1-1-2011


Steven Miller  
*Nova Southeastern University, smiller@nova.edu*

Leanne M. Rutten  
*Nova Southeastern University*

Mark Chiappone  
*Nova Southeastern University, mc191@nova.edu*

Find out more information about Nova Southeastern University and the Halmos College of Natural Sciences and Oceanography.

Follow this and additional works at: [https://nsuworks.nova.edu/occ_facreports](https://nsuworks.nova.edu/occ_facreports)

Part of the [Marine Biology Commons](https://nsuworks.nova.edu/occ_facreports), and the [Oceanography and Atmospheric Sciences and Meteorology Commons](https://nsuworks.nova.edu/occ_facreports)

Recommended Citation

Sampling Methods for *Acropora* Corals, Other Benthic Coral Reef Organisms, and Marine Debris in the Florida Keys

Field Protocol Manual for 2011-2012 Assessments

December 2011

Steven L. Miller, Leanne M. Rutten and Mark Chiappone
Center for Marine Science, University of North Carolina at Wilmington,
515 Caribbean Drive, Key Largo, FL 33037, USA
Sampling Methods for *Acropora* Corals, Other Benthic Coral Reef Organisms, and Marine Debris in the Florida Keys

Field Protocol Manual for 2011-2012 Assessments

December 2011

Principal Investigator
Steven L. Miller, Center for Marine Science (CMS), University of North Carolina at Wilmington (UNCW), 515 Caribbean Drive, Key Largo, FL 33037, Tel: 305 451 9030, Fax: 305 853 1142  
Email: millers@uncw.edu

Survey Team  
Mark Chiappone and Leanne Rutten, CMS/UNCW, 515 Caribbean Drive, Key Largo, FL 33037  
Email: chiappone@uncw.edu and ruttenl@uncw.edu

Suggested Citation

Acknowledgements
Funding for this multi-year project has been provided by NOAA’s Coral Reef Conservation Program, NOAA’s Aquarius Reef Base (ARB) through the University of North Carolina-Wilmington, and Emerson Associates International. Boat and diving support have been provided by NOAA and UNCW’s Aquarius Reef Base Program (*R/V Research Diver*, *R/V George F. Bond*), the upper Keys office of the Florida Keys National Marine Sanctuary, and a variety of local dive shops. J. Delaney and M Tagliareni (NOAA/FKNMS) have assisted with permitting and grant administration, respectively. S.G. Smith and J. Ault of RSMAS-UM have been instrumental in sampling design and statistical guidance. Research has been conducted in the Florida Keys under National Marine Sanctuary Permit FKNMS-2010-077.

Cover photo. Examples of benthic coral reef organisms and underwater survey methods used during 2011 in the upper Florida Keys National Marine Sanctuary. Upper left: *Acropora palmata* at Elbow Reef, Florida Keys; Upper right: Marine debris surveys; Lower left: Coral abundance, size, and condition surveys; Lower right: *A. cervicornis* colony measurements.
Table of Contents

Overview ......................................................................................................................... 4

I. Sampling Design ............................................................................................................. 7

II. Field protocols ............................................................................................................. 14

   A. Site Demarcation and Transect Deployment ................................................................. 14

   B. Physical Data ............................................................................................................... 18

   C. *Acropora* Corals ........................................................................................................ 19

   D. Anemones and Corallimorpharians ........................................................................... 29

   E. Urchins ........................................................................................................................ 33

   F. Mollusks ....................................................................................................................... 35

   G. Marine Debris ............................................................................................................. 38

References ......................................................................................................................... 42

Appendix ............................................................................................................................ 47

Appendix 1. Example Data Slates ................................................................................... 47

Appendix 2. Equipment and Supply List .......................................................................... 52
Overview

The 2011-2012 sampling of Acropora corals, other coral reef benthic invertebrates, and marine debris in the Florida Keys National Marine Sanctuary (FKNMS) is being undertaken as a spatially intensive effort to provide updated population distribution and abundance information. The particular focus of surveys in the Florida Keys, as well as in the U.S. Caribbean (Puerto Rico and the U.S.V.I.), concerns the habitat distribution, colony density, size, condition, and population abundance of Acropora corals. Surveys in the Florida Keys also include assessments of urchins, mollusks, anemones, corallimorpharians, and marine debris. These additional assessments are relatively fast and easy to perform. Annual surveys for Acropora corals began in 2006 in the Florida Keys in response to their listing on the Federal Endangered Species List, as well as the paucity of large-scale information on habitat distribution, abundance, and condition in the Florida Keys. Periodic surveys for Acropora corals as part of our long-term monitoring and assessment program date back to 1999. The purpose of this field protocol manual is to outline the Acropora sampling procedures used in the Florida Keys and to standardize survey methods for the Florida and U.S. Caribbean regional population assessments planned for 2012. A previous draft of this manual was prepared for Florida Keys National Marine Sanctuary personnel in June 2011 to help guide the field sampling in 2011.

