can result in reef survival.

## 25.1137

**Effects Of Elevated Seawater Temperatures On The Development And Survivorship Of Larvae Of The Eklhorn Coral *acropora Palmata***

**Carly RANDALL*[1]**, Alina SZMANT[1]

[1]Biology and Marine Biology, University of North Carolina Wilmington, Wilmington, NC

Elevated seawater temperatures during the late summer and fall, followed by periods of bleaching and increased susceptibility to disease, have led to a reduction in live coral cover on coral reefs. Bleached corals have also been found to exhibit reduced reproductive success. Both lower adult abundance and lower fecundity could result in a reduced ability of these populations to recover. The effect of elevated seawater temperatures on early life-stages of corals that reproduce during these warm times of year also remains poorly studied. If elevated temperatures reduce survival and settlement of coral larvae, the recovery of coral populations will be further impeded. Effects of elevated temperature on the survivorship of the larvae of the broadcast spawning coral *Acropora palmata* were studied experimentally. Larvae maintained at temperatures only one degree above historic summer values (29.5-31 ºC) exhibited reduced survivorship as compared to those maintained within the normal summer temperature range (27-28 ºC). Larvae maintained at the control temperature, 27.5 ºC, exhibited a cumulative average survivorship of 28.9 % over the 140 hour experiment whereas larvae maintained at the elevated temperature of 31.5 ºC exhibited a significantly reduced cumulative average survivorship of only 2.0 %. Intermediate survivorship of 10.9 % was observed at the intermediate temperature of 29.3 ºC. However, in a preliminary settlement trial, there was no significant difference among those larvae that survived to this stage. These results show that the supply of coral larvae to Caribbean reefs is being seriously reduced by global warming. Samples of embryos and larvae were fixed for electron microscopy at various times during the course of temperature exposure and processing of those samples is ongoing to examine the effects of elevated temperature on the larval development.

## 25.1138

**Coral Reef Monitoring In The Gilbert Group, Kiribati: Taking Into Account Long-term Monitoring And Limited Resources**

**Taratau KIRATA*[1]**, Toaea BEIATEUEA[1], Tebaua SAPOLU[1], Aaranteiti TEKIAU[1], Dr. Simon DONNER[2,3]

[1]Fisheries Department, Ministry of Fisheries and Marine Resources Development, Tarawa, Kiribati, [2]Geography Department, University of British Columbia, Vancouver, BC, Canada, [3]Woodrow Wilson School of Public & International Affairs, Princeton University, Princeton

The coral reefs of the western part of Kiribati (Gilbert Islands), a group of coral atolls stretching from 3°N to 6°S in the Western Pacific, are subject to multiple stresses including pollution (sewage), resources exploitation and coral bleaching. The increasing local and global demand for fish and other marine resources may be affecting coral reef health, resource availability and contributing to outbreaks of toxic fish poisoning. The region is also exposed El Nino-related warm water anomalies that can cause mass coral bleaching. There is a need for a long-term monitoring program that considers the limited resources of the isolated islands and increasing threats from climate change.

Here we describe a new continuous monitoring program for the Gilbert group. The protocol includes manta tows, PITs at 3m and 10m depth and random photo-quadrats at selected islands; more detailed monitoring is conducted around the central atoll of Tarawa due to easier access. Preliminary results show hard coral cover of 10-20% on the outer reefs of South Tarawa, possibly due to population pressure and wave action; hard coral cover is higher (25-40%) at similar depths around Butaratari and Abaiang. *Acropora* sp. is surprisingly rare around Tarawa and Abaiang. There are a high number of dead colonies of *Pocillipora* sp. at most sites, particularly around Butaritari, possibly from coral bleaching in 2004. The results from ongoing monitoring could help the people of Kiribati understand how to adapt to the rising pressure on marine resources, outbreaks of fish poisoning and climate change.

## 25.1139

**Effects of elevated pCO2 and temperature on calcification and photosynthesis of the Mediterranean coral Cladocora caespitosa**

**Riccardo RODOLFO-METALPA*[1]**, Sophie MARTIN[2], Christine FERRIER-PAGÈS[3], Jean-Pierre GATTUSO[4]

1Marine Biology and Ecology Research Centre, University of Plymouth, Plymouth, United Kingdom, 2International Atomic Energy Agency, Monaco, Monaco, 3Centre Scientifique de Monaco, Monaco, Monaco, 4CNRS-Centre National de la Recherche Scientifique, Villefranche-sur-mer Cedex, France

Atmospheric CO2 partial pressure ($p$CO2) is expected to double by the end of the present century, and will be accompanied by an increase in seawater temperature. Since $p$CO2 was shown to decrease calcification rates in tropical corals, it might also affect temperate corals, such as those living in the Mediterranean Sea. Colonies of the Mediterranean coral *Cladocora caespitosa* were collected at *ca*. 30 m depth in the NW Mediterranean Sea and maintained under normal and elevated temperature (T and T+3°C, respectively) and $p$CO2 (400 and 700 µatm, respectively) levels, alone or in combination. Temperature (T = 13-22°C) and light (20-60 µmol photons m-2 s-1) varied seasonally while $pCO_2$ was kept constant. Rates of photosynthesis and calcification, and symbiont parameters were measured during two short-term (one month) experiments carried out in Summer 2006 and Winter 2007. Additionally, coral growth and the effective quantum yields ($\Delta F/F_m'$) were measured during a long-term (1 year) experiment.

A 3°C increase in temperature had some effects on coral physiological parameters, increasing photosynthetic and respiration rates and decreasing $\Delta F/F_m'$, depending on the season. Conversely, a doubling in $p$CO2, alone or in combination with elevated temperature, had no significant effect on any of the parameters tested, either during the short or the long-term experiment. In particular, no significant effect was found on calcification and growth rates. This result seems different from tropical corals, in which rates of calcification decrease at elevated $p$CO2. However, it is important to note that the corals used were collected at the deeper end of their bathymetric range, were grown at low irradiance and were therefore likely light-limited. It is critical to investigate the response of shallow-water colonies to elevated $p$CO2 to investigate a potentially significant interaction between light, temperature and $p$CO2 to control the metabolism of Mediterranean corals.

## 25.1140

**Distribution of algal symbionts (Symbiodinium spp.) in reef corals along a latitudinal gradient in Western Australia**

**Rachel SILVERSTEIN*[1]**, Adrienne M. S. CORREA[2,3], Andrew BAKER[1]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL, [2]Ecology, Evolution and Environmental Biology, Columbia University, New York, NY, [3]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami

Mutualisms involving dinoflagellate algae in the genus Symbiodinium metabolically support reef-building corals, thereby underpinning the high levels of productivity characteristic of coral reefs. High temperature-related "bleaching" events cause reef corals to lose their endosymbiotic algae and, if prolonged, lead to coral mortality. However, corals may be able to recover from bleaching and to acclimatize to climatic changes by shuffling between symbiont types with varying environmental optima. The diversity of these symbiont types within scleractinian corals is still being realized and appears to be geographically specific in many cases. To document symbiont diversity in Western Australia, where little Symbiodinium research has previously taken place, this study examined symbiotic algae within more than 30 coral hosts sampled from five sites that span over 2500 km of coastline. Collection locations include the sub-tropical Ningaloo Reef, which hosts high coral diversity, Rottnest Island and Dunsborough, an extreme high latitude (~33°S) with respect to the range of reef corals. In order to study the genetic diversity of Symbiodinium, the ITS-2 region of the nuclear ribosomal DNA was amplified and sequenced. Resulting ITS-2 types were then compared to a database of known Symbiodinium diversity and novel sequences were placed in an evolutionary context by building phylogenetic trees and statistical parsimony networks. This study demonstrates patterns of symbiont distributions in accordance with the prevailing environmental conditions varying along a gradient of irradiance and temperature. Our data indicate that Western Australia is a region of high symbiont diversity both between and within host coral species, with many apparently unique symbiont types. This study both reconfirms ecological symbiont patterns previously reported and shows some unexpected distributions.

## 25.1141

**Variation in Zooxanthella Production Of Dimethylsulfoniopropionate (Dmsp)**

**Mary Alice COFFROTH*[1]**, Maria Gabriella JACKSON[1], Patricia MATRAI[2], Carlton RAUSCHENBERG[2]

[1]Geology, University at Buffalo, Buffalo, NY, [2]Bigelow Laboratory for Ocean Sciences, W. Boothbay Harbor, ME

Dimethylsulfoniopropionate (DMSP) is produced by many marine phytoplankton, including dinoflagellates. DMSP's proposed functions include an antioxidant, an osmolyte and a defensive compound, among others. Dinoflagellates within the genus *Symbiodinium* (zooxanthellae) that form symbioses with cnidarians also produce DMSP. However, its role in these organisms is not fully understood. We examined the variation of dissolved and particulate DMSP cellular quota (DMSPp and DMSPd, respectively) among different strains of *Symbiodinium* and investigated how this cellular quota changed in the presence of environmental stresses. *Symbiodinium* isolates from Pacific and Caribbean cnidarian hosts, reared under identical environmental conditions (14h:10h, light:dark cycle at 26oC), exhibited variation in DMSPp content both between and within clades (A, C, D, and F). *Symbiodinium* clade A isolates had the highest DMSPp cellular quota, suggesting a potential antioxidant role for these symbionts common in shallow, high light environments. In the intact symbiosis, DMSPp concentrations did not vary within colonies of *Porites divaricata* (Pd). However, significant variation was detected among coral species (*Montastrea cavernosa* (Mc), *M. faveolata* (Mf), *Porites astreoides* (Pa), and Pd), with Mf having the highest concentrations. We also investigated changes in DMSPp and DMSPd concentrations occurring in the intact symbiosis under temperature stress. Mc, Mf, Pa, and Pd were exposed to water temperature 2$^{o}$ C above ambient for 2 weeks. Elevated temperatures did not result in a measurable increase in DMSPp concentrations compared to non-stressed corals; instead, DMSPp concentrations were greater prior to stress. However, DMSP concentrations in Pd did not change after 2 weeks of heat stress. When this coral was subjected to elevated temperature over a longer time period (3.5 wks), it bleached and showed very high DMSPp levels.

## 25.1142

**Coral Ultrastructural Response To Elevated $Pco_2$ And Nutrients During Tissue Repair And Regeneration**

**D. Abigail RENEGAR*[1]**, Patricia L. BLACKWELDER[1,2], Alison L. MOULDING[1]

[1]National Coral Reef Institute, Nova Southeastern University Oceanographic Center, Dania, FL, [2]RSMAS, University of Miami, Miami

Corals and coral reefs have recently experienced widespread decline attributed to anthropogenic pressure on reef systems. Growing coastal population density is expected to result in a concomitant increase in coastal runoff and nutrification of the coastal zone. Rising atmospheric CO2 partial pressure (pCO2) is predicted to change ocean surface water carbonate saturation, resulting in reduced coral calcification and reef growth. While it has been shown that nutrient and pCO2 stress effect coral growth and calcification, study of the specific effects on coral tissue has not received significant attention in the literature despite considerable current interest. The objective of this research is to examine, at the ultrastructural and histological level, the process of tissue repair in corals and how it is affected by exposure to elevated nutrients and pCO2. The target species of this proposed research, *Montastraea cavernosa* and *Porites astreoides*, are important and widespread Caribbean reef-builders. Coral tissue recovery and repair processes will be assessed with transmission (TEM) and scanning (SEM) electron microscopy by examining fragments of *M. cavernosa* and *P. astreoides* exposed to elevated nitrate, phosphate, and $pCO_2$ during wound healing. These analyses will result in a more complete understanding of the complex process of tissue repair and regeneration in corals under varying environmental conditions.

## 25.1143

**Using The Concept Of Degree Heating Weeks And The Threshold Of Coral Bleaching Temperature To Assess The Risk Of Coral Bleaching in Taiwan**

**Tai-Ying WU*[1]**, Sharon HORNG[1], Chang-Feng DAI[1]

[1]Institute of Oceanography, National Taiwan University, Taipei, Taiwan

Degree Heating Weeks (DHWs) represent the accumulation of thermal stress that coral reefs experienced over the past 12 weeks was applied to evaluate the risk of coral bleaching under the impacts of climate change. One DHW is equivalent to one week of sea surface temperatures (SSTs) one degree Celsius greater than the expected summertime maximum. We used the threshold of coral bleaching temperature instead of the expected summertime maximum to estimate the DHW values for assessing the risk of coral bleaching in Taiwan. By reviewing the existing articles, we found the thresholds of coral bleaching temperature are negatively correlated with latitudes. To verify the applicability of the threshold, we collected SSTs from 1990 to 2006 around Taiwan together with the records of coral bleaching, and the results confirmed the temperature thresholds are adequate for indicating the occurrence of coral bleaching. The DHWs of Kenting Reefs in 2007 were used to verify its applicability as an indicator for the risk of coral bleaching. The DHW was 1.03 in mid-July when the spotted cases of coral bleaching were observed. During August and September, the DHWs were above 5, when severe and extensive coral bleaching was observed in Kenting Reefs. These results support the DHW is a good indicator for coral bleaching in Taiwan. We further used the simulated SSTs from CGCM2 SRES A2 and B2 scenarios to evaluate the risk of coral bleaching from present to 2100. The results show the risk of coral bleaching in Taiwan will increase significantly after 2050 under the A2 scenario; however, under the B2 scenario, coral bleaching will be occasional events even after 2070. Thus, lowering the greenhouse gas emission will reduce the threats of global warming on coral reefs and provide longer time for preventing coral reefs from degradation in Taiwan.

## 25.1144

**Heat Tolerant Corals (*porites Lutea* and *galaxea Fascicularis*) From Near-Shore And Offshore Reefs in Northern Vietnam**

**Suzanne FAXNELD*[1]**, Tove Lund JÖRGENSEN[1], Michael TEDENGREN[1], Magnus NYSTRÖM[1], Ngai Dang NGUYEN[2]

[1]Systems Ecology, Stockholm University, Stockholm, Sweden, [2]Institute of Marine Environment and Resources, Hai Phong, Vietnam

The objective of this study was to investigate how two coral species, *Porites lutea* and *Galaxea fasicularis* responded to increased water temperature and if the responses differed between species and between corals from near-shore / offshore reefs.

Corals were collected from near-shore, i.e. disturbed reefs, and offshore, i.e. reefs considered pristine. The corals were exposed to gradually increased temperatures for 96 h. (day 1: 27.5°C, day 2: 30.5°C, day 3: 33.5°C, day 4: 25.5°C). The corals in the control group were exposed to 25.5°C.

The results show that both species, with no regard of area, experienced a decrease in GP/R ratio day 1, after a moderate temperature increase. However, on the other exposure days there were no differences between heat treated and control corals, even though the temperature increase was 8°C above ambient on the third day of exposure.

For *Porties* there were no differences in gross production or respiration between the two areas, while the pattern was different for *Galaxea*, where gross production and respiration increased only for corals from the pristine area.

These results illustrate that even a small temperature increase affects the corals, but the corals then seem to adapt to the temperature changes. One explanation could be that these species are tolerant to bleaching and temperature increases, since they come from a high latitude reef and experience large temperature fluctuation over the year.

The different results between disturbed and pristine area samples for *Galaxea* might be due to *Galaxea* being a sediment tolerant species which might therefore tolerate another stressor (i.e. elevated temperatures), due to useful clade types, genetic or physiological adaption to different environmental changes, or their ability to induce heat shock proteins.

## 25.1145

**The Effect Of Moderate And Extreme Temperature Increases On The Physiological Responses Of Coral Reef Organisms (*porites Lutea* and Five Different Algae) in Northern Vietnam**

**Tove Lund JÖRGENSEN*[1]**, Suzanne FAXNELD[1], Michael TEDENGREN[1]

[1]System of Ecology, Stockholm University, Stockholm, Sweden

Global warming and increasing sea temperatures have shown to induce bleaching events and generate phase shifts on coral reefs. In combination with other anthropogenic factors, such as overfishing, sedimentation and pollution, this has caused world-wide coral reef degradation. Here we investigated the physiological responses to moderate temperature (30 °C) and extreme temperatures (34 °C) during 24 hours on one coral species (*Porites lutea*) and five algae species from three different phyla (*Chlorophyta*, *Rhodophyta*, *Phaeophyta*). The experiment was conducted in Do Son, close to Halong Bay in Northern Vietnam. To determine the organisms' physiological responses, oxygen levels were measured in light (net production) and in darkness (respiration). The result from the organisms' GP/ R ratio showed that only the member from *Phaeophyta* (*Sargassum sp.*) was significantly negatively affected by elevated temperature (34 °C). None of the other organisms showed any variation in GP/ R ratio to moderate or extreme temperature increases, which may be a result of adaptation to high seasonal temperature fluctuations. Furthermore, the results showed a positive correlation between the GP/ R ratio and temperature for *Gracilaria sp.* (*Rhodophyta*), however a negative correlation was obtained for *Sargassum sp.* The results from this experiment demonstrate that coral reef organisms' physiological responses to increased temperatures are unequal, even within the same phylum. This in turn suggests that the consequences of global warming may be severe, since it not only will affect coral reef organisms directly, by reduced metabolism/ growth rate and increasing mortality, but also indirectly by altering competition between species, which in turn may lead to decreased biodiversity and an increase in coral reef vulnerability to further anthropogenic or natural disturbances.

## 25.1146

**Evidence For Normal Gametogenesis in Bleached Colonies Of The Stony Coral *oculina Patagonica***

**Rachel ARMOZA-ZVULONI*[1,2]**, Roee SEGAL[1], Yossi LOYA[1]

[1]Department of Zoology, Tel-Aviv University, Tel Aviv, Israel, [2]The Interuniversity Institute for Marine Sciences of Eilat, Eilat, Israel

Coral bleaching events (BEs) are occurring with increasing frequency in coral reefs worldwide and are likely to become annual, triggered by seasonal changes in water temperature. The stony coral *Oculina patagonica* experiences seasonal BEs in most locations along the Israeli Mediterranean coast. Therefore, it can be used as a model for assessing potential effects of expected annual BEs on physiological parameters in coral populations. Previous studies showed that overlapping between bleaching and reproduction seasons in *O. patagonica* impedes gametogenesis. The major objective of this study was to examine the reproductive capabilities of *O. patagonica* colonies undergoing chronic cyclical BEs and compare it with colonies undergoing bleaching for the first time. Samples were collected for histology during two reproductive seasons of 2004-2005 at three sites, along 140 km of the Israeli Mediterranean coast. Monthly surveys were conducted to examine bleaching prevalence and severity. In two of the three sites studied, seasonal BEs were observed during both years, while in the third site bleaching was apparent only during the second year. In contrast to previous findings, in the first two sites, bleached colonies did not differ significantly from non-bleached colonies in the reproductive parameters studied (percentage of fertile polyps, number of testes and their state of maturation, oocyte number and size). However, in the third site the reproductive effort of bleached colonies was found to be significantly reduced compared with the non-bleached colonies. We suggest that in colonies experiencing BE for the first time reproductive effort may be reduced, while colonies undergoing chronic BEs may acclimatize over time to the loss of their symbiotic algae and support the development of gonads during bleaching. This study provides the first evidence for normal gametogenesis in bleached colonies and may indicate that acclimatization processes might enable more coral species to overcome expected chronic BEs.

## 25.1147

**Conservation, Mass Mortality And Population Dynamics Of Long-Lived Octocorals**

**Roberta CUPIDO*[1]**, Silvia COCITO[1], Mimmo IANNELLI[2], Lorenzo BRAMANTI[3], Ilaria VIELMINI[3], Giovanni SANTANGELO[3]

[1]Enea - Marine Environmental Research Centre, La Spezia, Italy, [2]Mathematics, University of Trento, Trento, Italy, [3]Biology, University of Pisa, Pisa, Italy

Conservation of long-lived, slow growing, low turnover species is one of the most difficult task for ecologists. Gorgonians are among the most long-lived marine animals. Provided of complex morphologies, they played a paramount role in shaping rocky shore benthic communities and in ecosystem functioning. The conservation of the highly diverse Mediterranean "*coralligenous community*" is linked to their survival. Some gorgonians, namely *Paramuricea clavata* and *Corallium rubrum* (the precious, overexploited Mediterranean red coral), suffered in 1999 and 2003 anomalous mortality events in the North-Western Mediterranean, which were associated with a sharp temperature increase linked to GCC. As a consequence of these mortality events the *P. clavata* population living in the Gulf of La Spezia (Ligurian Sea, Italy), reduced by 74% and the dominant size class in the population shifted towards smaller-yonger colonies. Some shallow red coral population in Italy and France, suffered, at the same time, a mortality ranging between 8.5 and 15 %. In order to simulate the effects of such mortalities on the structure and dynamics of gorgonian populations we developed demographic models, based on life-history tables (in which population structure, survival and reproductive coefficients are reported), and Leslie-Lewis transition matrixes, that allowed us to project the population trends overtime. Such demographic approach can supply useful tools to predict population dynamics in response to mass mortality events and harvesting, to assess population performance, and to forecast population availability overtime. The results we obtained suggest that, also if both gorgonian populations show a good resilience due to the reproductive output of the younger-smaller colonies more resistent to mortalities and to the high growth rate of the survived colonies, an increased frequency of such morality events could lead local populations to extinction.

## 25.1148

**Assessment Of Potential Threat On Coastal Ecosystem By Future Sediment Load Trends in The Southeast Asian And West Pacific (Sea-Wp) Regions**

**Varigini BADIRA*[1]**, Kazuo NADAOKA[1], Seita EMORI[2]

[1]Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan, [2]Center for Global Environmental Reseach, Japan National Institute of Environmental Studies (NIES), Tsukuba, Japan

Monitoring and prediction of global and regional sediment discharge are extensive undertaking due to the countless number of rivers worldwide. Presently, only less than 10% of the global rivers are monitored for sediment discharge. This is a major concern as abnormal sediment discharge patterns due to anthropogenic influences may go unnoticed, and hence uncontrolled, into coastal environments certainly posing a threat to the marine ecosystem. Of the total global sediment budget flowing into the world's oceans and seas, an estimated 70% of the sediment load into the coastal zone is accounted for within the SEA-WP region. Coincidently, the SEA-WP region is an eco-system hotspot in biodiversity and encompasses a region known as the Pacific coral triangle. This paper presents our recent findings on the future sediment load trends in the SEA-WP region using a new Regional Sediment Discharge predictor. The predictor was developed by incorporating influence of vegetation shifts, rainfall and soil moisture content together with the conventional parameters of basin area and elevation. The model is coupled with GCM predicted rainfall data, for IPCC global warming scenarios of A1B and B1, and predicted vegetation shift to calculate and forecast future sediment load trends within the SEA-WP region. The model prediction results strongly suggest that the SEA-WP region will become highly threatened due to increased mean sediment loads for the periods from 2010 to 2100 and also predicts high sediment load variability for uncontrolled future carbon dioxide emission.