The Florida Keys surveys during May-September 2011 were conducted from the southern boundary of Biscayne National Park to the Alligator Reef area offshore of Islamorada. These surveys are an outgrowth of previous efforts conducted by our program to quantify the abundance and condition of coral reef benthic organisms throughout the FKNMS, including the Tortugas region (Miller et al. 2002, see http://people.uncw.edu/millers), with a particular focus on comparisons of organism distribution, abundance, size, and condition related to the FKNMS no-take zones implemented in 1997. The goal of the 2012 field effort is to expand the geographic scope of these surveys to include Biscayne National Park and a large portion of the FKNMS from northern Key Largo to Key West, which encompasses most of the geographic distribution and hence populations of the two Acropora species (A. cervicornis and A. palmata). Previous benthic survey efforts by our program in the FKNMS, excluding the Tortugas region, consisted of:

- 80 sites sampled Keys-wide in 1999;
- 45 sites in the lower Keys region in 2000;
- 107 sites in the upper Keys region in 2006;
- 235 sites Keys-wide in 2007;
- 145 sites Keys-wide in 2008;
- 160 sites Keys-wide in 2009;
120 sites sampled in the upper Keys in 2010; and
280 sites sampled in the upper Keys in 2011.

Three hundred sites were targeted for the 2011 surveys; ultimately, we were able to sample 280 sites in the upper Florida Keys region during May-September 2011. Data obtained from earlier efforts, together with existing habitat mapping information for the FKNMS, were used to guide the sampling of benthic coral reef organisms and marine debris in 2011. In a similar manner, we will use existing data and habitat maps in the U.S. Virgin Islands and Puerto Rico to help guide their sampling in 2012.

The overall goals of the 2011 sampling effort were to:

- Continue the temporal data sets on the abundance and size of *Acropora* corals, urchins, anemones and corallimorpharians, and mollusks, as well as the frequency, density, amount, and impacts of entangled marine debris throughout the upper Florida Keys and a portion of the middle Keys region.
- Use the 2011 surveys as a guide for the 2012 Keys-wide effort to optimize sampling of *Acropora* corals in terms of the number of sites, effort expended per site, and the allocation of sites among habitat types, along-shelf position (regional location), and management zones (i.e. FKNMS no-take zones).

The 2011 surveys provided the opportunity to conduct detailed population assessments of several groups of benthic invertebrates dating back to 1999. The sampling effort in 2011 provided information on the:

- Depth range and physical structure (maximum vertical relief) of survey sites;
- Density, size class, and condition (percent live tissue, disease, bleaching, predation) of all scleractinian corals greater than 4 cm in maximum diameter;
- Distribution, density, size, and condition of *Acropora* corals, including counts, measurements, and assessments of condition (e.g. bleaching, disease, and predation) at the skeletal and physiological levels of a colony;
- Density and size (test diameter) of sea urchins, representing an ongoing effort to monitor recovery of the historically abundant long-spined sea urchin *Diadema antillarum*;
- Density of sea anemones and corallimorpharians;
- Density and total/shell length of mollusks such as sea slugs, nudibranchs, and select gastropods (*Coralliophila* spp., *Leucozonia nassa*, and *Thais deltoidea*), including queen conch (*Strombus gigas*); and
Density, amount (length and weight) of marine debris, especially lost fishing gear (angling gear and trap debris), and the number of sessile benthic invertebrates exhibiting tissue abrasion from debris entanglement.
I. Sampling Design

The sampling design for assessing benthic coral reef organisms and marine debris in the Florida Keys during 2011 consisted of a target sampling effort of 300 sites, from northern Key Largo near the boundary between the FKNMS and Biscayne National Park to the Alligator Reef area. The sampling design for 2012 will ideally include most of the Florida Keys archipelago, excluding the Marquesas and Tortugas regions, from northern Biscayne National Park to Key West. The sampling incorporates three factors or levels in a two-stage stratification design: habitat type (includes cross-shelf location and depth), geographic region (along-shelf position), and management zone (i.e. areas inside and outside FKNMS no-take zones). The habitat strata selected for the 2011 sampling incorporated most of the hard-bottom and coral reef habitat types from the island platform (e.g. inshore patch reefs such as Tavernier Rocks) inshore of Hawk Channel to ~15 m depth along the offshore reef tract. Based upon previous surveys and existing knowledge of the distribution of Acropora corals, the 2011 (and 2012) efforts did not (and will not) include nearshore hard-bottom, hard-bottom/seagrass matrix habitats, or deeper (>15 m) fore-reef areas. The following hard-bottom and coral reef habitats were sampled in 2011, with examples shown in Figures I-1 and I-2 below:

- Inshore patch reefs along the island platforms, inshore of Hawk Channel (e.g. Cheeca Rocks and Tavernier Rocks);
- Mid-channel patch reefs from the shoreward to seaward edge of Hawk Channel;
- Offshore patch reefs seaward of Hawk Channel;
- Shallow (<6 m), low-relief hard-bottom;
- Back-reef rubble;
- High-relief spur and groove; and
- Deeper fore-reef habitats (6-15 m) encompassing continuous, low-relief hard-bottom, patchy hard-bottom, and low-relief spur and groove.

In addition to habitat type, sites are further categorized by geographic region, or along-shelf position (e.g. upper, middle, and lower Keys). During 2011, only two regions in the Florida Keys were surveyed:

- The upper Keys region from the southern BNP boundary down to Davis Reef (Tavernier Creek) and
- A portion of the middle Keys region from Crocker Reef to Alligator Reef.

Management zone is a third factor in the stratification design and consists of randomly selected sites located inside and outside of FKNMS no-take zones designated as Sanctuary Preservation Areas (SPAs), Ecological Reserves (ERs), and Research Only Areas (ROs). The sampling design also incorporates areas inside and outside
of John Pennekamp Coral Reef State Park (designated in 1960), where spearfishing, lobster/crab trap fishing, and marine life collection are prohibited, as well as the Key Largo Sanctuary Management Area, which encompasses the boundaries of what was the Key Largo National Marine Sanctuary (designated in 1975). The following Sanctuary no-take zones were sampled in 2011, arranged from northeast to southwest, while the 2012 surveys will ideally include all 23 no-take zones from Key Largo to Key West (see Figure I-3):

- Carysfort/South Carysfort SPA: offshore patch reefs, back-reef rubble, high-relief spur and groove, and deeper fore-reef habitats;
- The Elbow: back-reef rubble, high-relief spur and groove, and deeper fore-reef habitats;
- Dry Rocks SPA: offshore patch reefs and high-relief spur and groove;
- Grecian Rocks SPA: high-relief spur and groove and deeper fore-reef habitats;
- French Reef SPA: back-reef rubble and high-relief spur and groove;
- Molasses Reef SPA: back-reef rubble, high-relief spur and groove, and deeper fore-reef habitats;
- Conch Reef SPA: shallow hard-bottom and deeper fore-reef habitats;
- Conch Reef RO: deeper fore-reef habitats;
- Davis Reef SPA: shallow hard-bottom and deeper fore-reef habitats;
- Hen and Chickens SPA: mid-channel patch reefs;
- Cheeca Rocks SPA: inshore patch reefs; and