## 25.1149

**Using Global Circulation Models And Optimized Bleaching Thresholds To Assess The Future Of Reefs**

**Ruben VAN HOOIDONK*[1]**, Matthew HUBER[1]

[1]Earth and Atmospheric Sciences, Purdue University, West-Lafayette, IN

Global, thermally induced bleaching is projected to increase in frequency due to anthropogenic climate change. The predicted-time to widespread bleaching and subsequent mortality is strongly influenced by the thresholds used and the uncertainties surrounding these thresholds. Therefore there is a need to optimize techniques that predict bleaching and their local thresholds. Using the Peirce Skill Score we can establish the predictive techniques skill or accuracy, and we can also find a local threshold value that objectively maximizes the accuracy of the technique at any given location. We use these optimized thresholds in combination with several SRES scenarios in Global Circulation Models to assess the likelihood of bleaching at all reefs worldwide in next century and beyond. And with the measured skill we can quantify the uncertainty in our predictions of bleaching and the possible implications of uncertainties in global warming rates in climate models used in the IPCC report.

## 25.1150

**Species Susceptibility To Bleaching And Disease Before, During, And After The 2005 Caribbean Warm Water Event On Deep And Mid-Depth Reefs Of The Us Virgin Islands**

**Jacqulyn CALNAN*[1]**

[1]University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

During the months of September to December 2005, the northeastern Antilles experienced an unprecedented warm water event that had a dramatic impact on the health of coral in this region of the Caribbean. Annual monitoring of coral health since 2001 has allowed for the examination of species susceptibility to bleaching and disease over four time periods; "pre bleaching", "bleaching," "recovery" and "post bleaching." Bleaching was severe for a number of common coral species during the event, most specifically those in the genus *Montastraea* as well as for *Agaricia agaricites*. A cause for concern is that many corals continued to show an above normal prevalence of bleaching into the "post bleaching" (6-12 months) period. *Colpophyllia natans*, *Montastraea annularis*, *Porites porites*, *Siderastrea siderea*, and *Diploria strigosa* appeared slower to recover than other species such as *Agaricia agaricites* which showed no signs of bleaching six months following the event. Although all common corals species showed greater than 70% bleaching during this event, there very few incidences of disease observed until the "recovery" period (2-5 months later). During this period, coral diseases reached unprecedented levels at many of the sampling sites. White plague was the most common disease following the bleaching event and affected primarily *Montastraea franksi* (22% prevalence). *Siderestrea siderea* was also frequently affected by disease, largely due to a high prevalence of dark spots disease in the post bleaching period. Overall, prevalence of partial mortality on common coral species increased from only 7% to 80% in the months following the bleaching. Species specific responses to thermal related stresses are therefore important to understanding and predicting the future trajectories of coral reefs.

## 25.1151

**Environmental Correlates Of Symbiodinium Population Clade Identity**

**Thomas OLIVER*[1]**, Kevin ARRIGO[2], Stephen PALUMBI[1]

[1]Hopkins Marine Station, Stanford University, Pacific Grove, CA, [2]Geophysics, Stanford University, Stanford, CA

Recent studies have shown that the genetic identity of a reef coral's obligate endosymbionts, dinoflagellates in the genus *Symbiodinium*, determines in part that coral's likelihood of resisting temperature increases. If this effect is common, we may be able to better understand a given reef's likelihood of resisting temperature increase based in part on the composition of its *Symbiodinium* community. By correlating reefs with documented *Symbiodinium* community compositions to a range of environmental variables we can potentially predict areas more likely to house symbionts that better resist thermal stress. We review 41 published papers that genotyped wild *Symbiodinium*, at 110 sites, and correlated the observed *Symbiodinium* community compositions at each site to the site's Sea Surface Temperature (SST), Chl-A compostion, cloud-cover corrected photosynthetically active radiation (PAR), turbidity, degree heating weeks, and bleaching history. Bleaching history was reconstructed using the ReefBase database of bleaching events, and all other variables were derived from satellite observations. Frequencies of the resistant *Symbiodinium* clades A and D showed significant positive linear correlations with annual mean and maximum SST, as well as annual mean PAR. Multiple linear regression models return corrected R2s from 0.44-0.79, depending on the genus of corals examined, with *Poccillopora's Symbiodinium* community having the strongest environmental correlations. From these models, we have produced global maps with predicted proportions of *Symbiodinium* clades A-D, given an area's environmental characteristics.

## 25.1152

**Global Warming And Caribbean Coral Reefs Collapse: The Case Of Star Corals (Montastraea Annularis And M. Faveolata) in Puerto Rico.**

**Edwin HERNANDEZ-DELGADO*[1]**, Raisa HERNANDEZ[1]

[1]Biology, Universtity of Puerto Rico, San Juan, Puerto Rico

A catastrophic warming event occurred during 2005 through the northeastern Caribbean Sea that caused a mass coral bleaching event in Puerto Rico that was followed by an unprecedented mass mortality of star coral species complex (Montastraea annularis and M. faveolata), among other species. It resulted in a severe net physiological fragmentation of large coral colonies. Permanent photo-stations were established in 4-6 m deep reef terraces dominated by Montastraea spp. at four sites in Culebra Island, Puerto Rico. Digital photography was used to document changes in benthic community structure before (2005) and after (2007) this event. All coral colonies bleached during 2005. Mass coral mortality caused a 60 to 95% decline in % living tissue cover in both species. No significant difference in % living tissue cover loss was documented among sites. Abundant physiological tissue fragments were formed in each colony, typically ranging from just below 1 to 105 cm2, but mostly in mean sizes below 10 cm2. There was no significant difference in mean fragment size among sites. Fragment density was significantly higher ($p<0.0001$) at Carlos Rosario Beach (130/m2) in comparison to other sites (25-40/m2). Percent tissue cover was also significantly higher at this site before this event. There was also a total collapse in coral mass spawning in both species during 2006 and 2007. There are not known precedents through the Caribbean of catastrophic events of this magnitude. The synergistic consequences of climate change and variable local anthropogenic impacts in major reef engineer taxa still remain largely unknown. However, a single warming event was unequivocally capable of causing an acute coral mortality event that resulted in a major ecological collapse. This resulted in a phase shift in benthic community structure that coupled with major recurrent failures in sexual reproduction in the near future may risk coral reef ecosystem resilience.

## 25.1153

**Algal Symbiont Communities in Scleractinian Corals in The Galapagos During The 1997-1998 El Niño-Southern Oscillation Bleaching Event**

**Lauren VANDEPAS*[1]**, Andrew BAKER[2], Peter GLYNN[2], Josh FEINGOLD[3]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmorpheric Science, University of Miami, Miami, FL, [2]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [3]Division of Math, Science and Technology, Nova Southeastern University, Ft. Lauderdale, FL

The El Niño-Southern Oscillation (ENSO) bleaching event of 1997-1998 was a severe disturbance to coral reefs in the Galapagos. Sustained sea surface temperature anomalies of 3.5–4.5oC resulted in bleaching in a reported 70–90% of all coral species by February 1998, and eventual mortality was approximately 26%. In March 1998, we sampled the algal symbiont communities (*Symbiodinium* spp.) from 139 samples of bleached and healthy corals, and compared them with 20 samples taken from healthy corals in June 1997, before the bleaching event. Algal symbionts were identified using restriction fragment length polymorphisms (RFLPs) in large subunit ribosomal DNA, and denaturing gradient gel electrophoresis (DGGE) of the ITS-2 ribosomal region. Samples taken before the bleaching event (1997) contained a variety of *Symbiodinium* in clade C, but no clade D was detected, even in the scleractinian coral *Pocillopora*, which commonly hosts D at other sites in the far eastern Pacific (Panama, Mexico). Clade D was also rare in samples taken during the bleaching event (1998), although they were found in a few *Pocillopora* that were unaffected by bleaching, as well as in two almost-dead *Pocillopora* sampled with the intention of identifying symbionts still remaining in bleached tissues. These results suggest that the comparative scarcity of heat tolerant symbionts in the Galapagos may explain why bleaching-related mortality was relatively higher in the Galapagos in 1997-98 compared to elsewhere in the eastern Pacific. These findings also indicate that heat tolerant symbionts may have been present in some hosts, but at levels that were not sufficiently high to affecting survivorship following bleaching. We hypothesize that the normally cool waters of the Galapagos result in the virtual absence of heat tolerant symbionts in clade D, resulting in these coral communities being particularly susceptible to the effects of high temperature bleaching in 1997-98.

## 25.1154

**Coral Reefs Of The Gulf Of Mannar, Southeastern India -Observations On The Effect Of Elevated Sst During 2005-2007**

**Edward JK PATTERSON*[1]**, G. MATHEWS[1], K. DIRAVIYARAJ[1], Jerker TAMELANDER[2]

[1]Suganthi Devadason Marine Research Institute, Tuticorin, India, [2]IUCN Global Marine Programme, Dar es salaam, Tanzania

The effect of elevated sea surface temperature (SST) on the coral reefs of the Gulf of Mannar, Southeastern India was monitored during 2005-2007 using quadrate and LIT methods. The pattern of effect was almost similar on the reefs every year except the modest fluctuations in the temperature levels. The temperature varied between 31.50C and 33.60C during summer (April–June). The major reef areas in the Gulf of Mannar are shallow, between 0.5-3.0m depth and in general, comparatively high temperature prevailed and the reefs seem to be acclimatized to such situation. The average percentage of bleached corals during 2005, 2006 and 2007 was 14.6, 15.6, and 12.9 respectively. The bleaching of corals was noticed from mid April and high temperature existed for about a month from the end of April. Massive corals especially *Porites* sp. were the first to be affected and the other dominant coral species partially / fully bleached were *Acropora cytherea, A. formosa*, *A. intermedia, A. nobilis, Montipora foliosa*, *M. digitata* and *Pocillopora damicornis*. The incidence of bleaching was not uniform every year, in terms of area and depth, but the pattern was same. Depends on rainfall and winds, recovery began during June-July and completed in 1-4 months. The branching corals recovered quickly after temperature reduction, but massive corals took longer time. The fastest recovered coral size groups were 40-80 cm and 80-160 cm. There was no coral mortality in 3 years due elevated SST, but 80% of the bleached recruits dead in 2007.

## 25.1155

**What Is The Scope For Adaptation And Acclimatization Of Corals – Seeing The Wood For The Trees**

**David OBURA*[1]**

[1]CORDIO East Africa, Mombasa, Kenya

Understanding the role of bleaching in corals and therefore its role in corals adapting to change has been an elusive goal. A rationale is presented here for a primary role of bleaching in regulation of the coral-zooxanthellae symbiosis. Stress magnifies the differential metabolic potential between coral and zooxanthellae such that a control mechanism limiting this differential is necessary for homeostasis; bleaching is induced to minimize damage from stress. Two general pathways have been demonstrated for bleaching: reduction of the productivity of individual zooxanthellae by reducing chlorophyll concentrations and reduction in the population of zooxanthellae. These are mediated through a variety of physiological mechanisms in the coral and/or zooxanthellae, and these have explicit gene-environment interactions and therefore also evolutionary implications where a persistent directional selective pressure is applied. The extreme thermal stress events causing mass coral bleaching worldwide lie outside the reaction norms for most corals, revealing the limitations of bleaching as a control mechanism. Limits to the rates and capacity for change in bleaching mechanisms are not yet known in sufficient detail to predict the scope for adaptation and acclimatization of corals under present scenarios of climate change.

## 25.1156

**Effects Of Uv Radiation On The Sexual Reproduction Of The Threatened *acropora Cervicornis***

**Juan TORRES*[1]**, Roy ARMSTRONG[2], Ernesto WEIL[2]

[1]Biology Department, University of Puerto Rico, San Juan, Puerto Rico, [2]Department of Marine Sciences, University of Puerto Rico at Mayaguez, Lajas, Puerto Rico

The effects of enhanced ultraviolet radiation (280-400nm: UVR) on the fecundity of *Acropora cervicornis* were measured in field-transplanted colonies from 20 m to 1 m depth and vice versa at La Parguera, Puerto Rico. Fecundity was estimated from histological sections made from tissue samples obtained at different time intervals during the experimental period (March – August 2003). All colonies transplanted from 20 m to 1 m showed a 100% reduction in gonads per mesentery per polyp one month after transplantation, while those transplanted from 1 m to 20 m did not show any significant reduction in fecundity throughout the experimental period. The latter colonies did show however, a delay in the spawning times by releasing their gamete bundles approximately two-three weeks after the controls at 1 m and two months after the controls at 20 m suggesting an induced response as a consequence of changes in their daily light cycle due to less radiation (PAR and UVR) available at 20 m compared to 1 m. Control colonies at 20 m spawned after the full moon of June 2003, while the controls at 1 m spawned 5-6 days after the full moon of July 2003. While a possible reabsorption of the gametes occurred in *A. cervicornis* colonies transplanted from 20 m to 1 m, the expulsion of these gametes due to the sudden stress caused by the transplantation is not discarded. The results suggest that sudden increases in UVR can completely stop sexual reproduction in ramose broadcasting coral species, which in turn can affect the dominance of the species and the composition and structure of shallow reef environments.

## 25.1157

**Potential Impacts Of Anthropogenic Climate Change On Coral Reefs And Mangroves In Madagascar**

**Katie ARKEMA*[1]**, Jameal SAMHOURI[2]

[1]Ecology, Evolution and Marine Biology, University of California, Santa Barbara, Seattle, WA, [2]Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA

Madagascar is best known for its terrestrial biodiversity and endemism. However, the approximately 6,000 km of Malagasy coastline are also home to an impressive diversity of marine habitats and species. Coral reefs and mangroves, which are expected to be particularly vulnerable to anthropogenic climate change, occur along much of the country's coastline. World Wildlife Fund (WWF) and Conservation International (CI) are assessing the vulnerability of coral reefs to increases in ocean temperature, sea level rise, changes in water chemistry, and other potential impacts of climate change on Malagasy marine ecosystems. One aspect of this assessment is a synthesis of peer reviewed literature to determine current knowledge about the geographic distribution of various habitats and identify research explicitly examining the impacts of climate change on ocean ecosystems in Madagascar. We found very few papers with the objective to explore potential impacts of climate change on Madagascar marine ecosystems; however, the consensus view based on recent field surveys is that Madagascar's coral communities are healthy relative to other areas in the western Indian Ocean. Nevertheless, some areas of Madagascar were heavily impacted by the 1998 El Nino associated bleaching event and many corals could die if such intense bleaching events occur in the future. Furthermore, the literature indicates that coral reefs and mangroves extend along >3,500 km of coastline, including the entire west coast and parts of the north and central east coast. The southwestern coast of Madagascar is heavily populated and much of the country's rivers drain to the west, dumping sediments, altering salinity levels and increasing turbidity. Although Malagasy reefs are relatively healthy now, our review suggests that they could be particularly vulnerable to anthropogenic climate change in part because of the potential for global warming to interact with other stressors already impacting Madagascar coastal ecosystems.

## 25.1158

**Coral Mortality And Recovery On A Jamaican North Shore Reef Following The 2005 Caribbean Region Bleaching Event**

**Peter GAYLE*[1]**, Nigel WALTHO[2], Bernadette CHARPENTIER[3]

[1]Centre for Marine Scences - UWI, Discovery Bay Marne Laboratory, St. Ann, Jamaica, [2]Biology, Carelton University, Ottawa, ON, Canada, [3]Research & Development, DUWATECH, Ottawa, ON, Canada

In September 2005, extensive coral bleaching was observed on the north coast of Jamaica which occurred in the wake of elevated sea surface temperatures observed in the Caribbean region during the summer of that year. The local impact of this region-wide bleaching event was monitored over a two year period commencing in November 2005. Reefs at Dairy Bull, Rio Bueno and Discovery Bay on Jamaica's north shore were surveyed using photo transects. The purpose of this study was to determine the extent of the coral bleaching at all sites and to assess species specific mortality and recovery as a function of abundance, time and depth. Bleached and healthy corals (220) were tagged at depths ranging between 8.5m and 36.6m and their condition monitored over time. The mean incidence of bleaching at all three locations decreased from 60.4% (±23.5 SD) to 22.2% (±12.9 SD) during the monitoring period. Initial bleaching observed on the Discovery Bay west fore reef was 63.9% (±15.5 SD) for shallow water (8.5m) in contrast to the 80% (±5 SD) bleaching observed at 24.4m and 36.6m depth. By August 2006, the numbers had decreased to 10.3% (±7.3 SD) for the shallow and 17.6% (±2.1 SD) for deep corals. Complete or partial mortality of tagged corals in shallow water was 21% and 14% for corals tagged at deeper sites. Agaricia and Montastrea spp. were most affected in shallow water. At depth, A. grahamae was most affected by bleaching. Montastrea spp. appeared more robust whereas the Porites spp. were less hardy than their shallow water counterparts. Further studies are required to investigate the relationship, if any, between depth and the resilience and ability of various coral species to withstand the impacts of repeated bleaching events.

## 25.1159

**Coral Bleaching And Spatio-Temporal Variation Of Thermal Stress in Shiraho Fringing Reef Of Ishigaki Island, Southwest Japan**

**Kazuo NADAOKA*[1]**, Takahiro YAMAMOTO[2], Kazuma ARISAKA[2], Yuji MAEDA[2], Shunsuke MOTOOKA[2], Hajime KAYANNE[3], Satoshi MAEKAWA[4], Enrico PARINGIT[5]

[1]Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan, [2]Tokyo Institute of Technology, Tokyo, Japan, [3]University of Tokyo, Tokyo, Japan, [4]WWF-J, Okinawa, Japan, [5]University of the Philippines, Quezon, Philippines

Significant coral bleaching occurred in theYaeyama islands southwest Japan in 2007 summer. To examine detailed characteristics of spatio-temporal variation of thermal stress in a reef and their relationship to the coral bleaching, we made a field survey at Shiraho, a well-developed fringing reef located in the southeast coast of Ishigaki island, in 2007 summer by deploying data loggers of water temperature at 23 points in the reef and 1 point outside the reef. The data was analyzed and compared with the data in 2003 summer obtained by a similar field survey at the Shiraho reef. We made also computational analyses of water temperature variation both in time and space around the reef based on a hydrodynamic and thermal transport model. Besides we performed satellite image analyses to detect coral bleaching distribution in more detail. In 2007 the daily mean temperature outside the reef was around 29°C until July 20 and then rose up to 30.5°C in late July. In the reef the daily mean temperature rose up to about 33.5°C in late July and even the daily lowest temperature exceeded 30°C in the wide area of the reef. Concurrently with this trend of the water temperature in the reef, the coral beaching started to develop extensively in late July. Obviously the significant water temperature elevation indicates the importance of local thermal effects due to shallow topography. Moreover the numerical simulation analysis clarified that the water temperature increase in the reef was augmented by an atmospheric effect; i.e., in late July 2007 the wind became so small that the latent heat flux to the air was decreased. The spatial distribution of the coral bleaching in the reef was found well correlated with the thermal stress distribution, which was appreciably influenced y the local hydrodynamic circulation.

## 25.1160

**Investigating Spatial Variation in Coral Recruitment With Respect To Temperature Along The Southern Coast Of St. John, Us Virgin Islands**

**Daniel GREEN*[1]**, Peter EDMUNDS[1,2]

1California State University, Northridge, CA, 2California State University, Northridge

Studying the effects of physical environmental factors on scleractinian corals has been popularized by the increased frequency of thermal bleaching, however few studies have documented the effect of temperature on coral recruitment. The goals of this study were to test for kilometer-scale variation in seawater temperature and coral recruitment on the southern coast of St. John, US Virgin Islands, and to explore the extent to which temperature might be influencing coral recruitment. To measure temperature and recruitment, a logging thermistor and settlement tiles were deployed at 5-6 m depth at 10 sites in August 2006. Thermistors and settlement tiles were replaced and analyzed every six months in order to capture seasonal variation in biological and physical events. The two sampling periods occurring between August 2006 and July 2007 revealed strong east-to-west relationships in temperature and densities of coral recruits, which is likely a result of the prevailing westward water current. In both sampling periods, the abundance of coral recruits differed significantly among sites, with mean densities declining from ≈ 1.7 recruits tile-1 in the east, to ≈ 0.4 recruits tile-1 in the west. Seawater temperature also varied significantly among sites over both sampling periods, and this effect was reflected in greater daily variation in temperature at western sites compared to eastern sites. Together, through a significant negative correlation between daily variation in temperature and coral recruitment, these results suggest that small-scale variations in temperature are associated with the rate of coral recruitment in St. John. If this relationship applies to larger spatial scales, then it might provide insights into the causes of variation in coral recruitment throughout the Caribbean.

## 25.1161

**Combined Model Assessment Of Geographic Patterns in Warming Rates On Coral Reefs Through 2050**

**Lauren FRANCK*[1]**, Andrew BAKER[1], Amy CLEMENT[2]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, [2]Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

Climate change is profoundly affecting coral reef ecosystems worldwide, but the likely scale of future impacts is still unknown. Much of the uncertainty stems from differences among climate models and different scenarios for future increases and/or management of greenhouse gases. Recent studies have shown that using the average result of several popular climate models outperforms any single model in isolation. We used this approach to identify reef areas likely to experience significantly less warming than average ("Reefs of Hope") over the next 50 years. We combined the results of 20 coupled Atmosphere-Ocean General Circulation Models (AOGCMs), including GFDL, NCAR, and Hadley, to project warming trends in the tropical-subtropical oceans (40˚N to 40˚S) with a spatial resolution of one degree and a temporal resolution of one month. We then calculated Degree Heating Months (DHMs) for each year, using the maximum mean monthly climatology of the current decade (2001-2010) as a baseline. Annual DHM values were calculated as the sum of all monthly positive temperature anomalies, compared to monthly baseline means. These values were used to construct maps that forecast bleaching pressure in the world's coral reef regions from 2010 to 2050. Annual probability maps for DHM>3 (mild bleaching pressure), DHM>5 (moderate) and DHM>7 (severe) were produced. Overall, warmer latitudes warm fastest. We identified certain areas that are particularly threatened by rapid warming, including the Pacific equatorial belt (Line Islands and Marquesas), and parts of southeast Asia (Bali and Malaysia) and west Africa (Ivory Coast). In contrast, certain areas are projected to experience warming rates that are considerably lower than expected for that latitude. These areas include the tropical western Atlantic (Bermuda, the Florida Keys and the Caribbean) and parts of the far eastern Pacific (Galápagos Islands). This approach may help forecast the survival trajectories of reefs worldwide and determine conservation priorities.