Sites are selected for sampling using a habitat map of the Florida Keys and a grid system constructed in a geographic information system (GIS). Grid cells 200-m x 200-m (40,000 m²) in dimension are used to randomly select sites from the combination of habitat type, geographic region, and management zone factors (Figure I-4). Benthic habitat types are designated using regional benthic habitat maps provided by NOAA and Florida’s Fish And Wildlife Research Institute. The habitat classification scheme accounts for features that correlate with benthic faunal distributions, including cross-shelf position, topographic complexity, and the proportion of sand interspersed among hard-bottom structures. A geographic regional stratification variable is used to account for oceanographic and geological features in the Florida Keys that influence the distribution and community composition of hard-bottom and reef habitats. Geographic regions are defined as follows: upper Florida Keys (BNP boundary south to Davis Reef), middle Florida Keys (Crocker Reef southwest to Moser Channel), and lower Florida Keys (Big Pine Shoal west to Satan Shoal). FKNMS no-take zones are incorporated as a third stratification variable that delineates areas open and closed to consumptive activities. Within each no-take zone, a minimum of two replicate sites are sampled in a given habitat type.
A two-stage sampling design following Cochran (1977) and adapted by Smith et al. (2011) is used to control for spatial variation in population metrics at scales smaller than the grid cell minimum mapping unit. Using this design, the 200-m by 200-m grid cells containing targeted coral reef and hard-bottom habitats are designated as primary sample units (Figure I-4). The second-stage sample unit is defined as a belt transect of fixed area (15-m x 1-m in dimension) within each primary sample unit. The size of an individual primary sampling unit allows divers to swim to the location of any given second-stage sampling unit from a moored or anchored vessel. The power of the stratified random sampling approach is essentially two-fold: 1) the habitats comprising the most area are initially allocated more sites than those with less area (i.e., a proportional design); and 2) habitats exhibiting more variability with respect to particular metrics (e.g. coral density) are allocated more sites than those with less variability. The ultimate power of this approach is derived more from the number of sites sampled rather than the effort expended per site.
Figure I-1. Examples of patch reef and shallow hard-bottom habitats in the Florida Keys.

Inshore patch reef
Tavernier Rocks, 2.4-4.6 m
24° 56.594’N, 80° 33.376’W

Offshore patch reef
West of Elbow Reef, 4.3-6.1 m
25° 09.213’N, 80° 16.074’W

Mid-channel patch reef
West of Turtle Rocks, 2.1-3.7 m
25° 17.210’N, 80° 13.425’W

Offshore patch reef
Inshore of Conch Reef, 3.7-6.1 m
24° 57.363’N, 80° 29.576’W

Low-relief hard-bottom
Little Pickles Reef, 4.3-5.5 m
24° 59.023’N, 80° 25.148’W

Low-relief hard-bottom
Crocker Reef, 3.4-4.3 m
24° 54.518’N, 80° 31.631’W
Figure I-2. Examples of high-relief spur and groove and deeper fore-reef habitats in the Florida Keys.

<table>
<thead>
<tr>
<th>High-relief spur and groove</th>
<th>High-relief spur and groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Carysfort Reef, 1.5-5.2 m</td>
<td>Sand Island, 3.0-5.2 m</td>
</tr>
<tr>
<td>25° 12.566’N, 80° 13.102’W</td>
<td>25° 01.089’N, 80° 22.099’W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low-relief hard-bottom</th>
<th>Low-relief spur and groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Conch Reef, 8.8-10.1 m</td>
<td>Conch Reef, 13.4-14.3 m</td>
</tr>
<tr>
<td>24° 56.428’N, 80° 28.515’W</td>
<td>24° 57.156’N, 80° 27.133’W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patchy hard-bottom</th>
<th>Low-relief spur and groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>East of Dry Rocks, 6.4-7.9 m</td>
<td>Pickles Reef, 8.5-9.4 m</td>
</tr>
<tr>
<td>25° 07.719’N, 80° 17.641’W</td>
<td>24° 59.031’N, 80° 24.968’W</td>
</tr>
</tbody>
</table>
Figure I-3. The Florida Keys National Marine Sanctuary study area and additional management units in the larger south Florida ecosystem.
Figure I-4. The two-stage stratification designed for the Florida Keys: (A) incorporates habitat type (cross-shelf position and depth), geographic region (along-shelf position), and management zone, utilizing a grid of 200-m x 200-m cells overlain onto existing habitat and bathymetry maps. (B) The example below shows an example of the two-stage stratification approach, where first- or primary-stage units shown as squares with a targeted habitat type are randomly selected based upon the three stratification variables. (C) An enlarged view of the sample grid with the arrow indicating a 200-m x 200-m cell containing a targeted benthic habitat type. (D) An enlarged view of one sample cell where second-stage units (transects) are deployed at random GPS points within a particular cell. Note that in 2011 we deployed two 15-m transects in each cell (site) surveyed.
III. Field Protocols

A. Site Demarcation and Initial Transect Deployment

The sample effort for 2011 targeted 300 sites, with an additional 156 alternate sites, from the southern boundary of Biscayne National Park to Alligator Reef offshore of Islamorada. Sites are randomly selected from the total domain of 200-m x 200-m cells overlaying the Florida Keys habitat map, constrained proportionally by habitat type, geographic region, and management zone factors. Ultimately, we surveyed 280 sites (Figure A-1) during May-September 2011 during 29 days of field operations. Randomly generated waypoints are located in the center of each 200-m x 200-m cell selected for sampling. Details regarding the sample design are found in Smith et al. (2011). Upon arrival at the waypoint, if the intended habitat is not immediately found, an area up to 100-m radially out from the waypoint is searched. If the appropriate habitat type is still not found, a note is made and the closest alternate site should be sampled instead.