## 26.1162

**Inventory And Distribution Of Coral Reef Ascidians Biodiversity In Bearau Regency Waters Of East Kalimantan**

**Muhammad ABRAR*[1]**, Anna E.W. MANNUPUTY[2]

[1]Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, Indonesia, [2]Research Center for Oceanography, Indoensian Institute of Sciences, Jakarta, Indonesia

Inventory of Ascidian (Tunicate) biodiversity on some island in Bearau Regency, East Kalimantan was conducted in September 2004. Site selected were islands with placed far from Kalimantan mainland with assumption that as far as from mainland have biggest of river run off, the Ascidian biodiversity to be reduced. The island selected was placed in north to south consist of Panjang Island, RabuRabu Island, and Derawan Island were representative of islands nearest from mainland and Maratua Island was representative of island far from mainland. Inventory was done by visualization with census on coral reef from site selected. The census was conducted by snorkeling and diving to reach 15 – 20 meter deep. Recording was covered, life form, color and substrate. A total of Ascidian species founded were 41 species from 9 family. The higher number founded from Family Didemnidae, they were 12 species and the low number founded from Family Pheroporidae and Corellidae, they were 1 species. The high biodiversity founded on Raburabu island and low on Derawan island and Maratua island.

Key words: Inventory, Biodiversity, Ascidian

## 26.1163

**Diversity Of Marine Ornamental Fishes in Gulf Of Mannar Biosphere, India**

**Rajagopalsamy CHINNAKONDA*[1]**, Venkataramani VK[2], Jawahar PAULRAJ[1]

[1]fisheries Biology And Capture Fisheries, Fisheries College And Research Institute, Tuticorin, Tamilnadu State, India, [2]fisheries College And Research Institute, Tuticorin, Tamilnadu State, India

Gulf of Mannar is one of the world's richest marine biosphere and which occupies an area of 10,500 sq.km. There are 21 coral reef islands which extend between 80 47' N Lat. 780 12' E Long. To 90 15' N Lat. 790 14' E Long. from Pamban to Thoothukudi as an arc and these islands provides a very interesting heterogeneous group of fauna and flora. About 3600 species of fauna and flora has been identified from this region. Only limited research work was made on the biodiversity of marine ornamental fishes in the Gulf of Mannar. In the present study, Six fish landing centres were selected for estimating the diversity of marine ornamental fishes available in the Gulf of Mannar Biosphere. Fifty five marine ornamental fish species were found to occur during the period of three months of study from the six fish landing centers such as Thoothukudi(28 nos.), Valinokam(14 nos.), Chinna Ervadi(10 nos.), Keelakarai(28 nos.), Mandapam North(20 nos.) and Mandapam South(23 nos.). The Simpsons diversity (D) value of marine ornamental fishes calculated for different landing centers (Thoothukudi 0.068 - 0.086; Valinokam 0.1 - 0.128; Chinna Ervadi 0.123 - 0.156; Keelakarai 0.071 - 0.107; Mandapam North 0.113 - 0.124 and Mandapam South 0.111 - 0.164 ) indicates that diversity was highest in Thoothukudi and lowest in Chinna Ervadi. This research work has been funded by the Gulf of Mannar Biosphere Reserve Trust, Ramanathapuram, Tamilnadu, India under the UNDP-GEF assisted project "Conservation and sustainable use of Gulf of Mannar Biosphere Reserve's Coastal Biodiversity"

## 26.1164

**Alpha And Functional Biodiversity-Biomass Relationships in Coral Reef Fishes Of The South Pacific**

**Kulbicki MICHEL*[1]**, Vigliola LAURENT[2], Wantiez LAURENT[3], Moutham GERARD[4]

[1]Marine Biology, IRD, Perpignan, France, [2]IRD, Plouzane, France, [3]Marine Biology, UNC, Noumea, New Caledonia, [4]Marine Biology, IRD, Noumea, New Caledonia

The production of biomass is one of the major services supplied by natural ecosystems to humankind. Theoretical considerations, field, and experimental data all indicate strong relationship between biodiversity and biomass in many terrestrial and marine ecosystems, suggesting that biomass production is an ecosystem service delivered, at least partly, by biodiversity. As such, a better understanding of factors influencing diversity-biomass relationships appears crucial. Here, we used data collected by underwater visual censuses across 28 South Pacific islands to study the influence of local (reef type, coral cover, algae cover, depth, fishing level) and large scale factors (island size, island isolation, distance to the biodiversity center, latitude) on reef fish alpha and functional diversity-biomass relationships at four spatial scales: within reefs, among reefs, among islands, and among regions. Functional groups were based on the combination of four life history traits (diet, size, home range and schooling behavior) and redundancy was defined as the average number of species per functional group. Results revealed that fish biomass tended to level off for very large alpha diversities and that slopes between alpha diversity and biomass were largest on smaller and more isolated island. Slopes also increased with oceanic influence as these were largest on barrier reefs, intermediate on lagoon reefs, and lowest on fringing reefs. Slope of functional diversity-biomass relationships decreased with redundancy at most spatial scales. Our results suggest that coral reef fishes better utilize available resources when these are limited and/or when there is limited competition between species within a functional group.

## 26.1165

**A Practical Guide To The Large And Abundant Diatoms in Farmer-Fish Territories**

**Christopher LOBBAN*[1]**

[1]Natural Sciences - CNAS, University of Guam, Mangilao, Guam

Diatoms are abundant in damselfish (farmer fish) territories, despite limited recognition in the literature. Diatoms were scarcely mentioned in studies of farmer-fish ecology until Jones et al. (2006: *Mar. Ecol. Progr. Ser.* 328: 215) documented their importance in farmer-fish turfs and guts: for three farmer fishes in Papua New Guinea, diatoms made up 30–80% by volume of stomach contents. Jones et al. also concluded that these damselfish facilitate rather than deplete diatoms in their territories. The taxa involved have not yet been documented but in Guam (and presumably elsewhere) several large and readily-recognized chain-forming centrics can form blooms on the seaweed turf or macroalgae or directly on rock surfaces in these territories. The objective of this on-going study is to document some of the dominant species present and to advance knowledge of the diatom biodiversity of Guam. *Chrysanthemodiscus floriatus* and *Biddulphiopsis membranacea* are particularly common and abundant in the territories of damselfishes on Guam (such as *Plectroglyphidodon lacrymatus* and *Stegastes nigricans*). The giant centric diatom *Stictocyclus stictodiscus* is also common and easily recognized. Stalked pennate diatoms, particularly *Licmophora* spp. and *Climacosphenia elongata* are also common. I present illustrations to help biologists not familiar with diatoms to take account of this component of farmer-fish diets.

## 26.1166

**Protist Biodiversity: Ciliates With Zooxanthellae and Other Noteworthy Ciliates on Coral Reefs**

**Christopher LOBBAN*[1]**, Maria SCHEFTER[2]

[1]Natural Sciences - CNAS, University of Guam, Mangilao, Guam, [2]University of Guam, Mangilao, Guam

The benthic ciliate communities of coral reefs are virtually unknown, but some striking species have recently been found, including two with *Symbiodinium* endosymbionts. The objective of these on-going studies is to document the marine ciliate biodiversity of Guam. Working with an international group of collaborators, we have found the following. *Maristentor dinoferus* is gregarious and large enough (nearly 1 mm long) to allow observations of its diurnal movements in situ. Its abundant pigment, maristentorin, has been chemically characterized and shown to be hypericin-like (thus also related to gymnochromes and fringelites from crinoids) and is most likely a feeding deterrent. We have been able to document the interaction between grazing acanthurid fish, *Ctenochaetus striatus*, and *Maristentor* clusters. *Maristentor* is a heterotrich ciliate that looks like *Stentor* but is more closely related to folliculinids and was placed in its own family. In addition to maristentorin, *Maristentor* also has mycosporine-like amino acids. A hypotrich ciliate, *Euplotes uncinatus*, lives in the same community as *M. dinoferus* and also has *Symbiodinium*. It is microscopic and the only zooxanthellate member of a large genus. These two species are the only two currently known ciliates with zooxanthellae, although an additional species was reported from Florida in 1942, but presumably these or similar symbioses occur on other tropical reefs. We have also observed a large (500 µm) black nassophorean ciliate that consumes filamentous cyanobacteria. It could be mistaken for one posture of *Maristentor* and is visible with the naked eye in the same habitat, but its movement is different and it does not form erect clusters. Also present in the *Maristentor* communities is a species of *Condylostoma*. Finally, we show pictures of a striking and as yet unidentified, small, bright red ciliate found so far only in University of Guam Marine Laboratory seawater tanks.

## 26.1167

**The Sponge Fauna Of Indonesian Marine Lakes**

**Leontine BECKING*[1]**, Nicole DE VOOGD[1]

[1]Zoology, National Museum of Natural History - Naturalis, Leiden, Netherlands

Marine lakes are little known, yet fascinating, habitats. These land-locked salt water bodies are thought to have been formed in the Holocene and have maintained a marine character ever since through a network of submarine connections to the sea. The marine flora and fauna of these lakes are sparsely documented, although as a result of the relative isolation from the marine continuum, the lakes are expected to harbour small, isolated, rapidly evolving populations, endemic subspecies, and new species. The objective of the present study was to survey the sponge fauna of five marine lakes in Indonesia: three located on the islands of Kakaban and Maratua in East Kalimantan, and two located on the islands of Mansuar and Wayag in Papua. We, furthermore, surveyed the coastal mangroves and reefs adjacent to the lakes in order to establish true lake-endemics. We will present preliminary results on the sponge diversity of the marine lakes. Over 200 sponge specimens were collected from the five lakes, belonging to at least 52 species, 32 genera and 25 families. Six species were present in all lakes and are also known from the adjacent coastal habitats, e.g. Cinachyrella australiensis, Myrmekioderma granulata, and Tehthya aff. seychellensis. Two species are abundant in all lakes and appear to be lake endemics: Suberites sp. and Darwinella sp. Interestingly, these species are also known from other marine lakes in Palau and on Satonda Island (near Sumbawa, Indonesia). Further comparison still has to be made in order to determine whether these species also occur in the surrounding reefal area, if the species prevalent in all lakes are indeed the same species and if any new sponge species are recorded from these lakes.

## 26.1168

**Coral Reef Profile in Layang Layang Island Of Malaysia**

**Daud AWANG*[1]**

[1]Department of Fisheries Malaysia, Fisheries Research Institute, Sarawak, Malaysia

In order to protect our shoreline from natural disaster and erosion, that's where we need coral reefs. The distribution of the coral reef is important for the coastal zone management and it is depend on the profile of the reef itself. It is important for us to know the exact profile of coral reefs in our region.. Atoll reefs are not very common in Malaysia. Atoll reefs can be found such as Beting Patinggi Ali, Gugusan Semarang Peninjau (Layang Layang Malaysia of Malaysia, Terumbu Siput, Ubi, Peninjau etc). In this research, we are trying to find out the situation, pattern and profile of reef around Pulau Layang Layang Malaysia.

## 26.1169

**Species Boundaries And Evolutionary Lineages in The Blue Green Damselfishes *chromis Viridis* And *c. Atripectoralis* (Pomacentridae)**

**Tawfiq FROUKH*[1]**, Marc KOCHZIUS[2]

[1]Biotechnology, Faculty of Agricultural Technology, Al-Balga Applied University, Salt, Jordan, [2]Biotechnology and Molecular Genetic, University of Bremen, Bremen, Germany

The blue green damselfishes were described as a complex of two species (*Chromis viridis* and *C. atripectoralis*), mainly based on the colouration of the pectoral fin base. In this study, we analysed the mitochondrial control region of 88 blue green damselfishes from Indonesia, the Philippines, Red Sea, and the Great Barrier Reef. The phylogenetic analysis revealed four major monophyletic clades. Two clades included specimens of *C. atripectoralis* from the Great Barrier Reef; and individuals of *C. viridis* from the Red Sea, respectively. The remaining individuals of *C. viridis* from Indonesia and the Philippines were grouped into two clades without phylogeographic structure. The obtained results verified (1) that *C. viridis* and *C. atripectoralis* are distinct species; and (2) revealed three deep evolutionary lineages of *C. viridis* in the Indo-Malay Archipelago and the Red Sea.

## 26.1170

**Cymothoid Isopods On Coral Reef Fishes in The Near Shore Marine Environment Of St. Kitts, Lesser Antilles.**

**Maureen SULLIVAN*[1]**, Raphaela STIMMELMAYR[2]

[1]St.Kitts Reef Ecology Watchgroup, Basseterre, Saint Kitts and Nevis, [2]Ross University Veterinary School, Basseterre, Saint Kitts and Nevis

Nine Species of Cymothoid isopods of the genera Anilocra spp. selectivily associate with specific West Indian fish species and are location specific. Anilocra infestation is thought to impact breeding success, interfere with swimming dynamics, decrease fish size, and is known to cause lesions in the host ranging from localized tissue inflammation to underlying bone deformities. As part of a larger marine ecosystem survey project (2006-2007) of the marine environment, isopod parasitism as a potential useful marine ecosystem health indicator was monitored during roving diver/snorkel fish species surveys. *Anilocra chromis Williams and Williams* on Brown Chromis (Chromis multilineatus) but not Blue Chromis (C. cyaneus) and Anilocra haemuli on French Grunt, Haemulon flavolineatum, Smallmouth Grunt, H.Chrysargyum, and Caesar Grunt, H.carbonarium were observed. The host location of isopods is beneath the eye of host. The observed isopods were of mature size and affected grunts appear depressed. We did not measure body size; however, no obvious size differences were apparent in affected vs. unaffected hosts. The distribution profile of isopods on grunts differed between different sites. Although other fish species (i.e. groupers) known to be parasitized by A. haemuli are present at many of these sites, only the grunts and Brown Chromis were affected. We do not know what environmental and ecological factors (i.e. sea-water temperature; algae; cleaner density) are contributing to the observed differences in isopod parasitism. Preliminary data suggests that there is no difference in presence of cleaner fish between the bays. Based on long term local observations, seasonal seawater temperature increases have been occurring earlier and lasting longer. This is the first report on isopod parasitism and geographical distribution for the marine environment of St. Kitts.

## 26.1171

**Species Diversity Of Fishes in Main Coral Reefs Of China**

**Wentao NIU*[1]**, Rongcheng LIN[1]

[1]Third Institute of Oceanography, State Oceanic Administration of China, Xiamen, China, People's Republic of

China's coral reefs are found mainly around Hainan Island and offshore, in the Nansha、Zhongsha and Xisha Islands of South China Sea. For rational conservation and management and sustainable use of reef fish resources throughout South China Sea, we analyzed the fish species composition of main coral reefs in China according to historical survey data and investigation of late years. The results indicated that there're more than 200 reef fishes (including more than 30 species cartilaginous fishes) in main coral reefs of China, of which 197 species (including 5 species cartilaginous fishes) in Hainan Island, 101 species (including 22 species cartilaginous fishes) in Nansha Islands, 115 Species (including 23 species cartilaginous fishes) in Xisha Islands, 68 species(including 11 species cartilaginous fishes) in Zhongsha Islands. Carcharhiniformes and Myliobatiformes were dominant families of the cartilaginous fishes, while Perciformes and Teraodontiformes were dominant families of the bony fishes. In fact, due to the restriction of investigation methods etc, coral-reef fish species in China could be far more than 200 species.

Keywords: species diversity, fishes, coral reef, China

## 26.1172

**Two Species Of Giant Clams (Tridacnidae) Show Different Depth Distributions And Divergent Feeding Strategies**

**Carin JANTZEN*[1]**, Christian WILD[2], Mohammed EL-ZIBDAH[3], Hilly ROA-QUIAOIT[4], Christoph HAACKE[2], Claudio RICHTER[1]

[1]Center for Tropical Marine Ecology (ZMT), Bremen, Germany, [2]Coral Reef Ecology Work Group (CORE), Center of Geobiology and Biodiversity Research, MÃ¼nchen, Germany, [3]Marine Science Station Aqaba, Aqaba, Jordan, [4]McKeough Marine Center, Xavier University, Cagayan de Oro City, Philippines

Two species of giant clams coexist in the Red Sea and show different depth distributions: *Tridacna maxima* occurs mostly in shallow water (reef flat and edge), while *T. squamosa* can be found mostly in deeper water (>40 m). This can be attributed to differences in hetero- vs. autotrophy in the two species. *T. maxima* shows high light adaptation through a significant higher Pmax and greater photosynthesis measured via oxygen fluxes during short time chamber incubations (gross oxygen production: 120.3 and *T. squamosa* 84.8 µmol O2 cm-2 mantle area d-1) than *T. squamosa*. *T. maxima* was also able to maintain a high productivity (92 % of Pmax) under reduced light levels corresponding to water depth of 20 m. The deeper-dwelling *T. squamosa*, by contrast, fared less well at simulated depths of 20 m (44 % of Pmax). Chamber incubations were used to calculate "the percent contribution of algal carbon to the host's daily requirements for respiration" (CZAR). This revealed that in shallow water (~ 0.5 m) autotrophy exceeds respiration by a factor of 1.88 for *T. maxima* and 1.53 for *T. squamosa*. The calculated compensation depth (where gross photosynthesis equals respiration) of *T. maxima* matches the actual maximum depth of occurrence (16 m). These findings suggest that *T. maxima* is obligately photoautotrophic, and its depth distribution is limited by light. By contrast, the compensation depth of *T. squamosa* (9 m) was much shallower than the maximum depth of occurrence. This suggests that *T. squamosa* relies – as a true mixotroph - on additional heterotrophic sources to fuel its metabolism (e.g. filter-feeding).

## 26.1173

**A Molecular Assessment of Speciation and Evolutionary History of the Globally Distributed Spotted Eagle Ray (*Aetobatus narinari*)**

Vincent RICHARDS[1], Marcy HENNING[1], Wayne WITZELL[2], **Mahmood SHIVJI*[1]**

[1]National Coral Reef Institute, Nova Southeastern University, Dania Beach, FL, [2]SouthEast Fisheries Science Center, NOAA, Miami, FL

The spotted eagle ray (*Aetobatus narinari*), a species of conservation concern (Near Threatened IUCN category) is commonly associated with coral reef ecosystems worldwide where it is likely to play an important predatory role. Currently described as a single, circumglobally distributed species, geographic differences in parasite diversity have led to suggestions that *A. narinari* may constitute a species complex. There has been no systematic evidence to support this suggestion, however. If multiple species of spotted eagle ray exist, each will likely posses decreased geographic ranges and population sizes, altering the impacts of threats and requiring separate assessments of conservation needs. We assessed the validity of *A. narinari* as a single cosmopolitan species using 1570bp of sequence data from two mitochondrial genes (cytochrome *b* and COI) and the nuclear ribosomal ITS2 locus. Individuals from four major geographic regions were examined: western north Atlantic, and western, central, and eastern Pacific. Phylogenies for each locus concordantly described three distinct lineages (western north Atlantic, western/central Pacific, and eastern Pacific) with no genetic exchange among regions. Genetic distances among the most divergent lineages were comparable to taxonomically uncontroversial batoid and teleost congener pairs. Using combined genealogical concordance and genetic distance results, we recommend 1) that the western/central Pacific lineage be recognized as a distinct species from the western north Atlantic and eastern Pacific lineages, and 2) the western north Atlantic and eastern Pacific lineages, separated by the Isthmus of Panama, be given subspecies status. Dramatically higher nucleotide diversity and sequence divergence coupled with a basal position in multiple phylogenetic analyses support an Indo-West Pacific origin for the *A. narinari* species complex, with subsequent migration into the Atlantic. Evolutionary relationships among lineages suggest a westerly migration around the southern tip of Africa, with intensification of the Benguela coldwater upwelling system a possible vicariant mechanism underlying speciation.

## 26.1174

**Coral Assemblages Of Cabo Verde Islands (North Atlantic): Preliminary Assessment And Description.**

**João MONTEIRO*[1,2]**, Corrine ALMEIDA[3], Rui FREITAS[3], Aricson DELGADO[3], Filipe PORTEIRO[1,2], Ricardo S. SANTOS[1,2]

[1]Departamento de Oceanografia e Pescas, Universidade dos Açores, Horta, Portugal, [2]Centro do IMAR da Universidade do Açores, Horta, Portugal, [3]Departamento de Pescas e Tecnologia de Recursos Aquáticos, Instituto Superior de Engenharia e Ciências do Mar, Mindelo, Cape Verde

The islands of Cabo Verde, North Atlantic, are an important hotspot of tropical reef biodiversity, and one of the top ten priority locations worldwide for the conservation of reef habitats. Despite the absence of major coral reef structures, and of the relative poor diversity of coral species, these islands' coral communities constitute unique habitats and thought to play a key role in local coastal ecosystems. The objective of this work was to conduct a preliminary ecological assessment of coral communities in Cabo Verde. Two fieldtrips were conducted using underwater transects with DAFOR semi-quantitative scale to estimate relative abundance of coral species. This effort, together with a review of historical records, allowed a preliminary identification and description of three major coral biotopes: i) antipatharians *facies* in vertical walls; ii) *Siderastrea radians* pavements over shallow bedrock; and iii) diverse coral coverage over rocky reef with sand patches. Coral species' diversity in these biotopes is comparatively lower than those from other tropical reef ecosystems (e.g. West Atlantic and Indo-Pacific regions). Observations from the fieldtrip to Sal Island, where a more extensive survey was possible, revealed greater living coverage and biodiversity on the leeward side when compared with the windward side of the island. Depth and hard substrate orientation (vertical/horizontal) appear to act as major environmental factors structuring these biotopes. The importance of other abiotic factors affecting their distribution, structure and diversity, such as water temperature, West African upwelling influence and dust deposition from Sahara desert, by prevailing and harmatan winds, are briefly discussed. An experimental design, including a quantitative approach and the use of data loggers for temperature and photosynthetic irradiance monitoring, is proposed for future research and accurate ecological characterisation of these biotopes and associated coral communities.