Once on-site, a diver-flag with a GPS receiver attached to a buoy is deployed to mark the site. We presently use a Garmin® global positioning system receiver (model GPS76) to determine the position at each site. Upon water entry, the survey team of two to four divers proceeds to the dive flag, descends to the bottom, and haphazardly lays out two 15-m transect tapes approximately 5 to 10-m apart. Because of dive-safety considerations, transect tapes should not be located more than 15-m apart (50 feet). A 1-m wide belt centered on each 15-m long transect tape (15 m²) is surveyed for most of the benthic variables described below (see Figure A-2), for a total of 30 m² surveyed per site. Exceptions to this pattern are the coral density/size/condition surveys for all non-Acropora corals, which are surveyed in 10-m x 1-m (10 m²) belt transects, and marine debris, which is surveyed in 15-m x 2-m belt transect (30 m²). At all sites sampled during 2011, 15-m² belt transect areas were surveyed for:

- Minimum and maximum depth;
- Maximum vertical relief of the substratum such as ledges, spur edges, crevices, coral heads, and sponges such as Xestospongia muta;
- Number of colonies, skeletal unit size, live tissue surface area, and condition (bleaching, disease, predation, overgrowth) of Acropora corals;
- Numbers of anemones and corallimorpharians; and
- Numbers and total lengths or shell lengths of nudibranchs, the lettuce sea slug (Elysia crispata), and the gastropods Coralliophila (all species), Leucozonia nassa, Thais deltoidea, and Strombus gigas.
Smaller transect areas (10-m x 1-m) were surveyed for the numbers of colonies, sizes (binned by size class), and condition of all other scleractinian corals greater than 4 cm in maximum diameter. Finally, 15-m x 2-m belt transect areas were surveyed for the density of marine debris, the length of all angling gear and lobster/crab trap rope recovered, the numbers of benthic organisms exhibiting abrasion stress (partial mortality due to tissue loss), and the wet weight of all debris collected per transect. Data are collected using pencils and pre-printed slates that facilitate efficient recording. At the end of the day, slates are photocopied for archival purposes, data are transferred to pre-printed sheets and checked for errors related to coding or counts, and then entered into spreadsheets using portable computers. Copies of information printed on the slates and an equipment list for the field are included in the Appendix.
Figure A-1. Sampling locations for *Acropora* corals, other benthic coral reef organisms, and marine debris in the upper Florida Keys National Marine Sanctuary during May-September 2011. Two-hundred and eighty (280) sites were surveyed for coral density, size, and condition, including *Acropora* corals, as well as urchins, anemones, corallimorpharians, mollusks, and marine debris from the southern boundary of Biscayne National Park to Alligator Reef.
Figure A-2. Images that illustrate underwater methods of data collection.

- Underwater slate for data collection
- Marine debris retrieval
- Using the 0.5-m scale bar
- Transect deployment
- Acropora cervicornis colony measurements
- Belt transect survey
**B. Physical Data**

In addition to GPS recordings of site location and general site description notes, additional physical data consist of measurements of minimum and maximum depth along sampled transects, as well as maximum vertical relief. These data are collected on both 1-m by 15-m belt transects at each site. The diver swims along the transect and notes the minimum and maximum depths of the transect using a depth gauge. The maximum vertical relief of hard substrate features (including ledges, spur edges, crevices, coral heads, and structural sponges (but excluding gorgonians and *Millepora alcicornis*) encountered within the 15-m x 1-m belt transect is recorded to the nearest cm. We use a 50- or 100-cm scale bar to estimate the greatest vertical relief features encountered within the belt transect boundaries. The surveyor also notes the identity of the maximum vertical relief feature. These data are used to summarize the depth range and average depth surveyed for each site, as well as the maximum and the average maximum vertical relief of the transects surveyed.
**C. Acropora Corals**

To document the current population status of *Acropora* corals, we assessed the spatial distribution, colony abundance, size, and condition of these two species in the upper Florida Keys during 2006, 2010, and 2011, as well as Keys-wide in 2007-09. These efforts contribute to a temporal record dating back to 1999 on the abundance, size, and condition of *Acropora* corals. Using a stratified random sampling design, the goals of the 2011 surveys were to continue this temporal record in the upper and a portion of the middle Florida Keys, but also to prepare for a Keys-wide assessment in 2012. The data will be used to construct population abundance estimates by size class and by habitat to provide comparisons to similar data collected in the Florida Keys during 2006-2011.

The field methodology for assessing *Acropora* corals consists of the following:

- Once replicate 15-m transects are deployed at a particular site, *Acropora* corals are sampled for presence-absence, colony numbers, colony sizes, and condition by species. *Acropora* corals are identified to species. If the F1 hybrid, *A. prolifera* is encountered, it is noted and sampled too.
- An area 0.5 m out on each transect side (a 15-m x 1-m or 15-m$^2$ belt transect) is searched for *Acropora* corals.
- *Acropora* colonies are assessed at both the skeletal unit and physiological unit levels, as described below, for numbers, size, and condition.

There are currently six levels of measurement we consider when *Acropora* corals are encountered. First, if *Acropora* corals are present, but are not encountered within transect boundaries, a note is made of their presence at the site. The second level of measurement consists of presence-absence recordings within transect boundaries. These data provide an estimate of transect frequency of occurrence; in other words, the percentage of transect stations where either species was encountered. We have found that even this semi-quantitative metric provides a clear picture of differences in habitat distribution in the Florida Keys.

The third and fourth levels of measurement (see Table C-1) for *Acropora* corals involve recording the size and condition of each colony (skeletal unit and physiologic unit) within the 15 m$^2$ belt transects. A skeletal unit is defined as a continuous skeleton, regardless of whether or not the colony is partitioned into several individual patches of continuous live tissue (Figure C-3). Physiologic units are defined as individual patches of continuous live tissue that are contained within a skeletal unit. Of course, it can be very challenging in some cases to determine what constitutes the original skeletal unit; for example, if a much older skeleton has been recently colonized by one or more new colonies. New colonies can generally be identified by regular tissue boundaries,
polyps and/or color different from other pieces of contiguous tissue. The tissue boundaries of physiologic units most often display evidence of recent or long-term tissue mortality. We purposely avoid ramet and genet terminology because it is impossible to know for sure, unless genetic analyses are conducted. In the past, we have sampled for genetic work (Hemond and Vollmer 2010). Distinguishing physiologic units within skeletal units provides a useful measure of colony fragmentation, especially when associated with predation, bleaching, or disease. However, it is problematic and time consuming to count and measure physiologic units on large skeletal units. In the Florida Keys, we have conducted these measurements because densities are low and most colonies we encounter are small.

The third level of measurement focuses on the skeletal unit. First, the skeletal unit’s size is determined by measuring the maximum branching diameter, secondary branching diameter (perpendicular to the maximum diameter), and maximum height to the nearest centimeter. Care should be taken to identify, as best as possible, the former extent of the skeletal unit in cases where tissue mortality has occurred. The skeletal unit observations are useful because they provide some measure of a colony’s history. Next, the skeletal unit should be assessed for percent live tissue or dead skeleton (no live tissue) using categories of 10% (e.g. completely alive, 0-10% dead, 10-20% dead, etc.). The recorder should note whether or not the dead colony areas appear to be recent or not. Recently dead areas are defined as any non-living part of the coral in which the corallite structures are white and either still intact or covered by a layer of fine mud and/or silt. In contrast, long-dead areas are generally defined as any non-living parts of the coral in which the corallite structures are either gone or covered over by organisms that are not easily removed. When recently dead areas of a colony are present, a cause of the mortality is noted if possible (e.g. disease, predation, breakage, or overgrowth). Finally, the condition of the skeletal unit is noted; the current notable conditions include, but are not limited to:

- Presence of disease (white band, white pox);
- Evidence of predation (damselfishes, snails, fireworms);
- Evidence of bleaching (pale, partially bleached, bleached);
- Overgrowth causing tissue loss by algae, *Palythoa*, gorgonians, sponges, and other corals; and
- Colony damage due to obvious physical impacts from breakage (i.e. storm events), abrasion, and burial.