## 26.1175

**Recent Sightings Of Longsnout Seahorse, Hippocampus Reidi in The Marine Environment Of St. Kitts, Lesser Antilles**

**Vajai LATCHMAN*[1]**, Maureen SULLIVAN[2], Raphaela STIMMELMAYR[3]

[1]Kenneth Dive CEnter St.Kitts, Basseterre, Saint Kitts and Nevis, [2]St.Kitts Reef Ecology Watch Group, Basseterre, Saint Kitts and Nevis, [3]Ross University Veterinary School, Basseterre, Saint Kitts and Nevis

Only two species of Seahorses occur in the Caribbean, the Longsnout, *Hippocampus reidi* and Lined Seahorse, *Hippocampus erectus*. General information on the abundance of Longsnout Seahorse is lacking and the species has been categorized as data deficient indicating a need for further studies. The Lined Seahorse is currently listed by the IUCN as a vulnerable species. In 2007, three single individuals, H. reidi have been repeatedly sighted at three different shallow reef dive sites. Although seahorses nearly always occur in pairs and the home ranges for the species is rather small, as of yet no pairs have been sighted. The reefs are mixed habitat with corals, sea grass beds, and sponges present. Later habitats are often associated with seahorses. Previous longsnout seahorse sightings dating back to 1993 have over the years been inconsistent and restricted to only one of the sites. The recent frequent sightings and identification of a new reef site could indicate an increase in the local seahorse population size. Further studies are needed to estimate the local seahorse population size and habitat characteristics.

## 26.1176

**Comparison of Bacterial Diversity within the Coral Reef Sponge, Axinella corrugata, the Encrusting Coral Erythopodium Caribaeorum and Adjacent Environmental Samples**

**Jose LOPEZ*[1]**, Peter MCCARTHY[2], Angela LEDGER[2], Llanie RANZER[3], Russell KERR[4], Alan DUCKWORTH[5]

[1]Oceanographic Center, Nova Southeastern University, Dania Beach, FL, [2]Harbor Branch Oceanographic Inst at FAU, Ft Pierce, FL, [3]Florida Atlantic University, Boca Raton, FL, [4]Department of Chemistry, University of Prince Edward Island, Charlottetown, PE, Canada, [5]Australian Institute of Marine Science, Townsville, Australia

In recent years, the Caribbean reef sponge, *Axinella corrugata,* has been developed as a model marine invertebrate for the study of molecular genetics and secondary metabolism. To continue this characterization, we performed a cursory survey of bacterial diversity of *A. corrugata* using 16S rRNA gene sequences. > 100 culture-independent sequences were generated from 16S rRNA libraries of 6 different *Axinella corrugata* specimens, and compared with 55 cultured isolates derived from the same species. This comparison indicated a fairly narrow taxonomic distribution for *Axinella* microbial communities. The diversity of cultured isolates was comprised mostly of Actinobacteria, such as *Brachybacterium paraconglomeratum*, and Alpha- and Gamma-Proteobacteria. The culture-independent 16S rDNA clones encompassed more diverse Proteobacteria based on the higher number of "uncultured" or "unknown" representatives, with lower % similiarity values, including the Delta-Proteobacteria. *Flavobacterium*, and Cyanobacteria sequences.

Further, this study also showed that *Axinella* sponges appear to host specific microbial symbionts, similar to previously identified clones termed ""OSO" environmental samples. In contrast to the sponge microbial communities, two different 16S libraries from seawater samples near one *Axinella* source sample were dominated by *Pseudoaltermonas*. Adjacent sediment samples yielded several clones of sulfate-reducing *Desulfovibrio*, Planctomycetes and other Delta-Proteobacteria. A *Clostridium*-like 16S rRNA sequence was also detected after the oxygen supply to one *Axinella* specimen was deliberately curtailed to assess temporal changes in the microbial community. In a final comparison, the Caribbean reef coral, *Erythopodium caribaeorum* yielded a higher number of Beta-Proteobacteria 16S sequences relative to *Axinella* cultured and culture independent 16S rRNA sequences. Overall this study indicates that marine microbial community diversity can be linked to specific source host and habitats. These data fit into current programs to census total marine diversity, such as ICoMM, the International Census of Marine Microbes (http: //icomm.mbl.edu/).

## 26.1177

**What Are The Genetic Relationships Among Morphospecies Within The Coral Genus Madracis?**

**Maria Catalina REYES-NIVIA*[1,2]**, Rolf PM BAK[1,2], Pedro R FRADE[1,2]

[1]Marine Ecology and Evolution, Netherlands Institute for Sea Research, Den Burg, Netherlands, [2]Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, Netherlands

Species morphological boundaries in scleractinian corals do not necessarily correspond to genetically distinct units. In this study, phylogenetic relationships among six closely related species in the genus *Madracis* were examined using two nuclear intron markers (ATPSα and SRP54). Bayesian probabilities, maximum-likelihood and parsimony analyses consistently recovered monophylies of *Madracis senaria* and *M. carmabi* using the ATPSα marker. High support values and congruent topologies suggest that morphological boundaries are consistent with these two genetically discrete units. Recurrent polyphyletic groups, shared nuclear sequences and high polymorphism at the intra- and inter-specific level between *M. decactis and M. pharensis*, suggest retained ancestral polymorphisms or introgressive hybridization between these taxa. Phylogenies derived from the SRP54 show continued lack of resolution or consistency, making these topologies not reliable. FST pairwise comparison based on ATPSα suggests that gene exchange is quite low among most of *Madracis* taxa. AMOVA analysis reveals that 59% of the genetic differentiation is attributable to variation among putative species ($p < 0.001$). Heterozygosity levels predicted under conditions of random mating rarely fulfilled expectations for Hardy-Weinberg equilibrium. *M. formosa* and *M. pharensis* exhibited significant heterozygote deficits, while, in contrast, *M. mirabilis* showed heterozygous excess, consequent with its common asexual dispersal mode. The overall results suggest that introgression events can occasionally occur but that inbreeding between closely related species is limited, keeping morphospecies boundaries recognizable.

## 26.1178

**Reef Corals Of Clipperton Atoll, Eastern Pacific**

**Pedro MEDINA-ROSAS*[1]**

[1]UNCW, Wilmington, NC

Clipperton Atoll (10°N and 109°W) is notable for its extreme isolation (1,100 km from the nearest continental shores of Mexico), small size (about 10 km2), low habitat diversity, and severely depauperate reef-building coral fauna. It is the eastern-most of all Pacific atolls. Studies of the corals in this isolated area are scarce, starting 50 years ago. Some observations and new records of corals are presented as a result of a survey during April 2007. Fifteen Tropical Eastern Pacific reef-building corals, living from the surface, close to shore, to deeper than 60 m, were identified. *Porites lobata* is the most abundant species, followed by the recently described, *Porites arnaudi*. Five species of genus *Pocillopora* are abundant in inner and mid 20 m terraces (shallow waters), meanwhile *Pavona varians* is abundant in the slope and in the deeper areas. New records of *Pocillopora eydouxi* and non confirmed *Pocillopora* sp are additions to the systematic list for the atoll. This atoll is considered as a critical "stepping stone" in the migration of coastal marine species across the east Pacific Barrier. Six species are Indo-Pacific distributed and the rest are present in the Tropical Eastern Pacific. Although richness is lower than the other reefs in the Eastern Pacific, cover is one of the highest of the region. Cover can be as high as 100% at some depths. Bleaching effects were not observed and condition of corals is good, except for the fishing lines and nets observed in the colonies, some of them covered by the corals. With 370 ha of coral cover, qualifies as the largest coral reef in the eastern Pacific.

## 26.1179

**Biodiversity And Spatial Composition Of Soft-Bottom Macrobenthic Communities in Coral Reefs Areas And Adjacent Shores From Reunion Island (Southwest Indian Ocean)**

**Lionel BIGOT*[1]**, Dorothée TADDEI[1], Patrick FROUIN[1], Jean-Michel AMOUROUX[2], Antoine GREMARE[3]

[1]Marine Ecology Laboratory, University of Reunion Island, St Denis, Reunion, [2]LOBB - UMR 7621, Banyuls/ mer, France, [3]Station Marine d'Arcachon - UMR 5085, Arcachon, France

This contribution is the first large scale overview of the soft-bottom macrobenthic communities in four fringing reefs (St Gilles / La Saline; St Leu; Etang Salé and St Pierre) and an adjacent sandy ecosystems (St Paul) in Reunion Island (South Western Indian Ocean). Among the 252 species recorded, polychaetes, were the most abundant with more than 80 species followed by many crustacean, molluscs and cnidarians. On the coral reef areas, specific communities have been recorded on Etang Salé and St Pierre reef and related to a swell gradient. At the St Gilles / La Saline reef complex no clear spatial trend is highlighted between the back reef and the reef flat in abundance. Moreover, several back reef stations of St Gilles and Etang Salé are characterize by actinarian communities (Edwardsia spp.) (more than 60 % in abundance) or polychaetes (Phyllochaetopterus spp.). In the St Paul bay (non coral adjacent area), the analyses performed on macrofauna highlighted a depth zonation, with three macrobenthic assemblages along the coastal shelf of Reunion Island (shallow, intermediate, deep assemblages). The community analysis, confirmed also pointed the role of sediment composition and strong hydrodynamic environment. Comparison of these environments showed different community composition between the coral reef complex and the nearest non coral area. Our results contribute to the knowledge on biodiversity of tropical soft bottom macrofauna in poorly studied tropical coasts, and illustrate several frameworks of the macrobenthic community composition in Indian Ocean coastal high-energy environments.

## 26.1180

**Biodiversity And Ecological Aspects Of Saint Martin's Coral Island, Bangladesh**

**Abu Hena Mustafa KAMAL*[1]**

[1]Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh

Bangladesh embarked into the global Convention of Biological Diversity (CBD) with the declaration of her Ecologically Critical Areas (ECA) in 2006. Saint Martin's Island which referred as only one coral bearing reef of Bangladesh is declared ECA recently with other tow coastal and one inland wetland areas. This island is enjoying tropical and subtropical climate, and boarding two countries Bangladesh at the north-east and Myanmar at the south-west. The major biodiversity of this Island are fishes (234 species), mollusks (187 species), coral (order Scleractinia; 66 species), coastal aquatic macrophytes (2-seagrasses, 133-seaweeds and 3-mangroves), coastal and land birds (130 species), marine turtles (4 species), sea snakes (5 species), marine mammals (9 species), numerous terrestrial animal and plants. Besides unregulated extraction and over-exploitation of coral colonies and resources, the anthropogenic activities especially sedimentation, land erosion and tourism beyond carrying capacity are the major threats to the island's ecology. The management and conservation activities are not followed properly, where users of the island still haphazardly utilize the natural resources of coral reef. The destruction of habitat and over-exploitation of these resources have resulted in decaling the biodiversity as well as degradation of coastal and island ecosystems. There is lack of awareness among the resource users about the interaction of various coastal components and they do not have enough knowledge about the resource and its importance, utilization and conservation. Studies revealed that in addition to the declaration of ECA by ministry of environment, Bangladesh, new scientific studies should be planned for the Saint Martin's island, since the unique and dynamic nature of the inter-tidal and sub-tidal rocky habitats offers excellent research opportunities for the national and international scientists as a global interest of coral reef biodiversity.

## 26.1181

**Diversity Of Gorgonians And Growth Of *menella* Sp. And *dichotella* Sp. in The Gulf Of Thailand**

**Thepsuda LOYJIW*[1]**, Suchana CHAVANICH[1], Voranop VIYAKARN[1]

[1]Department of Marine Science, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Gorgonian is one of the marine invertebrates that plays an important role in the marine ecosystem. Gorgonian diversity in Gulf of Thailand (GoT) was investigated as basic data for gorgonian conservation and restoration. The results showed that 18 genera from 6 families of gorgonians were found. These included Family Subergorgiidae; *Subergorgia*, Family Melithaeidae; *Melithaea*, *Mopsella*, *Acabaria*, Family Acanthogorgiidae; *Anthogorgia*, Family Plexauridae; *Euplexaura*, *Echinomuricea*, *Echinogorgia*, *Menella*, *Paraplexaura*, *Astrogorgia*, Family Gorgoniidae; *Rumphella*, *Pseudopterogorgia*, *Guaiagorgia*, Family Ellisellidae; *Ctenocella*, *Junceella*, *Dichotella* and *Verrucella*. The highest number of gorgonian, 15 genera, was found at Sattahip area (inner GoT), followed by 13 genera at Ko Tan (middle GoT) and 9 genera at Ko Chang area (eastern GoT). In this study, 5 genera; *Anthogorgia, Paraplexaura*, *Pseudopterogorgia*, *Guaiagorgia*, and *Verrucella* were the first records in Thai water. In addition, 5 genera, *i.e. Euplexaura, Echinomuricea*, *Menella*, *Astrogorgia* and *Dichotella* were also the first records in GoT. From the field surveys in 6 months, the results showed that specific growth rate of *Menella* were approximately 3.5 ± 3.9 % per month while *Dichotella* was approximately 1.2 ± 1.0 % per month.

## 26.1182

**Morphometric Examination Of Corallite And Colony Variability On The Caribbean Coral *montastraea Cavernosa***

**Hector RUIZ*[1]**, Ernesto WEIL[1]

[1]Marine science, University of Puerto Rico, Mayaguez, Puerto Rico

The genus *Montastraea* in the Caribbean was thought to be formed by two species, *M.annularis* and *M. cavernosa*. However, recent research has uncovered two more species in the *M. annularis* complex, and two different morphologies of *M.cavernosa* that commonly co-occur were separated based on polyp size and behavior. A small-polyped form mostly active during the day (diurnal ecomorph), and a large-polyped form only active during the night (nocturnal ecomorph). Nevertheless, no specific taxonomic separation has ever been proposed and most recent studies using this species lumped the two ecomorphs. In this work, a multivariate approach was used to explore the ecological, morphological and behavioral differences between the two behavioral ecomorphs of *M. cavernosa* proposed. Ecological surveys at four different reef localities of Puerto Rico showed that the two behavioral ecomorphs were abundant, but with a differential distribution along the reef profile. Results indicate that 90 % of shallow (6m) *M. cavernosa* colonies were of the diurnal ecomorph, and 60% of the deeper water (20 m) colonies were of the nocturnal ecomorph. High corallite and colony morphometric variability within each behavioral ecomorph across depth gradients support the idea that environmental factors might influence their morphology. Significant morphological differences in 10 micro-morphological characters analyzed in 60 colonies (30 diurnal and 30 nocturnal) from two reefs (Media Luna and Turrumote), and a Stepwise Canonical Discriminant Function Analysis, which separated two distinct groups (with 94.0% of all colonies correctly classified), suggest that the two behavioral ecomorphs are two separate species (sibling species).

## 26.1183

**Sipunculans Bioeroders From Dead Coral Substrate in The Colombian Caribbean**

**Carlos GÓMEZ SOTO*[1]**, Adolfo SANJUAN MUÑOZ[2], Tatiana RICO BUITRAGO[1], Andrés FRANCO HERRERA[2]

[1]Universidad Jorge Tadeo Lozano, Bogotá, Colombia, [2]Universidad Jorge Tadeo Lozano, Santa Marta, Colombia

In the Colombian Caribbean coral reefs have suffered a gradual decline due to natural and anthrogenic factors leading to a replacement of the living coral tissue coverage and inducing structural changes in the communities that live associated. Sipunculans are exclusively marine animals capable of bore into coral skeletons, although they are important in consolidating the structure and form of modern coral reefs, in the colombian Caribbean have been poorly studied. For this reason the present study evaluated the structure of sipunculans associated with dead coral skeletons of *Diploria strigosa, Montastraea cavernosa* and *Montastraea annularis-faveolata-franksi* complex in Gaira Bay (Santa Marta), from the collection of 45 samples of approximately 1 dm3. The samples were preserved with 10% formalin and the specimens extracted manually, which were quantified and identified to species whenever possible. All the specimens were preserved in 70% alcohol. There were 381 individuals in approximately 37 dm3 belonging to four families, six genera and 10 species. The average density was 10.22 ± 1.25 Ind./dm3. The bioeroders *Aspidosiphon* cf. *fischeri* (48.76%) and *Phascolosoma perlucens* (24.79%) were the most abundant species. While skeletons of *M. cavernosa* presented the greatest abundance, greater diversity was presented in skeletons of *M. annularis-faveolata-franksi* complex. The analysis of similarity (ANOSIM) showed that there were not significant differences in the assemblage structure of sipunculans among coral skeletons (coral species), assuming that the colonization of these organisms is rather a product of a number of factors and conditions in the skeleton when settlement than the skeletal structure itself. It is important to continue with studies concerning base line data in different habitats as this would further expand our knowledge of its population dynamics in the Colombian Caribbean.

## 26.1184

**Icthiofauna Associated With Coral Reef System in San Esteban National Park, Venezuela**

Ana HERRERA-REVELES[1,2], **José G. RODRÍGUEZ*[1]**

[1]FACYT Universidad de Carabobo, Valencia, Venezuela, [2]PhD Ecology. I.Z.T. Universidad Central de Venezuela, Caracas, Venezuela

The principal aim of this research was to characterize the fish community of the coral reefs of Isla Larga and Alcatraz, located in San Esteban National Park, Venezuela. In general, 93 species from 28 families were identified within the study area using visual censuses. Differences were observed in terms of the community structure of fishes between the two reefs; the coral reef of Alcatraz has a greater richness of fishes, 83 species compared with 71 species found at the Isla Larga reef. The Pomacentridae family was the most numerous at both reef systems (47–43%, respectively). Nevertheless, differences were found between the structures of the communities at the two different locations: the Scaridae and Acanthuridae families were more abundant at Alcatraz, while Haemulidae was more numerous and richer in species at Isla Larga. In spite of the fact that the herbivorous group was the most important trophic one, at all depths in both systems, it should be emphasized that there was also a great abundance of carnivors in Isla Larga while at Alcatraz there was greater abundance of piscivors and corallivors. The difference in richness of species and dominant families as well as trophic group between these systems might well due to their different types of structures: Alcatraz is a shallow reef whose greatest depth is between 6-8 meters, while Isla Larga´s, is approximately of 18 meters. In spite of the fact that there was no evidence found of any differences in the degree of negative impacts on the benthic communities of the two locations, it should be noted that Isla Larga is a recreational area with a great anthropogenic activity which probably accounts for the difference observed between the basic structures of the fish communities of the two different systems.

Key words: Coral Reef Fishes, Fish Community Structure, Venezuela

## 26.1185

**Biodiversity Of Cryptofauna Associated With Coral Reefs In Los Roques National Park, Venezuela**

**Kira LOPEZ*[1]**, David BONE[2], Carmen RODRÍGUEZ[3], Fabiola PADILLA[1], Kira LOPEZ[1]

[1]Universidad Simón Bolívar, Caracas, Venezuela, [2]Biología de Organismos, Universidad Simón Bolívar, Caracas, Venezuela, [3]Biología, Universidad de Carabobo, Valencia, Venezuela

The general aim of the project was to assess the biodiversity of cryptofauna associated with coral reefs. To achieve this, the reef community was characterized in terms of its structure, composition, abundance of organisms, and wealth of species present, paying special attention to polychaeta. Likewise, the presence of spatial variations in the distribution of these organisms among several locations and depths was determined. Samples were collected from colonies of dead coral of *Montastraea annularis* at two different depths, 6-8 metres, and between 9-14 metres, taking three fragments in each stratum at each location. The weight, size, and volume of the colonies were estimated for their standardization. The organisms were separated, quantified, and identified in large groups, polychaeta families, and species in the case of Eunicidae. In all, 1463 individual specimens were found, distributed in eight taxonomic groups of which the most abundant were sipunculids (53.73%) and polychaeta (20.98%), followed by crustaceans, nematoda, molluscs, and equinoderms. Among the most abundant families of polychaeta were the Eunicidae (65.9%), Syllidae (11.15%), Crysopetallidae (7.96%), and Nereididae (6.05%). The dominant species within the Eunicidae family were *Lysidice ninetta* (78.7%), *Marphysa cf conferta* (10.6%), and *Eunice vitatta* (4.8%). Qualitative analysis of some morphometric characteristics of these coral fragments and the ANOVA (between locations and depths) indicate no significant differences that might explain the community's distribution in the reefs, therefore the three locations are homogeneous and the parameters measured do not condition the community's structure and composition.

Key words: cryptofauna, *Montastraea annularis*, dead colonies, polychaeta, Eunicidae

## 26.1186

**Phylogenetic Relationships Within The Speciose Soft Coral Genus Sinularia**

**Catherine MCFADDEN*[1]**, Elizabeth BECKMAN[2], Leen VAN OFWEGEN[3], Yehuda BENAYAHU[4]

[1]Biology, Harvey Mudd College, Claremont, CA, [2]Harvey Mudd College, Claremont, CA, [3]Nationaal Natuurhistorisch Museum, Leiden, Netherlands, [4]Tel Aviv University, Tel Aviv, Israel

Soft corals belonging to the genus *Sinularia* are abundant and ecologically important members of shallow-water coral reef communities throughout the Indo-Pacific. The genus includes approximately 135 nominal species, with more currently being described. Species of *Sinularia* are distinguished by a combination of colony growth form and sclerite morphology; these characters exhibit a continuum of variation within and between species, making species boundaries difficult to detect morphologically. To explore phylogenetic relationships and species boundaries within this large genus, we used a 735 bp fragment of the mitochondrial *msh1* gene to construct a molecular phylogeny for approximately 120 specimens representing >50 identified morphospecies of *Sinularia*. The phylogeny revealed 7 distinct, well-supported clades, several of them separated by genetic distance values comparable to those typically found among different genera of alcyoniid soft corals. Some morphological character states, in particular the shape of the club sclerites in the colony surface, were congruent with the observed *msh1* clades. For instance, all species with the distinctive "leptoclados-type" clubs formed a well-supported clade. The recently described monotypic species *Dampia pocilloporaeformis* nested within *Sinularia* in a clade with *S. foveolata* and *S. fungoides*; all three of these species share a unique type of club sclerite. Despite evolving faster than other mitochondrial protein-coding genes, *msh1* was not variable enough to distinguish all species of *Sinularia*, and within each clade some morphologically distinct specimens shared identical *msh1* haplotypes. A more rapidly evolving nuclear gene such as *ITS* will be required to further explore species boundaries within clades of *Sinularia*.