The fourth level of measurement focuses on the physiologic units contained within the skeletal unit. The size, percent dead tissue, and condition are assessed for each individual physiologic unit using the same procedures described above for skeletal units. If a skeletal unit has not suffered partial mortality (or the living portion of the skeletal unit is a single patch of live tissue), the same size, percent dead tissue, and conditions should be noted for the physiological colony as for the skeletal unit. It is common to have multiple physiologic units per skeletal unit.
The fifth level of measurement consists solely of meticulous measurements of all live tissue (e.g. individual branches, patches, and bases) to accurately estimate the surface area of live tissue within each colony, and include the number and length of individual branches, sizes and numbers of individual living patches, and size of bases, where colonies attach to the bottom. For example, if an *Acropora cervicornis* colony is encountered and consists of two patches of live tissue on one larger skeletal unit, the following measurements would be made:

- Level three – one skeletal unit assessment of colony size, percent dead tissue, and colony condition;
- Level four – two physiologic unit assessments of colony size, percent dead tissue, and colony condition;
- Level five – two physiologic unit assessments surface area based on all live tissue (e.g. individual branches, patches, and bases).

These precision measurements are extremely time consuming, and may be omitted if surface area is not of primary importance to the investigation.

The sixth level of measurement transitions from population metrics to more of a mapping effort. Terminology transitions too, from skeletal and physiologic units to clumps, thickets and stands, based on the areal extant of the coral (Table C-1). For example, *Acropora palmata* is still abundant at a few locations in the Florida Keys (see Grecian Rocks, lower left image, in Figure C-2). At these locations, it is simply impossible to identify individual colonies and even if one could, it would not be practical to measure all of them individually. The same can be said for *A. cervicornis* (Figure C-1). Accordingly, new terminology is required to guide sampling. Methods for the sixth level of sampling focus on size measurements of the clumps, thickets, and stands, including perimeter, maximum diameter, secondary diameter, and height. Tapes are used at the smaller ranges of these categories, while enhanced GPS (e.g. accuracy to less than 3 meters, while typical differential GPS has 3-5 m accuracy) can be used for larger thickets and stands by measuring perimeters, if available. The perimeters may be recorded by divers swimming with the GPS or by a crew using a vessel, depending on the distance (height is still measured by tape). Decisions about using tape or GPS are based on feasibility to measure a thicket or stand in a timely and safe manner, and availability of enhanced GPS or standard dGPS, relative to the size of the clumps, thickets, or stands.

Clearly, clumps, thickets, and stands fall outside traditional population metrics. However, in the case of *Acropora cervicornis* and *A. palmata*, when such features are encountered using a two-stage stratified random design, they are a useful metric to help evaluate the status of the species. Results provide an estimate of the number of these larger features by habitat type, geographic region, and management zone. Further, when GPS is used to measure such features their locations are also determined, which could be useful in a repeated designs study. Repeated
measures designs, while not part of the current study, could have significant management relevance in the Florida Keys, where the location of the last remaining A. palmata thickets and stands are known. If recovery occurs, it will likely be from: the expansion of existing Acropora clumps, thickets, and stands; recruitment; growth and expansion of existing small colonies; or a combination of all these elements. Recruitment and growth and expansion of existing colonies are population metrics specifically measured as part of our sampling program. The larger clumps, thickets, and stands are also picked up in the existing sample design, but because they are rare, variance remains large.

A potential seventh level of measurement deals with sub-sampling of clumps, thickets, and stands. The metrics in level seven are similar to measurements in previous levels, and include condition (disease, predation, bleaching, overgrowth, and breakage), percent live versus dead, physiologic number and sizes, and branch numbers and sizes (for percent cover calculations). It is possible that percent cover might be a relevant metric, in cases where clearly defined patches exist, but are either not continuous or include other features (e.g. large head or mounding corals, sand patches). Which of these metrics are sampled will depend on questions being asked and time available to sample. Such sampling needs to be balanced against the larger program goal of trying to sample more sites, rather than intensely sampling a few sites. We do not have extensive experience sampling larger clumps, thickets, and stands, as these are relatively rare in the Florida Keys. A detailed manual for demographic sampling of A. palmata (Williams et al. 2026), to document the status and trends of individual colonies, includes colony measurements that are similar to ours, but breaks down at higher densities when identifying individual colonies becomes difficult. At a minimum, presence and absence of diseases, predation, and bleaching is a reasonable first approach, and is what we intend to include as a part of future sampling, along with an estimate of percent living tissue versus dead skeleton. Finer-scale measurements to obtain variance estimates using quadrats or point-intercept techniques can be considered as well. However, these finer-scale measurements fall outside the realm of our program goal, which is to estimate the population sizes of these two coral species.