## 26.1187

**Do Seagrasses Attract The Juveniles Of Coral Reef Fish?**

**Chen-Lu LEE*[1]**, Hsing-Juh LIN[1]

[1]Department of Life Sciences, National Chung Hsing University, Taichung, Taiwan

Seagass beds are often considered as nursery habitats of coral reef fish. What attracts juvenile fish to migrate into seagrass beds may be resulted from the complex hiding space or/and abundant food sources. To test the hypotheses, we surveyed transects through two species of seagrass beds (Thalassia hemprichii and Halodule uninervis) and bare sand area in the fringing reefs of Nanwan Bay, southern Taiwan. We recorded species, number and size of fish and the microhabitat for each individual. Our results showed that most reef fish living in seagrass beds were juveniles. The most dominant families are Labridae, followed by Lethrinidae, Mullidae and Scaridae. We found distinct fish assemblages among the two species of seagrass beds and bare sand area. In the Thalassia bed, some juveniles of Labridae and Scaridae were observed only with the seagrasses. However, the juveniles of Lethrinidae and Mullidae preferred the Halodule bed with the sediment of silt. Those differences were resulted from not only by seagrass species, but also by substrate in the seagrass bed.

## 26.1188

**The Centers Of Coral Reef Mollusc Species Richness in The Philippines**

**Benjamin VALLEJO JR*[1]**

[1]Environmental Science and Meteorology, University of the Philippines, Quezon City, Philippines

This study presents the results of biogeographical analysis of 100 years of faunal surveys and inventories of coral reef molluscs in the Philippines. The analysis indicates that the Verde Island Passage and Tayabas Bay have 443 recorded species of Philippine macromolluscs representing representing 81% of Philippine species. This is followed by the Tañon Strait which has 289 species representing 53% of Philippine species. These results support recent studies on coral reef shorefishes and other invertebrates.

## 26.1189

**Pocillopora Verrucosa And Pocillopora Meandrina Are Distinct Species: Morphometric Evidences**

**Jérémie VIDAL-DUPIOL*[1]**, Michel PICHON[1]

[1]Biologie Ecologie Tropicale et Mediterranéenne, UMR 5244 CNRS-UPVD-EPHE, Perpignan Cedex, France

Scleractinian coral identification to species level using a traditional morphological approach is often difficult and even experts sometimes experience difficulties to separate closely related species. Although morphometric data have sometimes been used in the past, they were in most instances restricted to simple data sets used to back up evidence derived from mere comparisons of morphological characters. Two nominal species of *Pocillopora, Pocillopora verrucosa* (Ellis & Solander, 1786) and *P. meandrina*, Dana, 1846 have been considered in the past either as one species or as two distinct species. The strategy used to unravel this taxonomic wrangle relies (1) on an analysis in a multidimensional space of morphometric data collected on the whole colonies and on individual branches, and (2) on unimodal statistical tests. Three types of analyses have been carried out: (1) A principal component analysis which has allowed to extract and visualize the most structuring variables, (2) a discriminant analysis which has allowed to classify each specimen within one of the two groups of specimens, and (3) a series of t tests (comparisons of means) to validate the differences identified between each group. The results obtained clearly show that *Pocillopora verrucosa* and *P. meandrina* can easily be separated on a morphometric basis. Our results should be confirmed by the combination of investigations focusing on other biological aspects such as ecological, molecular and physiological characteristics.

## 26.1190

**Environmental, Ecological, And Biogeographic Factors Controlling The Distribution Of Symbiodinium Diversity Among Coral Reef Habitats in Barbados, Eastern Caribbean**

**J. Christine FINNEY*[1]**, Todd LAJEUNESSE[2], Hazel OXENFORD[1]

[1]CERMES, University of the West Indies, Cave Hill Campus, Cave Hill, Barbados, [2]Department of Biology, Florida International University, North Miami, FL

The obligate symbiotic relationship between Symbiodinium and cnidarians plays a critical role in the existence and overall health of coral reefs. The extent to which this relationship can adapt will be a key determinant in the fate of coral reefs under global warming. However, the nature of the relationship, including the genetic biodiversity of the obligate symbionts remains poorly understood. Here we document the frequency and distribution of Symbiodinium spp. among host cnidarians and habitats in Barbados, eastern Caribbean for the first time. PCR-denaturing gradient gel electrophoresis of the internal transcribed spacer 2 (ITS2) region of Symbiodinium populations was used to analyze the diversity of Symbiodinium among five host cnidarians orders.Host species were collected July - August, 2005 from four distinct and representative habitats of the reef systems around Barbados, and one thermally polluted habitat. Congruent with other regions in the Caribbean, Symbiodinium spp. in Clades B (15 types) and C (14 types) were the most common and genetically diverse, while Symbiodinium in Clades A (4 types) and D (1 type) were less diverse. Of the 34 Symbiodinium types identified, only eight have been documented in the western Caribbean region. Such regional differences support the findings of population genetic studies on coral and fish species showing a clear biogeographic break between eastern and western Caribbean reef systems. The distribution of Symbiodinium diversity was strongly influenced by the presence and/or absence of host diversity. Furthermore, near-shore shallow fringing reefs demonstrated the highest levels of diversity in partner combinations, whereas the deep offshore reefs had the lowest levels. This confirms that external environmental conditions in shallow water (variability in irradiance) affects variability in symbiotic associations, but host taxonomic identity and geographic location are most important in predicting the presence of any particular symbiont type.

Keywords: Zooxanthellae biodiversity. Symbiodinium. Coral symbiosis. Cnidarian symbionts

## 26.1191

**Building Regional Taxonomic Capacity Supports Marine Management And Biodiversity Conservation Efforts**

**Edward LOVELL*[1]**, Johnson SEETO[2], Victor BONITO[3]

[1]School of Marine Studies, University of the South Pacific, Suva, Fiji, [2]School of Marine Science, University of the South Pacific, Suva, Fiji, [3]-, Reef Explorer Fiji, Coral Coast, Fiji

Marine management and biodiversity conservation are increasingly important, issues in the Pacific Islands, where there is a high reliance on coastal resources for subsistence livelihoods. In this context, an accurate understanding of the taxonomy of the fauna and flora underpins ecological understanding, which is essential for the implementation of conservation measures. This can only be achieved by the cataloguing and maintenance of reference collections. The University of the South Pacific's (USP) marine collection is the largest in the insular South Pacific and represents a valuable resource for the 12 Pacific Island USP member countries and other institutions. It was initiated through a United States Peace Corp programme in 1972 with the primary objective of building taxonomic capability in the region. Recently moved to a specialist facility, the collection has benefited from the addition of a full-time curator and subsequent reorganization, upgrading, and expansion. It currently houses approximately 9,000 specimens of algae, corals, mobile invertebrates and fish that are representative of Fiji's and regional biota. Collection information is being converted to a Biota/Lucid database to improve access. The collection of hard corals (Scleractinia) has been recently upgraded with digital photographs (living and skeleton), as well as expanded with new records and potentially new species as part of an ongoing effort to compile a checklist for Fiji and the Southwest Pacific. The marine collection is an important resource to students, scientists, and resource managers alike. As Fiji is signatory to the Convention for the International Trade in Endangered Species and has a thriving marine aquarium industry, USP's collection also provides important reference material for the identification of exports. Continued expansion of the collection and it's associated learning tools will be valuable for building regional taxonomic capacity.

## 26.1192

**Community Structure And Biodiversity Of Chinchorro Bank, Mexico**

**Ernesto CHAVEZ*[1]**, José Manuel BORGES-SOUZA[1]

[1]Pesquerías, Centro Interdisciplinario de Ciencias Marinas, IPN, La Paz, BCS, Mexico

Chinchorro Bank, with an area of 144,360 hec, is a complex coral reef whose long axis measures 43.26 km by 18.03 km wide. The lagoon reef, with nearly 53,379 hec, is shallow with depths decreasing from south to north (10 to 2 m). The southern half has numerous patches and coral ridges, some of them reaching up to 3 km long and arranged parallel to the eastern margin. Sampling consisted in 33 transects 50m-long, with 30 samples each, at depths from 1 to 35 m. Structure and spatial composition of the reef community and its biodiversity were evaluated. Species richness in the south leeward margin yielded 38 species per transect, distributed in 5 main groups (Macroalgae, Octocorals, Hexacorals, coralline algae, and sponges); 3,082 individual colonies were recorded. The internal margin of the windward surf was the poorest with 30 species. Species accumulation curves were analyzed and the spectrum of diversity in these areas was measured; the southern slope along the leeward side is a more diverse; by contrast, the southern lagoon on the windward side is the poorest. The windward lagoon showed that dominant groups were hexacorals and macroalgae with 38% and 37% respectively. In the lagoon on the leeward side, hexacorals and coralline algae were dominant with 36 and 24% respectively. On the windward slope, macroalgae and hexacorals are the dominant components with 30 and 32% respectively. Finally, on the leeward slope, sponges and coralline algae are dominant with 40 and 32% respectively. In general, hexacorals and macroalgae are dominant on the southern part of the reef with 32 and 23% respectively. The analysis was complemented with the examination of some satellite images describing oceanographic variables and a comparison with data on the benthos and fish previously recorded.

## 26.1193

**Patterns Of The Benthic Community Structure in Coral Reefs Of The North Western Caribbean**

**José M BORGES-SOUZA*[1]**, Ernesto A CHAVEZ[2]

[1]Pesquerías, Centro Interdisciplinario de Ciencias Marinas, IPN, La Paz, BCS, Mexico, [2]Pesqueriás, Centro Interdisciplinario de Ciencias Marinas, IPN, La Paz, BCS, Mexico

Quantitative data were obtained at six reefs of the eastern Yucatan peninsula using the photographic-transect method. Structural patterns in each reef comparing windward and leeward reefs, and shallow- and deep reefs. Windward reefs were dominated by hexacorals and octocorals, with 53% and 28% of total abundance, respectively. The most common species were: *Agaricia agaricites, Gorgonia ventalina, Pseudopterogorgia americana, Pseudopterogorgia acerosa, Acropora palmata, Gorgonia flabellum, Plexaurella dichotoma, Pseudopterogorgia bipinnata* and *Diploria strigosa*. Sponges and hexacorals dominated in leeward reefs, with 39% and 30% of total abundance, respectively. The most common species in this group of reefs were: *Agelus* sp, *Pandarus acanthifolium, Agaricia agaricites, Montastrea annularis, Haliclona hogarthi, Neofibularia nolitangere, Cliona delitrix, Hemectyon ferox, Verongia longissima, Plexaurella dichotoma* and *Plexaurella* sp. In the shallow stratum, hexacorals, sponges and algae dominated, with 38%, 34.6% and 14.5% of total abundance, respectively. The species most commonly found were: *Montastrea annularis, Agaricia agaricites, Agaricia tenuifolia, Siderastrea siderea, Diploria strigosa, Agelus sp, Pandarus acanthifolium, Haliclona hogarthi, Neofibularia nolitangere, Cliona delitrix, Dictyota dicthiota, Penicillus dumetosus* and *Halimeda opuntia.* Hexacorals and sponges dominated in the deep stratum, with 38% and 29% of total abundance, respectively. The species most commonly found were: *Montastrea annularis, Acropora cervicornis, Agaricia agaricites, Montastrea cavernosa, Goreauiella auriculata, Agelus sp, Cliona lampa* and *Chondilla nucula.* The Mexican Caribbean reefs display some differences in the benthic community structure and composition, which are determined by light intensity/depth and reef location in high or low energy areas. Differences detected in the benthic community structure may also depend on other unidentified extrinsic and intrinsic aspects, which may be regulating the benthic community dynamics in the study area.

## 26.1194

**Morphological And Genetic Variation Implicates Monotypy For *briareum* (Anthozoa: Octocorallia) in The Western Atlantic**

**Jaret BILEWITCH*[1]**, Kathryn COATES[2]

[1]Dept. of Geology, University at Buffalo, Buffalo, NY, [2]Dept. of Conservation Services, Bermuda Ministry of the Environment, Flatts, Bermuda

Subjective disagreement exists regarding the taxonomic status of two growth forms of the octocoral *Briareum* Blainville 1830 in the Western Atlantic; some studies refer to encrusting colonies as a separate species, *B. polyanthes* Duchassaing & Michelotti 1860, while others equate it with a digitate form *B. asbestinum* (Pallas 1766). We quantified the degree of both genetic and morphological variation within and between growth forms in an attempt to clarify their taxonomic status. Morphological variation was quantified by measuring sclerite lengths and comparing mean values between colony growth forms and geographic locations of *Briareum* samples collected from Bermuda and the Bahamas. Genetic variation was examined with sequences of *msh* mtDNA and cloned ITS1-5.8S-ITS2 rDNA. Both morphological and molecular results support a single-species status of *Briareum* in the Western Atlantic. More significant morphological variation was seen within each growth form than between them. Within the encrusting form, significant differences existed between mean sclerite lengths of colonies from Bermuda versus the Bahamas. DNA evidence was unable to differentiate growth forms. While *msh* mtDNA sequences were invariable across all colonies, the sequences of cloned rDNA indicated high levels of intra-genomic variation. However, the most commonly recovered rDNA haplotypes were shared between growth forms, suggesting little or no divergence. We interpret the sharing of many rDNA haplotypes between growth forms as evidence of either ongoing interbreeding or incipient divergence with incomplete lineage sorting. Given our observations that geographical variation within a growth form exceeds variation between growth forms and that a highly variable molecular marker is incapable of distinguishing between growth forms, there is currently no evidence for treating each as a separate species and we recommend adhering to the last valid taxonomic treatment, which synonymizes both under *Briareum asbestinum*.

## 26.1195

**Patterns Of Zooxanthellate Scleractinia Biodiversity In New Caledonia**

**Francesca BENZONI*[1]**, Gregory LASNE[2], Michel PICHON[3], Claude PAYRI[2]

[1]Dept. of Biotechnologies and Biosciences, University of Milan-Bicocca, Milano, Italy, [2]Institut de Recherche pour le Développement (IRD) Noumea, Noumea, New Caledonia, [3]Ecole Pratique des Hautes Etudes, Perpignan, France

The coral reefs around New Caledonia cover a total estimated surface of 4.538 km2. A wide range of reef geomorphologies and environmental conditions provide a diverse array of conditions for reef organisms. Taxonomic surveys of important reef taxa such as algae and crustaceans have been conducted. However, a limited number of studies have addressed the total biodiversity of reef Scleractinia and species distribution in New Caledonia. Moreover, the coral fauna of some neocaledonian coral reefs has never been studied until recently. In 2007 two scientific cruises organised by the Institut de Recherche pour le Développement (IRD) of Noumea have allowed for the first time the scientific exploration of two previously poorly known reef areas in the Southern Province: the Cote Oubliée, on the east side of the main island, and the Cap Bourail region, on the west side, respectively. During both expeditions a taxonomic survey of zooxanthellate Scleractinia has been conducted on coral reefs with different geomorphologic features and exposed to different environmental conditions. The main results of these taxonomic surveys are the first assessment of the extent of coral biodiversity in the examined reefs in the Cote Oubliée and Cap Bourail and the survey of coral species distribution showing some strong patterns between different reef types in both regions.

## 26.1196

**Cryptic Diversity Of Sea Cucumbers: The Nocturnal Monsters, *bohadschia* (Holothuroidea: Holothuriidae)**

**Sun KIM*[1]**, Alexander KERR[2], Gustav PAULAY[3]

[1]Marine Laboratory, University of Guam, Mangilao, [2]Marine Laboratory, University of Guam, Mangilao, Guam, [3]Florida Museum of Natural History, University of Florida, Gainesville, FL

Sea cucumbers are among the most poorly studied macrobiota on coral reefs. For example, the genus *Bohadschia* (Holothuroidea: Holothuriidae) is often considered one of the most taxonomically controversial groups. In this study, we investigated the systematics of this group using field and molecular methods. Initial findings include that the morphologically and ecologically distinct *B. argus* is derived within the taxonomically muddled *marmorata*-complex. Also, a clade, *B. bivittata* in part, has tiny lines over its dorsum, a character that was not previously considered taxonomically important. In addition, several species, including *B. koellikeri* appear to be hybrids. Finally, we have a lot more to learn about their systematics on reefs worldwide, as we are discovering many new *Bohadschia* species.

## 26.1197

**The Abundance, Size Classes And Diversity Of Fish in Various Reef Microhabitats At Bongoyo Island**

**Prisca MZIRAY*[1]**, Gregory M. WAGNER[2]

[1]Research, Tanzania Fisheries Research Institute, Kigoma, Tanzania, [2]Faculty of Aquatic Sciences and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania

The purpose of this study was to compare the abundance, size classes and species diversity of fish in different microhabitats associated with the coral reef on the sheltered, northwest side of Bongoyo Island in Dar es Salaam Marine Reserve System (DMRS). Data were collected from five different microhabitats (i.e., mixed hard coral, Acropora, Galaxea, seagrass and rubble) by repeated observations (3-min intervals) using a simple visual method whereby fish were recorded by species and size categories.

Results showed that, there was an extremely significant difference in total fish counts, with all species and size categories combined, among the five microhabitats (randomized block ANOVA: F = 20.655 DF1 = 4, DF2 = 44, p < O 0001), with Acropora having the highest counts, probably since the branches provide protection, especially for small fish species and juveniles. Fish biomass index of all species combined also showed an extremely significant difference amongst microhabitats (F = 20.655, DF1 = 4, DF2 = 44, p < 0.0001), again with Acropora having the highest values. Species diversity (Shannon-Weaver Index) was highest in mixed hard coral, probably due to the variety of hard coral structures which create numerous microhabitats. In this study, almost all fish were of the small size category (0 – 10 cm), indicating serious overfishing in the area.

It is recommended that appropriate management and conservation actions be implemented to eliminate coral reef destruction and overfishing. There should be regular monitoring on the reefs for early detection of any significant negative changes.

## 26.1198

**The Corallosphere: A Web-Based Collaboration Tool For The Taxonomy And Systematics Of Scleractinian Corals**

**Kenneth JOHNSON*[1]**, Jaroslaw STOLARSKI[2], Stephen CAIRNS[3], Ann BUDD[4]

[1]Palaeontology, Natural History Museum London, London, United Kingdom, [2]Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland, [3]National Museum of Natural History, Smithsonian Institution, Washington, DC, [4]Geosciences, University of Iowa, Iowa City, IA

The field of scleractinian coral taxonomy is in the midst of a revolution as the community of taxonomists strive to incorporate new data resulting from advances in molecular systematics and the application of new techniques for extracting new sets of skeletal morphological characters. One important goal of this effort is to provide a rigorous taxonomic framework with well-circumscribed taxon concepts that can be used effectively by researchers and reef managers. The section on Scleractinia in the *Treatise of Invertebrate Paleontology* (Wells 1956) remains the main authoritative reference on the morphology, taxonomy, ecology and systematics of both extinct and extant scleractinians. In order to revise this work, synthesis of large volumes of information is required from sources such as existing taxonomic publications, museum collections, web-based data sets, and particularly the cumulative expertise of the community of experienced taxonomists. Harnessing these disparate data to produce useful taxonomic products presents a formidable challenge and will be facilitated by application of new collaborative techniques associated with other 'e-science' initiatives in biodiversity informatics. The *Corallosphere* will be used to compile the information and expert interpretations required to produce the next version of the *Treatise*. Main areas covered in the *Corallosphere* include text descriptions for diagnoses of valid genera, as well as tools for managing taxonomic synonymies, images, a bibliography, and an illustrated glossary of morphological terms. A flexible work-flow allows registered users with variable levels of access to compile, edit, and annotate generic diagnoses directly from the internet. The ultimate aim is to produce a system that will facilitate the rapid publication of the next version of the *Treatise* based on community-wide consensus, and help remove the taxonomic impediment that slows progress towards an increased understanding of the biology, ecology, and evolutionary history of the Scleractinia.

## 26.1199

**The Genus Pacifigorgia At Eastern Pacific Rocky Reefs (Colombia)**

**Nelson MANRIQUE RODRÍGUEZ*[1]**, Camila GRANADOS CIFUENTES[2], Luisa DUEÑAS[2], Néstor E. ARDILA[2], Juan A. SÁNCHEZ[2]

[1]Laboratorio de Biología Molecular Marina BIOMMAR, Departamento de Ciencias Biológicas, Universidad de los Andes, Bogotá D.C., Colombia, [2]Laboratorio de Biología Molecular Marina BIOMMAR, Departamento de Ciencias Biológicas, Universidad de los Andes, Bogotá, Colombia

The genus Pacifigorgia (Gorgoniidae) is one of the most common and diverse groups of octocorals in the tropical eastern Pacific rocky reefs. The aim of this study was to elucidate the diversity of Pacifigorgia spp. in Colombia using both morphological and molecular information. Sclerites and branching anastomosis were used for morphological analyses. The combination of sclerites shape, size, colour patterns and elliptical Fourier analyses of their fan meshes afforded great clarification to discern among Pacifigorgia species. Nuclear ITS2 and mitochondrial MSH1 sequences were obtained to reconstruct phylogenetic hypothesis. The ITS2 comprised a complex of multiple copies gene. Moreover, multiple ITS2 copies were pint pointed using denaturing gradient gel electrophoresis (DGGE) obtaining intraspecific and even up to intragenomic variation. We also depicted species-specific ITS2 fingerprinting-like DGGE banding patterns to identify Pacifigorgia species, which were concordant with morphometrics. The lack of concerted evolution at the ITS2 suggests a rapid and recent radiation of Pacifigorgia species in the eastern Pacific.

## 26.1200

**Algal Symbiont Distributions in Scleractinian Corals From The Eighth Continent**

Andrew BAKER[1], **Roxane BOONSTRA*[1]**, Herman WIRSHING[1], Faratiana RATSIFANDRIHAMANANA[2], Herilala RANDRIAMAHAZO[2], Mebrahtu ATEWEBERHAN[3], Timothy MCCLANAHAN[3,4]

[1]Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL, [2]Madagascar Program, Wildlife Conservation Society, Villa Ifanomezantsoa, Madagascar, [3]Coral Reef Conservation Project, Wildlife Conservation Society, Mombasa, Kenya, [4]Marine Programs, Wildlife Conservation Society, Bronx, NY

Madagascar, the world's eighth-largest island-continent, covers more than 225,000 square miles and spans 13° of latitude in the SW Indian Ocean. It is located at the meeting point of the warm Agulhas current, which flows southwards down the coast of East Africa, and the cool Madagascar current, which flows northwards from southern Africa. These currents result in a generally tropical environment, with the exception of the SE corner of the island, which is more temperate in nature. The scale and location of Madagascar, combined with the prevailing current patterns, provide an opportunity to study how algal symbiont communities (*Symbiodinium* spp.) in scleractinian corals vary by latitude and habitat. Samples were collected in September 2001 from the four corners of the island: Nosy Bé (NW), Vohemar (Volhmarina) in the NE, Tuléar (Toliara) in the SW and Fort Dauphin (Tolagnaro) in the SE. A second sampling was made in March 2007 from various sites in the Nosy Bé and Tulear areas to assess the stability of these distributions. Symbionts were identified using restriction fragment length polymorphisms (RFLPs) in large subunit ribosomal DNA, and denaturing gradient gel electrophoresis (DGGE) analysis of the ITS-2 ribosomal region. We found the majority of symbionts from this high latitude location to be in *Symbiodinium* clades C and D, with a number of unusual symbiont types also being documented, as well as a number of hosts containing multi-clade combinations of A, C and D. Hypotheses for these symbiont distributions over space, time and across coral taxa, will be discussed.

Key words: coral, symbiont, climate change, *Symbiodinium*, bleaching

## 26.1201

**The Octocoral *carijoa Riisei* (Duchassaing & Michelotti, 1860) As A Potencial Ecosystem Engineer in Brazilian Coast**

**Barbara MOURA NEVES*[1]**, Carlos PEREZ[2]

[1]ccb-Zoologia, Ufpe, Recife, Brazil, [2]cav-Biologia, Ufpe, Recife, Brazil

Carijoa riisei is a common colonial octocoral of the littoral of Pernambuco (Brazil), with growth by creeping stolons with an arborescent structure wich creates new habitats. These conditions introduce this octocoral as a potential ecosystem engineer. The aims of this work were to identify the associated taxa with C. riisei, and to assess the seasonality in its ecological parameters. Two expeditions were realized at Porto de Galinhas and at Gamela beaches (wet and dry season). 40817 specimens associated to C. riisei were found on the studied beaches. The main taxa found were seaweed, sponges, hydroids, nematodes, bristle worms (mainly Syllidae and Nereididae), gastropods, crustaceans (mainly Amphipoda and Copepoda), ophiuroids, pycnogonids and chironomids. In Gamela, crustaceans were the most abundant during the dry season (46 %) and nematodes during the wet season (43,78%). Concerning Porto de Galinhas, crustaceans were the most abundant during both season (62,4% and 81% respectively). The dry season presented the biggest abundance in both beaches (66,4 % for Gamela and 82% for Porto de Galinhas). The associated community of Gamela showed the highest values of richness, abundance and diversity. In Gamela no significant seasonal differences were found in the ecological parameters but Porto de Galinhas showed a strong seasonality concerning abundance and diversity of the associated organisms. These results would indicate homogeneity in the ecological parameters in Gamela and an intense seasonality in Porto de Galinhas perhaps associated to high human impact of tourism activities. Based on these results, it could be concluded that C. riisei acts as an autogenic engineers that changes the reef environment via their own physical structures modulating the supply of resources (such as currents, food, refuge and nursery) to other reef species.

## 26.1202

**We Are Family: Phylogenetic Analysis Of Family Level Relationships Among Scleractinian Corals (Cnidaria, Anthozoa)**

**Joel STAKE*[1]**, Cherissre BOATENG[1], Elisha JNO-BAPTISTE[1], Sandra ROMANO[1]

[1]Division of Science and Math, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

The order Scleractinia consists of 25 families comprised of more than 1300 species. Morphological characters have always been the basis of the taxonomy for this group. High levels of variability in the morphological characters coupled with difficulties in identifying homologies have made understanding the relationships within the order particularly difficult. Recent molecular phylogenetic data do not support hypotheses of relationships based on traditional taxonomy. Molecular phylogenetic analyses suggest the order is divided into two large clades that diverged early in the evolutionary history of the group. While there is strong molecular evidence for this major split, there has been little progress in resolving relationships of genera and families within each of these clades. We are analyzing approximately 5400 bp total from the complete nuclear 18S and 28S ribosomal RNA gene regions as well as partial sequences from the mitochondrial 16S and COI gene regions. Maximum Likelihood and Bayesian methods are being used to analyze a dataset consisting of representatives from each of the 25 families in the order. Inclusion of complete gene regions from a wider sampling of taxa, as many azooxanthellate taxa as possible, and multiple genera from polyphyletic families will lead to better resolution of relationships among genera and families within the two large clades supported by molecular data.

## 26.1203

**Rapid Speciation, Allopatric Differentiation, And Simple Morphology Confound True Diversity Of Some Of The Largest Mobile Reef Invertebrates (Actinopyga, Holothuroidea, Echinodermata)**

**Kris NETCHY*[1]**

[1]Marine Laboratory, University of Guam, Mangilao, Guam

As Asian economies grow, so too does the demand for beche-de-mer. In this multimillion-dollar industry, large holothuroids (sea cucumbers) are harvested and sold as food in Asian markets, and overharvesting is an imminent threat throughout the tropics. Holothuroids are among the most poorly known macrobiota on coral reefs, and their systematics is in a poor state worldwide, hampering research and resource management. The systematics of sea cucumbers in the genus *Actinopyga* has been especially neglected. This is primarily because they show limited diversity and variation in ossicle form, the primary characters used in holothurian taxonomy, making species differentiation difficult. I used two mitochondrial genes, one nuclear gene, and morphological characters to differentiate and systematically characterize species of *Actinopyga*. Results indicate that (1) the genus is more diverse than previously recognized because of the existence of several cryptic species, (2) some wide-ranging forms show strong, allopatric differentiation across their range, and (3) one group has undergone rapid speciation, with many of the resulting species now co-occurring. Rapid speciation, allopatric differentiation, and morphological simplicity have all contributed to the confusing taxonomy of *Actinopyga*. Delimiting species and understanding their geographic and ecological range will allow for better management of beche-de-mer fisheries.

## 26.1204

**A Multi-Scale Analysis Of Coral Species Diversity Patterns Along The Florida Reef Tract**

**Mark CHIAPPONE*[1]**, Dione SWANSON[2], Leanne RUTTEN[1], Steven MILLER[1]

[1]Center for Marine Science, University of North Carolina-Wilmington, Key Largo, FL, [2]Division of Marine Biology and Fisheries, RSMAS-University of Miami, Miami, FL

Large-scale sampling of stony coral, gorgonian, and sponge habitat distribution and frequency of occurrence was undertaken during multiple large-scale surveys from 1999-2007 throughout the 350-km long Florida Reef Tract. Stratified random sampling using belt transects incorporated multiple reef and hard-bottom habitats, oceanographic regions, and areas inside and outside of protected management zones and yielded data on site species richness and species frequency. These data provide insights into the spatial extent and factors influencing reef biodiversity. For stony corals, a pool of ~50 taxa among the Orders Milleporina and Scleractinia, including species and morphotypes, was documented from sampling at over 800 sites. One of the most significant factors influencing species distribution is habitat type, with greater numbers of coral species on inner shelf margin patch reefs, followed by deeper fore reef slope habitats that extended to the 30 m depth limit of this study. In contrast, the shallow fore reef, especially in areas historically dominated by the branching coral Acropora palmata, yield relatively low numbers of species that are either widely distributed and frequently encountered (Porites astreoides) or are relatively rare (Favia fragum) in other habitats. Regional variations in stony coral and octocoral distribution potentially related to continental influence such as Florida Bay-Atlantic Ocean water exchange are less apparent than for sponges. Gorgonians are either represented by the majority of the shallow-water species pool of ~30 species in particular habitats or by very low numbers of species in other habitats, especially wave-swept shallow fore reef areas or coral-dominated patch reefs. Gorgonian species richness tends to be inversely related with coral species richness. While species richness data for these sessile benthic invertebrates is useful for characterizing habitat types, temporal patterns are less apparent, despite significant changes in species abundance.

## 26.1205

**A Multivariate Analysis Of The Scleractinian Genus Meandrina (Lamarck, 1801): Evidence For A New Species.**

**Jorge PINZON*[1]**, Ernesto WEIL[2]

[1]Biology, Pensilvania State University, University Park, PA, [2]Department of Marine Sciences, University of Puerto Rico, Lajas, Puerto Rico

The scleractinian genus Meandrina is found from Bermuda to Brazil. Species diversity has varied from twelve in the late 1900's, to only two currently recognized species, the Caribbean sub-massive, crustose and platy M. meandrites with two formae (f. typica and f. memorialis) and M. brasiliensis, a small, free-living taxon described for Brazil, but also reported for the Caribbean. The Caribbean ecomorphs are commonly found living side-by-side suggesting a genetic component rather than environmental influences in explaining their morphological differences. A multivariate approach was used to test the hypothesis that these morphs are different species. Three colony-level characters were measured on 760 M. "brasiliensis" colonies,779 M. meandrites memorialis and 320 M. meandrites typica colonies distributed along different reefs off La Parguera, southwest Puerto Rico. Thirteen calice-level characters were measured from bleached and curated colonies (46 M. "brasiliensis", 45 M. meandrites memorialis and 32 M. meandrites typical). Data was analyzed with univariate and multivariate statistics. Spatial distribution and reproductive characteristics were assessed from populations in seven different reef sites in La Parguera. Results showed consistent and significant differences in morphological, ecological and reproductive characteristics between the two sub-massive ecomorphs and the free living taxon. These results were supported by an extensive review of museum specimens and all available published information providing therefore, enough evidence to support the separation of the two ecomorphs as two distinct species, the massive, crustose and platy M. meandrites (Linnaeus, 1758), and a new undescribed, large, mostly crustos especies with wide valleys and narrow ridges, Meandrina caribbea nsp. Results also validated Vaughan's (1901) suggestion that M. danae (Milne-Edwards and Haime, 1848) is the free living form living in the Caribbean and is distinct from M. brasiliensis, and endemic taxon for Brazil.

Keywords: Meandrina, scleractinian coral, Taxonomy, Caribbean, ecomorphs, multivariate analysis

## 26.1206

**Octocoral Abundance And Diversity Associated To Eastern Pacific Rocky Reefs (Colombia)**

**Nestor ARDILA*[1]**, Johana PARRA[1], Dairo ESCOBAR[1], Nelson MANRIQUE[1], Juan SANCHEZ[1]

[1]Ciencias Biológicas, Universidad de los Andes, Bogota, Colombia

Octocorals assemblage patterns and spatial distributions were studied from the Colombian eastern Pacific covering ten sites in a range of water depths (3-17 m) in order to evaluate different diversity measures at Gorgona island (Montañita I y II, Farallones, Juanchincho y el Horno) and Cabo corrientes (La Roñosa, Punta Arusi, Punta Diego, El chuzudo, Parguera). A total of 25 species were quantified using belt quadrants (50x50cm). Pacifigorgia spp. afforded the greatest number of species (>10 species), followed by Leptogorgia spp. (four species), Muricea spp. (three species) and the rest of genera with only one species: Eugorgia, Heterogorgia and Carijoa. Carijoa riisei, an invasive species from the Caribbean, was locally very abundant at a few stations both continental and oceanic areas. In terms of abundance, L. alba was the best represented (40 %). Octocoral densities were highly variable (2 - 30 colonies m-2) and showed evidence of a relationship to a bathymetric gradient. Alpha diversity was highly variable (1-8 species) and La Roñosa, Montañita II and Juanchincho were the localities with higher diversity and densities. The community structure showed the dominance of Pacifigorgia cf. symbiotica in shallow waters and L. alba in deeper waters. Muricea fruticosa was exclusive to Cabo corrientes and has been recorded in other expeditions from continental rocky reefs in Puerto Lopez, Ecuador, but was absent in Gorgona island. Finally, L. alba was the only species spanning the entire sampling area and depths.

## 26.1207

**Does Vertical Symbiont Transmission Always Lead To A 'closed' Association? Symbiont Diversity Of Parents, Planulae And Recruits Of The Brooding Caribbean Coral Porites Astreoides**

**Mary Alice COFFROTH*[1]**, Lyndsey HOLLAND[1], Cynthia LEWIS[2]

[1]Geology, University at Buffalo, Buffalo, NY, [2]FWC/FWRI, Marathon, FL

The symbiosis between reef building corals and dinoflagellates in the genus *Symbiodinium* is the basis for the massive structures that dominate coral reefs. Coral offspring acquire their algal symbionts either vertically from the maternal colony or horizontally from the surrounding environment. In species with horizontal transmission, new recruits can initially harbor a range of symbiont types which revert to the adult assemblage over time. In vertical acquisition, it is assumed that maternal symbionts are passed to the larvae and that the maternal symbiont type is the only one found within the newly settled recruit. However, this has not actually been demonstrated. Using variation in chloroplast large subunit (23S) ribosomal DNA , we compared symbiont types within maternal colonies, larvae, newly settled recruits and year old juveniles from the Caribbean scleractinian *Porites astreoides,* a brooding coral that transmits its symbionts vertically. In the majority of cases, the offspring do indeed harbor solely the symbiont type of the maternal colony. However, in some cases the offspring harbor additional *Symbiodinium* types that are not the dominant type found in the maternal colonies. This suggests that either exogenous symbionts are acquired following planulae release or that cryptic *Symbiodinium* spp. within the maternal colony are passed to the developing larvae.

## 26.1208

**Multiple Ecological Radiations Of Sea Cucumbers Onto Coral Reefs**

**Alexander KERR*[1]**, Ronald CLOUSE[2], Mark O'LOUGHLIN[3], Tim O'HARA[3], Daniel JANIES[4]

[1]Marine Laboratory, University of Guam, Mangilao, Guam, [2]Museum of Comparative Zoology, Harvard University, Cambridge, MA, [3]Marine Biology Section, Museum Victoria, Melbourne, Australia, [4]Department of Biomedical Informatics, Ohio State University, Columbus, OH

Aspidochirotida is a large order of sea cucumbers (ca. 25% of extant diversity) consisting of three families: Synallactidae, Stichopodidae and Holothuriidae. Most members are either found on coral reefs or at great depth. We present a phylogeny of 45 species of aspidochirote holothuroids (13% of ordinal-level diversity) based on PCR-amplified partial 16S, 12S, 28S, 18S and H3 gene sequences. Estimated maximum likelihood and maximum parsimony topologies, the latter estimated via POY direct optimisations, indicated that Synallactidae is polyphyletic and renders Stichopodidae paraphyletic. This jumble suggests that members of the former family experienced at least two parallel losses of planktotrophic larvae and complicates interpretations of the bathymetric diversification within the aspidochirotes. The third family, Holothuriidae, appears monophyletic and consists of two large basal subclades. Surprisingly, several previously unconsidered gross anatomical and ecological characters define these groups. The first subclade, "Holothuriinae," is primarily of cylindrical, diurnally cryptic to burrowing forms, while the second subclade "Bohadschiinae," consists mostly of large, diurnal and epibenthic species with flattened ventrums. Further, bohadshiines often release a fluorescent green exudate when first placed in alcohol. These obvious characters permit straightforward diagnosis of two large clades in a family with a tumultuous nomenclatural history.

## 26.1209

**Structure Of Coral Reef Fish Communities Associated With Massive And Branching Corals At Gorgona Island, Tropical Eastern Pacific**

**Julio C. BENÍTEZ*[1]**, Santiago CUEVAS[1], Alan GIRALDO[1], Fernando A. ZAPATA[1]

[1]Department of Biology, Universidad del Valle, Cali, Colombia

The reef fish communities of two coralline microhabitats in the Tropical Eastern Pacific are described. A total of 447 individuals of 35 species of fish in 16 families were sampled in massive and branching colonies using a box-mesh of 1m3 and clove oil as anesthetic. *Cirrhitichthys oxycephalus* (34.9 %) and *Pseudogramma thaumasium* (15.7 %) were the most abundant species, whereas the remaining species were rare. Massive colonies had a more diverse fish community (mean Shannon H'= 1.36 ± 0.36 SD) than branching colonies (H'= 1.14 ± 0.33 SD). Correlation analyses indicated that topographic complexity was not related to any structural parameter of the community (total abundance, richness, Shannon diversity (H') or evenness). H' increased with increasing available volume only among branching colonies. Colony isolation (distance to nearest coral) showed a positive relation with total abundance, species richness, and H' only for branching colonies. Cluster analyses based on occurrence and abundance of the 12 most abundant species did not indicate the existence of a distinctive assemblage structure on either coral microhabitat. *Apogon dovii* was the only species whose mean total length differed between microhabitats, with larger sizes in branching (57.5 mm ± 13.0 SD) than in massive colonies (35.3 mm ± 19.4 SD). Although branching corals had more available space within colonies than massive corals, the latter had more species per unit volume. However, abundance was more equitably distributed in massive corals. In spite of obvious differences in coral morphology, the total richness and species composition of the fish communities did not differ markedly between the two microhabitats.

## 26.1210

**Species Catalogs For Deepwater Coral Communities Of The Northwestern Gulf Of Mexico**

**Emma HICKERSON*[1]**, G.P. SCHMAHL[1]

[1]Flower Garden Banks National Marine Sanctuary, Galveston, TX

Rocky outcrops and hard-bottom banks are common on the continental shelf throughout the northwestern Gulf of Mexico (NWGOM). Select sites in the NWGOM have been the focus of recent mapping, remotely operated vehicle (ROV) and submersible surveys, and biological sampling by the Flower Garden Banks National Marine Sanctuary (FGBNMS). Investigations were conducted in depths of approximately 18m to 150m. Over 180 surveys were conducted over a period of seven years, resulting in more than 218 hours of survey time, over 8400 high resolution georeferenced digital still images, and 247 directed sample collections. Initial attempts to identify species from video surveys illuminated the need to develop photographic records of living species that corresponded to collected samples identified in laboratory settings. Commonly, taxonomists were not familiar with what the living sample looked like and therefore could not provide identifications based simply on *in situ* photographs. A systematic approach was developed to accomplish this. The major biological components of the study sites were identified and relocated through knowledge of their distribution from georeferenced surveys and photographs. Once located, photographs were obtained for each species *in situ*, collected when necessary and feasible, and identified by a suite of taxonomic experts. The result is the development of regional catalogs for conspicuous inhabitants of deepwater communities in the NWGOM. A series of posters has been developed that includes deepwater fishes, antipatharians, octocorals, invertebrates and algae, and sponges. The goal of this project is to facilitate regional exploration through the identification of deepwater species, and to limit the need to collect future specimens. The series of posters is presented here, and are made available on CD.

## 26.1211

**Distribution And Abundance Of Soft Corals in Thai Waters**

**Thanongsak CHANMETHAKUL*[1]**, Hansa CHANSANG[2], Suparoek WATANASIT[1], Philip ALDERSLADE[3]

[1]Biology, Prince of Songkla University, Songkla, Thailand, [2]Marine and Coastal Resources, Phuket Marine Biological Center, Phuket, Thailand, [3]Cnidaria (Octocorallia), Museum and Art Gallery of the Northern Territory, Northern Territory, Australia

This study aims at conducting surveys on the biodiversity of soft corals (Alcyoniina) in Thai waters, with emphasis on genera richness, distribution, and several related ecological aspects. The study was conducted in the Gulf of Thailand and Andaman Sea. Eighty five sites, among 12 major inshore and offshore islands, and 118 sites, among 14 major inshore and offshore islands, were surveyed in the Gulf and Andaman Sea, respectively. The surveys were conducted between March 2004 – June 2005. The abundance and generic distribution were recorded by visual estimation. A total of nineteen genera, within four families, were recorded. They are Alcyoniidae; *Sinularia, Dampia, Cladiella, Klyxum, Sarcophyton, Lobophytum,* and *Eleutherobia*, Nephtheidae; *Nephthea, Stereonepthya, Scleronephthya, Dendronephthya, Umbellulifera,* Nidaliidae; *Nidalia*, *Siphonogorgia*, *Chironephthya*, *Nepthyigorgia*, Xeniidae; *Xenia, Heteroxenia*, and *Sansibia*. The major soft coral genera observed belong to the Alcyoniidae and Nephthidae families. All 19 genera were found in the Andaman Sea, whereas only 12 genera were recorded in the Gulf. The highest diversity was observed at Similan and Adang-Rawi Islands of the Andaman Sea. In comparison, Losin Island yielded the highest richness for the Gulf. Rare genera found in the Andaman Sea were *Nidalia*, *Heteroxenia*, and *Nephthyigorgia*, most of which were found at Similan and coastal Islands of Satun Province. While *Dendronephthya*, *Scleronephthya*, *Nephthyigorgia*, and *Eleutherobia* were rare in the Gulf of Thailand, they were observed at Losin Island. Genera richness and abundance were highest in offshore islands, where the visibility was comparatively good. Moreover, the distribution and abundance of soft corals revealed a correlation with reef zonation. The majority of soft corals were found on reef slopes. Most zooxanthellate group was found on both horizontal and inclined substrates of up to 90 degrees. In comparison, azooxanthellate genera were found on substrates of all inclines.

## 26.1212

**Habitats and Biodiversity of Ningaloo Reef Lagoon, Western Australia**

**Mike VAN KEULEN*[1]**, Neil LONERAGAN[1], Greg SKILLETER[2], Nicole PINNEL[3], Halina KOBRYN[3], Lynnath BECKLEY[3]

[1]School of Biological Sciences & Biotechnology, Murdoch University, Murdoch, Australia, [2]School of Integrative Biology, University of Queensland, Brisbane, Australia, [3]School of Environmental Science, Murdoch University, Murdoch, Australia

As part of the CSIRO Wealth from Oceans Ningaloo Collaborative Cluster programme currently underway in Western Australia, this study aims to examine the habitats and biodiversity of lagoonal areas within Ningaloo Reef. Key habitat types were identified using information from hyperspectral remote sensing and were used to develop a stratified sampling approach. Two focal areas were selected, based on sanctuary zones within Ningaloo Marine Park: Osprey Bay in the north and Coral Bay in the south. A nested sampling programme was initiated within each location, consisting of surveying transects at different spatial scales: cross-reef transects (shore to reef-edge) to identify major habitat types and boundaries between habitats; and finer-scale habitat surveys of biodiversity and abundance of different major groups of organisms, focussing on non-scleractinian cnidarians, macroalgae, sponges, echinoderms and molluscs. Four geomorphological categories have been sampled at each location: reef-crest, back-reef, lagoon and inner reef-flat. Ground-truthing was carried out on the extent of habitats along defined transects selected to maximize the diversity of each site. Sub-sampling for macro-invertebrates was conducted along 50 m transects, with counts of holothurians, the gastropod *Drupella cornus* and clams (*Tridacna* spp.). A nested quadrat sampling regime will attempt to link field-collected data with remotely-sensed data, collected at different scales. Preliminary results confirm that the northern section of Ningaloo Reef differs greatly from the southern section, with a greater diversity of habitats present in the broader lagoons in the south. Greater areas of coral are found close inshore and across the entire reef at the southern location, compared with the northern section, which has a broad expanse of sand and limestone pavement before grading to corals further offshore (the back-reef and reef-crest). These differences in habitat may have implications on the overall biodiversity of the two locations.

## 26.1213

**Applying Dna Barcode On Species Identification And Recruitment Of Coral Fishes**

Hui-Ling KO[1], **Kwang-Tsao SHAO*[1]**, Li-Lian LIU[2]

[1]Research Center for Biodiversity, Academia Sinica, Taipei, Taiwan, [2]Institute of Marine Biology, NSYSU, Kaoshiung, Taiwan

Although identifying species of fish larvae morphologically is much easier than fish eggs, it doesn't guarantee the identification is accurate. Without proper identification, we can not obtain spawning season, spawning ground or life history data at the species level for recruitment studies. In this study, we attempted to apply the DNA barcode method on fish larvae collected from Kenting National Park in the southern tip of Taiwan during 2005-2007. A total of 1,549 specimens of fish larvae in the postflexion stage were collected using light traps at four coastal stations and three harbor stations. Fifteen types of damselfish (Pomacentridae) larvae and five types of butterflyfish (Chaetodontidae) larvae were identified based on their morphological characters. The mtDNA CO1 sequence was then used as the barcode to identify different morphological types of damselfishes and butterflyfishes to the species level. Overall, 15 morphotypes of damselfishes were identified to 11 species level and 3 genera level, and five morphotypes of butterflyfishes were identified to four species level and one genus level. After the species were identified, we can then make a diagnostic key and compile an encyclopedia on larval fishes in the future. In the meantime, the spawning season and abundance of fishes were investigated to the species level. These more precise results are useful in understanding the recruitment and population status of coral reef fishes in the Kenting area as well as in planning the work on their resources conservation and restoration.

## 26.1214

**Fish Community Structure in Two Coral Formations From Malpelo Island, Colombian Pacific.**

Adriana ALZATE-VALLEJO[1], **Fernando A. ZAPATA*[1]**

[1]Department of Biology, Universidad del Valle, Cali, Colombia

The structure of a coral reef fish community in a Tropical Eastern Pacific oceanic island is described for the first time. To that end visual censuses were done on two coral formations of Malpelo Island, in the Colombian Pacific. Out of a total of 66 species observed at both sites combined, 51.5% of them were observed on both, 36.4% were observed only at El Arrecife and 12.1% were observed only at La Nevera. The species in common made up > 95% of the total abundance in each community, in each case characterized by having a few highly dominant species and many rare species. The distribution of abundance (log-normal in both cases), α-diversity, trophic structure, and taxonomic structure were similar at both sites. However, total species richness was greater at El Arrecife (60 species) than at La Nevera (42 species), which can be partially explained by a greater sampling effort and possibly a greater β-diversity due to a broader depth range and more pronounced coral zonation at El Arrecife than at La Nevera. This is supported by results of an analysis of similarity in community composition and species abundance that reflected differences in habitat and depth between sites.

## 26.1215

**Diversity Of *Symbiodinium* In Mesophotic Coral Communities On The Great Barrier Reef**

**Pim BONGAERTS*[1]**, Thomas BRIDGE[2], Eugenia SAMPAYO[1], Norbert ENGLEBERT[1,3], Tyrone RIDGWAY[1], Mauricio RODRIGUEZ-LANETTY[1], Jody WEBSTER[2], Ove HOEGH-GULDBERG[1]

[1]Centre for Marine Studies, University of Queensland, Brisbane, Australia, [2]School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, [3]IBED, University of Amsterdam, Amsterdam, Netherlands

The large variability in light availability in the underwater realm provides an important axis for niche diversification of light-dependent biota on tropical coral reefs. As irradiance decreases with increasing depth so does the variability in available irradiances at a specific depth, which has been correlated to a drop in the diversity of the light-dependent benthos, such as scleractinian corals. Whilst the algal symbionts (*Symbiodinium*) that are associated with scleractinian corals can be specific to their host species, they have also been shown to be specific to certain depth/light environments. In this study we identify the algal symbionts associated with corals on the mesophotic reef to determine community diversity of *Symbiodinium* at previously unstudied depths. This was done using ITS2 rDNA and denaturing gradient gel electrophoresis (DGGE). A total of 76 corals were collected on board the RV *Southern Surveyor* from depths between 50-75m through dredge sampling on three sites along the Great Barrier Reef margin (Ribbon Reefs, Noggin Pass and Hydrographer's Passage). Collected coral were mostly identified as belonging to the genera *Montipora*, *Leptoseris*, *Seriatopora*, with a few members of the genera *Pocillopora*, *Acropora* and *Galaxea*. The results provide new insights on the community structure of *Symbiodinium* in a understudied yet important coral habitat. In addition, it is envisaged that the results will aid in understanding whether the mesophotic reef constitutes a distinct habitat with its own specialized coral and symbiont community or whether it is a mere extension of the shallower reef.

## 26.1216

**Distribution Of The Family Pomacentridae in The Depth Gradient Of A Coral Reef in Isla Larga, San Esteban National Park, Venezuela.**

**Lisette MOLINS*[1]**, Jose RODRIGUEZ[1]

[1]Universidad de Carabobo, Valencia, Venezuela

The main objective of this study was to determine whether or not there is a distribution pattern among the species of the family Pomacentridae along the depth gradient in a coral reef of Isla Larga, San Esteban National Park, Venezuela. Visual census were carried out using the transect method with observation stops in different depth strata, where the species of the family Pomacentridae were identified. Additionally, a behavioral study was carried out to determine the importance of the competition among congeners in the establishment of this pattern. Nine species were recorded, where the most abundant was *Stegastes partitus* followed by *S. planifrons*. A differential distribution was observed along the depth gradient, in which *S. adustus* and *Microspathodon chrysurus* were located mainly up to 1m of depth. In the range from 3 to 6m, up to the 80% of the pomacentrids were represented by *S. planifrons* and *S. partitus*, which diminished their abundance between 9 and 12m, as *S. variabilis* increased. There was not a clear relationship between the substrata and the distribution of the pomacentrid's species, although in general the most abundant substratum in the reef was the coral *Montastraea annularis* as well as surfaces of dead coral covered with filamentous algae. The composition, distribution and abundance of the species of the family Pomacentridae suggests a close relationship with depth, while the interspecific competition does not seem to be a regulating factor in the described distribution, since it was mainly intraspecific. It is possible that this family's distribution is regulated by other factors such as the establishment of larvae and of juveniles in different areas of the reef.

## 26.1217

**Species Richness Of Marine Benthic Habitats in South Florida**

**Sitti Zayda HALUN*[1]**, James FOURQUREAN[2]

[1]Department of Biological Sciences and Southeast Environmental Research Center, Florida International University, Miami, FL, [2]Biological Sciences and Southeast Environmental Research Center, Florida International University, Miami, FL

A survey of species diversity of primary producers of benthic habitats in South Florida was conducted in 350 randomly chosen sites from June to September of 2007 using a modified Braun-Blanquet technique. Ten 0.25 $m^2$ quadrats were placed randomly along a 50-m transect placed in a north-south direction at each site. All species occurring in the quadrat were listed and a ranking based on abundance of the species in that quadrat was assigned. Seagrass materials were collected at each site and analyzed for elemental composition (carbon, nitrogen and phosphorus). Plant tissue stoichiometry was used as an indicator of the fertility of the ecosystem. The results suggest that species richness was highest at intermediate fertility.

## 26.1218

**Species, Distribution And Community Structure Of The Scleractinian Corals Genus Acropora in The Gulf Of Thailand**

**Anchalee CHANKONG*[1]**, Vipoosit MANTHACHITRA[2]

1Department of Marine and Coastal Resources, Eastern Marine and Coastal Resources Research Center, Rayong, Thailand, 2Aquatic Science, Burapha University, Chonburi, Thailand

Scleractinian corals genus *Acropora* are the dominant group within coral assemblages in the Gulf of Thailand. The purpose of this study was to investigate the diversity, abundance, species composition and community structure of *Acropora* in the Gulf of Thailand. The 30 x 1 m. belt transect with 3 replicates were employed at 80 stations from 30 islands along the Gulf of Thailand. A total of 37 species were found covering the average of area of 14.9%. The dominant species were *A. millepora*, *A. samoensis* and *A. digitifera*. Common species were *A. valida*, *A. hyacinthus* and *A. divaricata*. The rare species were *A. cytherea*, *A. humilis* and *A. valenciennesi*. Ma Island and Phangan Island had the highest species richness (15 species). Kra Island had the second species richness (14 species). The diversity indices at all stations were 0.5-2.0 while the evenness indices were 0.5-1.0. Species composition of *Acropora* based on area coverage varied significantly on habitats depending on locations. Community structure could be divided into 4 groups; the first group was at the station at Klang Island, a winward-reef slope (KL12) and at station Klang Island, a leeward-reef slope (KL22), having *A. aculeus* as the dominant species at station Kra Island, a leeward-reef slope (KR22) having *A. nana* as the dominant species. The second group, at station Klang Island, a leeward-reef slope (KL22) had *A. formosa* as the dominant species. The third group, a station Kra Island, a leeward-reef flat (KR21) had *A*. cf. *copiosa*, *A. longicyathus*, *A. tenuis* and *A. microphthalma* as the dominant species and the last group of the stations had common species and rare species. This study shows the recent condition of *Acropora* in the Gulf of Thailand that they had recovery after bleaching phenomenon in 1998.

## 26.1219

**Preliminary Results Of Marine Algae Of Madagascar Reef, Yucatan, Mexico: A Functional Group Approach.**

Ileana ORTEGÓN-AZNAR[1], Noemi RAMIREZ-MISS[1], **Hilda LEÓN-TEJERA*[2]**, Michele GOLD-MORGAN[2], Stjepko GOLUBIC[3]

[1]Marine Biology, UADY, Merida, Mexico, [2]Biología Comparada, UNAM, Facultad de Ciencias, UNAM, Mexico, Mexico, [3]Biological Science Center, Boston University, Boston, MA

The abundance and distribution of marine algae was recorded with in Madagascar Reef; located at the Northwest corner of the Yucatan Peninsula. It forms part of the Inner Campeche Bank Reefs. The main objective is implanting a monitoring program to detect changes in the spatiotemporal patterns within a algae community with respect to environmental changes. Using groups of species as the unit of measurement assumes that the grouped species will respond similarly to environmental changes.

To evaluate the validity of using the functional-form group approach, we use a modification of Steneck and Dethier (1994) classification and we will compare the variation on space of functional groups with the species composition.

Between august to September 2007 four sites were collected along the reef. Two 10m transect marked at 2m intervals were used at each site with a 25 x 25 cm quadrant, placed every two meters. Analyses of environmental factors, species and functional groups abundances and distribution, is carried on.

About 30 taxa of marine algae were recorded. The class Rhodophyceae has the largest number of species and abundance over sandy bottom, but the Phaeophyceae abundance dominates over the other class over the ridge especially Dictyota spp. Nine different functional-form groups were determinate. The foliose corticated group were the most abundant along with the filament and the Chyanophyceae.

No spatial patterns were found but more work is needed to make conclusions.

To detect any change within a community we first need to understand the spatiotemporal patterns. We still do not know whether the functional form group model provides the correct resolution to detect temporal and spatial changes in community structure. One way to evaluate the efficacy of using the functional-form group model, or any grouping system, is to determine whether all members of a group act similarly in space over time.

## 26.1220

**Seasonal Variation in Zooplankton Composition And Grazing Impact On Phytoplankton Standing Stock in The Coral Reef Bay--Sanya, China**

**Liangmin HUANG*[1]**, Yehui TAN[2], Xingyu SONG[3]

[1]LMB, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of, [2]South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China, People's Republic of, [3]South China Sea Institute of Oceanology, Guangzhou, China, People's Republic of

The copepods biomass, composition, gut evacuation rates and grazing impact on phytoplankton were investigated in the Sanya Bay two season cruises during the autumn (November 2000) and spring (March 2001). The results showed that *Paracalanus aculeatus* and *Paracalanus larvae* were the copepods dominated species in autumn, and they became *Pavocalanus crassirostris* and *Cyclopina* sp. in spring. The average abundance of copepods were 8.917×103ind·m-3 and 1.073×103ind·m-3 in autumn and spring respectively. The average gut evacuation rates of the copepods were 0.029±0.006 min-1 for the two seasons, and the grazing impact calculating from this was up to 41.875%. We found by analysed the biomass of phytoplankon and copepods during two seasons that the primary production in Sanya Bay was much lower and the copepods and other meso-zooplankton were main consumer of phytoplankton; the grazing impact of copepods presented obviously spaces and times characteristic, which was higher in autumn than spring, and lower in off-shore than near-shores; the growth of phytoplankton was bottom-up controlled by nutrients in spring, and with the increasing of zooplankton abundance, the top-down effects by zooplankton became more powerful subsequently in autumn.

## 26.1221

**Diversity in A Marine Species Complex: A Study Of The Hypoplectrus Coral Reef Fish Genus.**

**Ben HOLT*[1]**, Isabelle COTE[2], Brent EMERSON[3]

[1]Biological Science, University of East Anglia, Norwich, United Kingdom, [2]Department of Biological Sciences, Simon Fraser University, Vancouver, BC, Canada, [3]School of Biological Science, University of East Anglia, Norwich, United Kingdom

Diversity in a marine species complex: a study of the *Hypoplectrus* coral reef fish genus.

Species complexes provide excellent systems for the study of evolutionary diversification in space and time. Despite the high diversity found in coral reefs, few species complexes have been well studied within these habitats. One exception is the Caribbean fish genus *Hypoplectrus,* which represents many striking colour forms and various studies have considered the evolutionary mechanisms responsible for this polymorphism. We have taken a wide scale approach to studying this system, sampling over 600 individuals representing seven different colour forms from eight different locations. Using AFLP molecular markers we have established that *Hypoplectrus* morphotypes are consistently very closely related, both within locations and across the region, with one notable exception in the Gulf of Mexico. These data are complimented by geometric morphometrics, which show that, whilst small, highly significant differences exist between the mean body shape of colour forms, *Hypoplectrus* morphological variation is more strongly associated with geography. Generally our results suggest that *Hypoplectrus* populations are highly connected across their distribution with little evidence that colour morphotypes within the species complex represent established or incipient species. We will discuss these results with reference to existing theories regarding the origin and maintenance of this polymorphism.

## 26.1222

**Spatial And Temporal Variation Of Macrofauna in Reef-Associated Halimeda And Seagrass Of A Bleach-Resisting Bay in Sri Lanka**

**Suki EKARATNE*[1]**, Danister JOHN[2]

[1]Zoology, Colombo University, Colombo, Sri Lanka, [2]Colombo University, Colombo, Sri Lanka

The composition and diversity of macrofauna inhabiting reef-associated *Halimeda* and seagrass, were studied over the two annual seasons using monthly triplicated 25cmx25cm quadrat samples. Crustaceans, gastropods, polychaetes and ophiuroids comprised the main inhabitants of *Halimeda* (at 1 495±225.8m-2, 980±207.8m-2, 543±127.4m-2 and 310±74.3m-2, respectively). Seagrass communities were dominated by crustaceans, sipunculids and polychaetes (at 819±137.7m-2 , 137±104.Im-2 and I00±46.6m-2 , respectively). Nemetinea, Echiura, Platyhelminthes and Chordata were less abundant in *Halimeda*. In seagrass gastropods, ophiuroids, holothuroids and poriferans occurred in lesser numbers.

Highest densities in *Halimeda* occurred in monsoonal season (6240±92.17m-$^2$) and lowest at nonmonsoonal season onset (2480±124.46m-$^2$) whereas a reverse trend occurred in seagrass, with highest densities at nonmonsoonal onset (1530±I2.02m-$^2$) and lowest in monsoonal season (l008±l0.60m$^2$).

Highest number of families occurred among crustaceans (26 and 20 in *Halimeda* and seagrass, respectively) and polychaetes (20 and 11 in *Halimeda* and seagrass, respectively), with amphipods as most dominant crustaceans. Dominant polychaetes in *Halimeda* were terrebellids and nereids, but in seagrass it was sebellarids and glycerids.

In *Halimeda,* the highest faunal density and diversity were observed during monsoons periods. There was no significant seasonal variation of faunal composition and diversity in seagrass, but fauna inhabiting *Halimeda* underwent significant seasonal variation. There was no faunal density variation between leaves and sediments of seagrass, but in *Halimeda.* leaves had significantly higher faunal densities.

Day-light densities of seagrass fauna were higher and were dominated by crustaceans, with the`lesser densities of dark hours being dominated by gastropods. Seagrass faunal dry biomass, faunal diversity and floral biomass increased from shoreward locations to deeper locations. In the most shoreward locations faunal composition was dominated by sipunculids and gastropods, and in all other locations, it was dominated by crustaceans.

## 26.1223

**Reef biodiversity research at the Florida Museum of Natural History**

**Gustav PAULAY*[1]**, John SLAPCINSKY[1], Amanda BEMIS[1], Sarah MACPHERSON[1]

[1]Florida Museum of Natural History, University of Florida, Gainesville, FL

The Florida Museum of Natural History is the largest natural history museum in the southeast US, and holds one of the most significant collections of reef invertebrates in the country. The invertebrate collection developed from one dedicated to mollusks, and is still dominated by specimens from that phylum. Approximately 450,000 lots (>3 million specimens) or mollusks and >30,000 lots (>100,000 specimens) of marine invertebrates from ~20 phyla are represented. The largest non-molluscan collections are of Crustacea, Echinodermata, and Cnidaria, especially reef corals. Over 440,000 lots are now databased and searchable online through the Division's website (http://flmnh.ufl.edu/malacology/), GBIF (http://www.gbif.org/) and Discover Life (http://www.discoverlife.org/). This electronic collection is the second largest available for invertebrates. The bulk of the records are georeferenced and mapable. The collection also holds >80,000 images, mostly of reef-inhabiting marine invertebrates, which are steadily being made available online. The Division is involved in documenting reef biodiversity in the NW Hawaiian Islands (CREEFS), Society Islands (BIOCODE), the SW Indian Ocean (BIOTAS), through much of Oceania, Oman, and Florida. The large tissue- and alcohol-preserved collections are now being sequenced to provide genetic barcodes for >5000 species of marine invertebrates, as part of the MarBOL project. Our long-term goals are to provide specimen, genetic, image, identification, and other taxonomic resources on a wide-range of reef-inhabiting marine invertebrates.

## 26.1224

**Checklist And Morphometry Of The Benthic Cnidarians Of Some Sites At The Fernando De Noronha, Archipelago, Pernambuco State, Brazil**

**Fernanda AMARAL*[1]**, Carla RAMOS[1], Zelinda LEÃO[2], Ruy KIKUCHI[2], Kyllderes LIMA[1], Leila LONGO[3], Selma VASCONCELOS[4], Ralf CORDEIRO[1]

[1]Biologia, Universidade Federal Rural de Pernambuco, Recife, Brazil, [2]Geologia, Universidade Federal da Bahia, Salvador, Brazil, [3]Zoologia, Universidade de São Paulo, São Paulo, Brazil, [4]Zoologia, Universidade Federal de Pernambuco, Recife, Brazil

The Fernando de Noronha Archipelago (Pernambuco State, Brazil), located 580 km from the city of Recife, is made up of 21 islands and islets that are volcanic in origin. This study aimed to update the checklist of benthic cnidarians of some of the archipelago's reef environments, as well as to carry out research on the morphometry of their corals and calcified hydroids. Fieldwork was undertaken from February 2005 through April 2006 and observations were carried out at 13 stations through snorkeling or scuba diving up to 30 m deep. A minimum number of samples were collected in order to reduce the impact on the environment and the samples were deposited in the collection of the Reef Environment Laboratory (LAR/UFRPE). Thirty-two species of cnidarians were recorded, from which 14 are new occurrences for the area studied. When added to other species listed in the literature, a total of 59 benthic cnidarians have been recorded for the Archipelago. This increase may be explained by the small number of studies that has been carried out in the area and by the augment in tourism activities. The latter increases the possibility of bioinvasion by organisms that may come into the archipelago attached to the hull of cruiser ships. *Stephanocoenia michelini* and *Mussismilia* sp., new occurrences of zooxanthellate corals, are worthy of mention, as well as the calcified hydroids *Millepora braziliensis* and *Millepora* sp. *Mussismilia* sp. showed several variations among its skeletal characters that surpassed the limits of intraspecific morphological variation when compared to those of *M. hispida* from the Brazilian coast and might be a new species. The abundance and frequency of these animals are being studied through the analysis of video transect images.

## 26.1225

**Update Of The Checklist And Distribution Of The Cnidarians Of Saint Peter And St. Paul Archipelago, Brazil**

**Fernanda AMARAL*[1]**, Carla RAMOS[1], Kyllderes LIMA[1], Susan SILVEIRA[1], Selma VASCONCELOS[2], Simone LIRA[1]

[1]Biologia, Universidade Federal Rural de Pernambuco, Recife, Brazil, [2]Zoologia, Universidade Federal de Pernambuco, Recife, Brazil

Phylum Cnidaria is presently divided into two subphyla: Medusozoa and Anthozoa; this phylum's organisms are extremely important for reef environments, especially the zooxanthellate corals, which perform an important role in reef-building. The data for this study was obtained from samples collected manually through free or scuba diving (0-60 m) during expeditions carried out between 1998 and 2007 at the St. Peter St. Paul Archipelago (0º 56,2' N and 29º 20,6' W), located 1100 km from the city of Natal (Rio Grande do Norte State, Brazil) at the top of the meso-oceanic range. This archipelago is comprised of islands and islets of plutonic origin, but may be considered a reef environment because it has a considerable coralline fauna and flora. The histomorphological studies identified 23 cnidarian taxa: three species of hydroids (*Halopteris alternata, Aglaophenia rhyncocharpa, and Sertularella sp.), four species of scleractinian corals (Scolymia wellsi, Madracis decactis, Astrangia braziliensis, and Polycyathus sp.), six species of sea-anemones (Actinia bermudensis, Aiptasia pallida, Anemonia sargassensis, Bunodosoma caissarum, B. cangicum, and Telmatactis roseni), seven species of zoanthids (Zoanthus sociatus, Z. nymphaeus, Zoanthus sp., Palythoa caribaeorum, Palythoa sp., Protopalythoa variabilis, and Parazoanthus sp.), one species of octocoral (Carijoa riseii), and two species of black corals (Antipathes sp. and Tanacipathes paula). This shows the reasonable diversity of this phylum when compared to other regions such as the Rocas Atoll, where 21 species have been identified. Species distribution and community descriptive indexes are being studied through the analysis of video transect images.*

## 26.1226

**Biodiversity Of Benthic Communities At High Latitudes Of The Red Sea**

**Moshira HASSAN*[1]**

[1]The American University in Cairo, Cairo, Egypt

Most research on coral reefs of the Red Sea has focused on the Red Sea proper and the Gulf of Aqaba, with comparatively little work published for the Gulf of Suez. The northernmost coral reefs of the Indian Ocean were situated here at N 29.95°, where temperatures range from less than 16°C to 30°C.

Due to its marginal setting, the Gulf of Suez has the potential to show us how coral reefs may develop in the face of increasing stress caused by climate change and a variety of stresses related to harbor activities and local industries.

Living and dead coral communities were surveyed from Suez to Ain Sokhna (N 29.47°) using a combination of line intercept, point intercept and quadrat methods.

Very different benthic communities were found. Former coral reefs near Suez were replaced by mats of the bivalve *Brachidontes pharaonis*, a Lessepsian migrant, interspersed with coralline red algae and *Enteromorpha* sp. A layer of barnacles, found under *Brachidontes*, indicates a succession after the reefs died. Several genera of live coral, which were heavily infested by borers, were present on other patches, together with mats of *Caulerpa* and *Brachidontes*, whereas oysters were the dominant bivalves farther south. Reefs south of Sokhna Port were heavily populated by the sea urchin *Echinometra matthei* (up to 50/m2), *Drupella* sp. or both, leaving large stretches of reef dead. It needs to be investigated whether these different communities can be used as bio-indicators of the particular stressors at each site.

Given the current developments it is unlikely that the dead reefs will recover. The question arises whether the damaged reefs around Ain Sokhna can be saved, or whether limited resources are better invested in trying to protect the reefs south of Ain Sokhna.

## 26.1227

**Cryptobenthic Reef Fishes At Los Roques National Park, Venezuela.**

**José RODRÍGUEZ*[1]**

[1]Biología, Universidad de Carabobo, Valencia, Venezuela

The objective of the present study was to characterize the cryptobenthic reef fishes community associated with coral reef at Los Roques National Park. The study included 11 locations in which these cryptobenthic fish were registered using visual censuses and some specimens were collected on SCUBA using a suction method and a fine-mesh net. A total of 30 species in 6 families were identified (3 Blenniidae, 7 Chaenopsidae, 7 Labrisomidae, 1 Tripterygiidae, 11 Gobiidae and 1 Gobiesocidae) and 6 represented new records in the park. The most important families (numerical abundance and species richness) were the Gobiidae followed by Chaenopsidae. Differences were observed in the community structure of cryptobenthic fishes between the locations, related to the reef environment, where Acanthemblemaria medusa (Chaenopsidae), Malacoctenus triangulatus and M. aurolineatus (Labrisomidae), were only observed at shallow reef, environments that do not overcome 5 m of depth and dominated by the corals Montastraea annularis, M. faveolata and Diploria strigosa. In fringing and barrier reefs, another species were important and differentially distributed. Tigrigobius dilepis and T. pallens (Gobiidae), Ophyoblennius atlanticus and Entomacrodus nigricans (Blenniidae) and Enneanectes pectoralis (Tripterygiidae), were typical in the reef flat and crest, shallow zones dominated by Acropora palmate; while Emblemariopsis sp, E. cf. bottomei and A. spinosa (Chaenopsidae) and the gobies Elacatinus randalli, E. chancei and Coryphopterus genus, characterized the seaward slope, below 6 m, dominated by Montastraea genus and Colpophyllia natans. These differences probably are related to the close association that these small fish maintain with the benthos. If we consider these closer relations and their abundance, cryptobenthic fish structure can be use as indicators of coral reef condition.

Key words: Cryptobenthic reef fishes, structure, Los Roques National Park, Venezuela

## 26.1228

**Cryptofauna Associated To Montastraea Annularis's Dead Fragments in Continental Coral Reefs From Venezuela**

Alessandra RIVOLTA[1], Carmen RODRIGUEZ[1], Marcos COLMENARES[1], **Jose RODRIGUEZ*[1]**

[1]Biologia, Universidad de Carabobo, Valencia, Venezuela

The cryptofauna associated to Montastraea annularis dead coral fragments were collected from two coral reefs from Isla Larga, San Esteban National Park, Venezuela, in November 2006 and March 2007. Fragments collected in the first reef located leeward of the island (AN) were extracted at 3 and 9m deep, were the dead coral cover ranged between 40-46%. The second reef, also leeward, was associated to a shipwreck (AA), were M. annularis was found only at 9m deep, with a dead coral cover reaching around 70%. The volume of the fragments was estimated to standardize density values. The most abundant fauna in both reef were polychaetes (44.06% AN; 48.78% AA), followed by sipunculids (28.7% AN; 22.22% AA), peracarids crustaceans (11.4% AN; 15.5% AA), and bivalves (9.23% AN; 7.82% AA). Twenty-one polychaeta families were identified, with Eunicidae, Sabellidae, Nereididae, Terebellidae y Syllidae as the most abundant, representing 91.78% of this group. The average density was larger in AF (545.13ind/l) compared to the AN reef (266.95ind/l). In AN reef the organisms were significantly more abundant in fragments collected form the shallow depth (Mann-Whitney U test $p<0.05$), specially polychaetes and decapods crustaceans. When comparing sampling times, density values for the sipunculids were statistically different, showing larger values in November, the rainy season.

Key words: cryptofauna, dead coral, polychaeta, Montastraea annularis, Venezuela

## 26.1229

**Barcoding Larval Rain in Moorea**

**Jonathan GELLER*[1]**, Serge PLANES[2], Jonathan GRONDIN[2], Meyer CHRISTOPHER[3], Gustav PAULAY[4], Alice ALDREDGE[5], Kate HANSON[6]

[1]Moss Landing Marine Laboratories, Moss Landing, CA, [2]Centre National de la Recherche Scientifique, Perpignan, France, [3]Smithsonian Institution, Washington, DC, [4]Florida Museum of Natural History, Gainesville, FL, [5]University of California at Santa Barbara, Santa Barbara, CA, [6]Scripps Institution of Oceanography, La Jolla, CA

The primary objective of the Moorea Biocode Project (MBP) is to genetically barcode an entire tropical ecosystem, from the top of the highest peaks to the limits of diving depth, including all macro-algae, fungi, plants and animals. A one-year pilot phase of the MBP concentrated on a few taxonomic groups that included fishes and macro-crustaceans. During the pilot phase, we also collected various samples of marine larvae and screened them using DNA barcodes to (A) verify proof of concept – that larvae could be sampled effectively using this technique, and (B) to determine the effectiveness of our sampling by examining the level of taxonomic overlap between larval collections and adult censusing. Concentrating on fishes and decapods at first, we were successful in generating marine barcodes for >90% of the individual larvae. However, only 25% of the decapod larvae matched adult sampled specimens, whereas approximately half (48%) of the fish larvae matched sampled adult species. These results are not surprising as efforts to comprehensively sample the decapod fauna were not as rigorous as those for fishes. Nevertheless, the lack of accurate matches (<3% genetic divergence) indicates that a large portion of the reef community remains under-sampled, either because of accessibility (buried deep within the reef matrix), rarity or depth (deep reef fauna). Future efforts in the next three years of the MBP are geared toward closing this gap between sampling methods and understanding the causes of this disparity.

## 26.1230

**Gamete Competition Is A Prezygotic Barrier in Broadcast Spawning Sea Urchins: Evidence From Mixing Gametes Of Two Species And Rearing The Offspring**

**M. Aminur RAHMAN*[1]**, Tsuyoshi UEHARA[2]

[1]Smithsonian Tropical Research Institute, PO Box 0843-03092, Balboa, Panama, Balboa, Panama, [2]Department of Chemistry, Biology and Marine Science, Faculty of Science, University of the Ryukyus, 1 Senbaru, Nishihara-cho, Okinawa 903-0213, Japan, Okinawa, Japan

Two tropical sea urchins belonging to the genus Echinometra, Echinometra sp. A (Ea) and Echinometra sp. C (Ec) occur nearly sympatrically and abundantly on Okinawan intertidal reefs. Earlier studies have confirmed that the two species are reproductively isolated and introgression is either very low or non-existence between them. To understand which mechanism(s) maintain their genetic integrity, a series of cross-fertilization and gamete competition experiments was conducted in the laboratory. Similar to previous studies, fertilization rates in heterospecific crosses were high when eggs of Ec and sperm of Ea were involved, whereas they were significantly lower with eggs of Ea and sperm of Ec, even at a very high sperm concentration. Gamete incompatibility probably prevents hybridization between eggs of Ea and sperm of Ec. However, because eggs of Ec are readily fertilized by sperm of Ea, gamate incompatibilty itself is probably not responsible for the absence of Ec x Ea hybrids in the field. We found that different exposure times of eggs and sperm at various sperm concentrations showed that conspecific crosses reached asymptotic fertilization level much sooner than heterospeciific crosses, indicating that conspecific sperm have higher affinity to their eggs than heterospecific sperm. In gamete competition experiments, eggs from either species or both in equal proportions were mixed with the sperm from either species or both in equal proportions at various sperm concentrations and the resulting larvae were reared through metamorphosis to 4-5 month old juveniles. Tubefoot spicules in Ea x Ea were always bihamate (100%), whereas those in Ec x Ec were always triradiate (100%). The spicule morphologies of the hybrids were intermediate mixes and tended toward maternal affinities; these differences were used to identity hybrids and their parental genotypes in each gamete competition experiment. We found that at lower sperm concentration (1.05 x 105/ml) where conspecifics reached only 60-70% fertilization, very few Ec x Ea (1.3-3.3%) hybrids were produced. At the sperm concentration (1.05 x 106/ml) where conspecific crosses showed near 100% fertilization, more Ec x Ea hybrids were found (8.7-12.7%) but no Ea x Ec hybrids. At higher sperm concentrations, 1.05 x 107/ml, 1.05 x 108/ml, and 1.05 x 109/ml, the percentages of Ec x Ea and Ea x Ec hybrids produced from the various competitive fertilizations were 13.3-18.0 and 0, 18.7-21.3 and 0.7-2.0, and 22.7-26.7 and 2.7-4.5, respectively. Moreover, in each gamete mixing experiments, the proportion of Ec x Ec conspecifics was significantly higher than that of Ea x Ea, suggesting that larger eggs of Ec may present a larger target for sperm than those of Ea, thereby producing higher numbers of Ec juveniles than Ea. Overall, the production of only a few hybrids in each competition experiment is likely due to conspecific sperm outcompeting heterospecific sperm for fertilization. Ea occurs mainly on the reef flat while Ec occurs on the reef's seaward margin, so most individuals are not found near each other. Their spawning seasons overlap extensively, and if they spawn simulataneoulsly, incoming waves would mix and then sweep gametes of Ec over the reef flat to mix with gametes of Ea.. Most of the eggs of Ec would likely be fertilized by sperm of Ec before they mixed with gametes of Ea on the reef flat, and excess sperm of Ec would have a competitive advantage to fertilized the remaining unfertilized eggs of Ec. Conversely, the incompatibility of eggs of Ea with sperm of Ec, decreases the chances of Ea x Ec hybrids. Consequently, habitat partitioning and asymmetric gamete compatibility both have significant roles in maintaining species boundaries between these broadcast spawning urchins.

## 26.1231

**Diversity And Abundance Of Reef Macro Invertebrates (Mollusca, Echinodermata) in The Southern Gulf Of California, México**

**Maria Dinorah HERRERO-PEREZRUL*1**

[1]Pesquerias y Biologia Marina, CICIMAR-IPN, La Paz, Mexico

There are three important islands in the southern Gulf of California, included in a Marine Protected Area, San José (SJI), Espíritu Santo (ESI) and Cerralvo (CRI). The islands support coral communities with associated invertebrates, especially mollusks and echinoderms. Some species of both groups are currently under protection or subjected to fishery. Even though the islands are protected, little is known about the diversity and abundance of these macro invertebrates. The objective of this work was to estimate the diversity and abundance of macro mollusks and echinoderms at these three islands. The study was done from February 2005 to February 2007, each island was visited twice, considering two seasons, warm (Jun-Nov) and cold (Dec-May). A total of 165 belt transects (25 x 2 m) were done to estimate species richness, diversity and abundance on each island and season. A total of 20 species of echinoderms (5310 individuals) and 19 of macro mollusks (2020 individuals) were identified. Species richness and abundance was statistically different among the islands for both Phyla; however, diversity showed no differences. Species assemblage was different on each island. ESI had more echinoderms and SJI had more mollusks. The most abundant echinoderms were asteroids, followed by echinoids and holothurians. The dominant species were the sea star *Phataria unifascialis*, followed by the sea urchin *Tripneustes depressus* and the holothurian *Holothuria fuscocinerea*. Regarding mollusks, the gastropods were the most abundant with 12 species, whilst bivalves had only 7. SJI and CRI had more gastropods species than ESI. The dominant gastropod and bivalve were *Serpulorbis margaritaceus* and the mother of pearl *Pinctada mazatlanica*, which is currently under special protection. Commercial species were not so abundant, like *Isostichopus fuscus* and *Muricanthus princeps*.

## 26.1232

**A Quantitative Assessment Of The Cryptobenthic Fish Assemblage On Isolated Coral Colonies in The Tropical Eastern Pacific.**

Adriana ALZATE VALLEJO[1], **Fernando A. ZAPATA*[1]**, Alan GIRALDO[1]

[1]Biology, Universidad del Valle, Cali, Colombia

The cryptobenthic fish assemblage associated to small, isolated massive and branching coral colonies at Gorgona Island, Colombia, was examined using two sampling methods. We compared samples obtained by direct capture using a $1m^3$ net-box and application of clove oil against samples obtained by visual censuses. A total of 38 species belonging to 16 families were recorded through both methods combined. More species were recorded by direct capture (33 species) than by visual censuses (23 species). Mean species richness was significantly greater in samples obtained by direct capture (4.2 species) than in samples obtained by visual census (2.4 species; $p<0.001$). Therefore, visual censuses underestimated total richness of cryptobenthic fishes by 30%, and mean richness by 43%. Moreover, 39.5% of all species were recorded only by direct capture, while 13.2% were recorded only by visual censuses. Comparisons of the cryptobenthic component with the whole coral reef fish assemblage, which is usually studied by visual censuses, revealed that 51% of the species directly captured had been visually recorded in previous studies of the whole community. However, the remaining portion of the cryptobenthic assemblage was not recorded through traditional visual censuses. Finally, carnivorous species made up a greater proportion of the cryptobenthic assemblage (~72%) than of the whole coral reef fish assemblage (~59%). Thus, cryptobenthic fishes on tropical eastern Pacific coral reefs represent a previously ignored yet potentially important component of the fish assemblage in terms of diversity and functional roles.

## 26.1233

**Absence Of Mitochondrial Variation in Three Species Of Tropical Sea Anemones, Heteractis Magnifica, Heteractis Crispa,, And Entacmaea Quadricolor, in Populations From The Indian And Pacific Ocean**

Tina DOHNA[1], Marc KOCHZIUS[1], **Tina DOHNA*[2]**

[1]Biotechnology and Molecular Genetics, UFT, Bremen, Germany, [2]Biotechnology and Molecular Genetics, UFT, University of Bremen, Bremen, Germany

Mitochondrial DNA (mtDNA) markers, such as the cytochrome *c* oxidase subunit I (COI), have been extensively used in population genetic studies and phylogeography to elucidate both past and present population patterns worldwide. The use of this marker has, however, lead to little success in the phylum Cnidaria, which includes hydroids, jellyfish, sea anemones, and corals. In contrast to other higher animal phyla, mutation rates in the mitochondrial DNA of this phylum appear to be much slower than that of the nuclear DNA, despite the fact that germ cells are not sequestered. Due to the multitude of studies on corals using mtDNA markers, this finding has been repeatedly generalized for all members of the cnidaria, even though no studies on sea anemones have been conducted to confirm this finding. This study has investigated the genetic variability of a 629 bp long fragment of the COI mitochondrial marker (DNA barcoding marker) for populations of three species of giant tropical sea anemones, *Heteractis magnifica (n=50), Heteractis crispa (n=15), and Entacmaea quadricolor (n=15)* from the Indian and the Pacific Ocean, spanning the Indo-Malay Archipelago. Though each species of sea anemone produces an individual genetic sequence for this fragment of the COI marker, within each species specific sequence, not a single base pair difference could be detected. Considering the extended separation of Pacific and Indian Ocean populations during the last ice age due to sea level changes these findings suggest a stringent mitochondrial replication control mechanisms. Several explanations have been proposed for this mechanism in corals that could also provide an explanation for the exceptional longevity of these animals and the lack of any apparent senescence.

## 26.1235

**What Are The Costs Of Bad Taxonomic Practices?**

**Kathryn COATES*[1]**, Jan LOCKE[2]

[1]Dept. of Conservation Services, Flatts, Bermuda, [2]Univ. of Puerto Rico, Flatts, Bermuda

The recent description of a new, but commonly encountered, Caribbean scleractinian coral species, *Madracis auretenra* Locke, Weil and Coates, 2007 brought our attention to the high costs of poor taxonomic practices. Since the mid-1970's more than 118 studies have named *Madracis mirabilis* (sensu Wells 1973) as one of the study organisms; in a number of these we believe this was actually the new species *M. auretenra*. However, for a variety of reasons, no specific identity can be verified for the individuals that were named as *M. mirabilis* in at least one-quarter of the studies. No matter what kind or how many data are applied to the question of taxonomic identity, if good taxonomic practices are not applied, then this is a predictable outcome. A few basic elements of practicing good taxonomy are 1) reference to original materials, including type specimens, original descriptions and study-specific reference materials; 2) a working knowledge and understanding of the international codes of nomenclature; and 3) maintenance of reference materials for all specimens where taxonomic identity is of significance to the application of related data. The immediate costs of bad taxonomy are the sum of the research funds plus the value of time and facilities that are used to produce compromised data. If these data are not referable to any species-level taxon then they cannot be applied in any analyses having species-level implications – including studies of diversity, physiology, reproduction, biogeography, ecology and evolution.

## 26.1236

**Knowledge base on coral Systematics of the Mascarene archipelago : presentation of the results**

Yannick GEYNET[1], **Michel PICHON*[2]**, Gérard FAURE[3], David GROSSER[1]

[1]IREMIA - University of La Réunion, St Denis - Réunion Island, Reunion, [2]EPHE - Perpignan, Perpignan, France, Metropolitan, [3]University of Montpellier, COURNONTERRAL, France, Metropolitan

In the process of monitoring, managing and conserving biodiversity, some biologists have become experts and have developed a unique know-how to produce species inventories. These experts are not simply living encyclopedias to be found in Museums, but also individuals with first hand experience, educated intuitions and reasoning powers applicable to decision making (naming, classifying, identifying a specimen) in particular domains of knowledge.

But expertise in Systematics is at a turning point: it is becoming rare. For future biodiversity studies relying on species identification, environmental officers and researchers will only be left with monographic descriptions and collections in museums.

This is the reason why a knowledge base on the zooxanthellate scleractinian corals of the Mascarene Archipelago is being developed. Based on the Gerard Faure's collection of approximately 4000 specimens (13 families) collected in the Mascarene Archipelago, this project relies on two online computer-based applications and a web site.

The web site offers an easy-to-use, worldwide, bilingual (English and French) interface to access the results. One part of the site is dedicated to the Scleractinia facts (biology, ecology, conservation, etc), another is dedicated to the taxonomic aspects and proposes online identification tools.

The first identification tool, called Xper² and developed by the LIS (Informatic and Systematics Laboratory) in Paris, is used for the identifications from the order to the genera. The second identification tool, named IKBS (Iterative Knowledge Base System) and developed by the IREMIA (Institute for Research in Applied Mathematics and Computer Science) in La Réunion, is used for the identifications from families to species.

During the two preceding phases of the project, 4 Scleractinian families (Pocilloporidae, Siderastreidae, Fungiidae, Astrocoeniidae) have been processed. The present (third) phase will deal with 3 additional families/genera (Faviidae, Acroporida, Mussidae).

## 26.1237

**Molecular Phylogenetic Analyses Indicate Very Low Genetic Variation Between *porites Porites*, *p. Furcata*, And *p. Divaricata***

**Matthew LUCAS*1**, Semoya PHILLIPS[2], Sandra ROMANO[3]

[1]Biology, Southeast Missouri State University, St. Thomas, Virgin Islands (U.S.), [2]University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.), [3]Div. of Sci. & Math, University of the Virgin Islands, St. Thomas, Virgin Islands (U.S.)

The taxonomy of Scleractinian corals is not well understood largely due to a high degree of overlap in morphological variation in skeletal characters used to distinguish closely related taxa and difficulties in determining character homologies. The ability to distinguish species is important as reliable taxonomy is necessary to manage coral populations**.** In the Caribbean, the genus *Porites* exemplifies the species problem in corals. A gradual continuum of morphological variation exists among three sympatrically occuring branching *Porites* species with branch diameters ranging from thin (*P. divaricata*) to thick branches (*P. porites*) with an intermediate form (*P. furcata*). Some allozyme and morphometric data provide some support for independent species status for these three nominal species. However these characters have limited taxonomic resolution. Ten colonies of each species were photographed, observed, and collected. DNA sequences from nuclear ribosomal DNA (IT*S*-1 & IT*S*-2) and three noncoding regions of mitochondrial DNA were PCR amplified, cloned, sequenced, and aligned. Molecular phylogenetic analyses of 850 bp demonstrate little genetic variation between the three nominal species suggesting that they are not good species as has been previously hypothesized. Further analyses will determine if these results are due to 1) a lack of variability in chosen markers or 2) lack of observed genetic variation within these species due to recent speciation.

# *Memo*

## C

## D

## L

## M

## N

## P

## W

# 11th International Coral Reef Symposium

Fort Lauderdale, Florida, USA
July 7–11, 2008


**11th ICRS Secretariat**
**(Meeting Office)**
FASEB
Office of Scientific Meetings & Conferences
9650 Rockville Pike
Bethesda, MD 20814-3998