Because disease, disease-like conditions, and predation on Acropora corals can be confusing, descriptions below provide some clarification, along with Figure C-4. White band disease is characterized by complete coral tissue degradation of Caribbean Acropora corals. The disease exhibits a sharp demarcation between apparently healthy coral tissue and exposed coral skeleton. These signs are identical to plague, except that white band is specific to Acropora corals; in addition, plague has not been found on these species. Tissue loss usually proceeds from the base of the colony branch to the tip, although it can begin in the middle of a branch in A. cervicornis. There are two etiologies of white band disease: type I and type II. In type I, tissue destruction is associated with the moving front of the band. In type II, there is at times a bleached zone between the area of tissue degradation and the
moving front. If the bleached zone is not present, type I is visually indistinguishable from type II. The only way to distinguish the two types is to observe the band progression over time.

White pox is characterized by coral tissue degradation that occurs in association with circular lesions on the Caribbean scleractinian coral Acropora palmata. Rapid loss of tissue progresses along a distinct line, or with small remnants of tissue sometimes present near the margin of, irregularly shaped patches anywhere on the upper or lower surfaces of Acropora palmata branches. The average rate of tissue loss is 2.5 $\text{cm}^2$/day, although rates up to 10.5 $\text{cm}^2$/day can occur.
Figure C-1. Examples of *Acropora cervicornis* in hard-bottom and coral reef habitats of the Florida Keys.

<table>
<thead>
<tr>
<th>Mid-channel patch reef, 3.0-4.0 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>West of Conch Reef</td>
</tr>
<tr>
<td>24° 57.529 N, 80° 29.427 W</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mid-channel patch reef, 1.5-3.0 m</td>
</tr>
<tr>
<td>Basin Hill Shoals</td>
</tr>
<tr>
<td>25° 13.250 N, 80° 15.618 W</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mid-channel patch reef, 2.1-3.7 m</td>
</tr>
<tr>
<td>West of Turtle Rocks</td>
</tr>
<tr>
<td>25° 17.210 N, 80° 13.425 W</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Offshore patch reef, 4.3-4.9 m</td>
</tr>
<tr>
<td>White Bank (NW of French Reef)</td>
</tr>
<tr>
<td>25° 03.022 N, 81° 21.612 W</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>High-relief spur and groove, 3.7-4.6 m</td>
</tr>
<tr>
<td>NE Pickles Reef</td>
</tr>
<tr>
<td>24° 59.465 N, 80° 24.478 W</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Low-relief hard-bottom, 4.6-6.1 m</td>
</tr>
<tr>
<td>Conch Reef C2</td>
</tr>
<tr>
<td>24° 57.292 N, 80° 27.504 W</td>
</tr>
</tbody>
</table>
Figure C-2. Examples of *Acropora palmata* in hard-bottom and coral reef habitats of the Florida Keys.

<table>
<thead>
<tr>
<th>Back reef rubble, 2.4-2.7 m</th>
<th>High-relief spur and groove, 2.4-5.5 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickles Reef</td>
<td>Carysfort Reef C5</td>
</tr>
<tr>
<td>24° 59.185 N, 80° 25.129 W</td>
<td>25° 13.332 N, 80° 12.603 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-relief spur and groove, 3.0-5.2 m</th>
<th>High-relief spur and groove, 2.7-5.2 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Island</td>
<td>Little Grecian Rocks</td>
</tr>
<tr>
<td>25° 01.089 N, 80° 22.099 W</td>
<td>25° 07.112 N, 80° 18.028 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-relief spur and groove, 2.7-4.6 m</th>
<th>High-relief spur and groove, 5.2-7.9 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grecian Rocks SPA</td>
<td>Elbow Reef SPA</td>
</tr>
<tr>
<td>25° 06.532 N, 80° 18.312 W</td>
<td>25° 08.752 N, 80° 15.421 W</td>
</tr>
</tbody>
</table>
Figure C-3. Examples of a skeletal unit versus a physiologic unit in *Acropora cervicornis*. Note branch in black box separated from larger colony by dead branch area, indicated by arrow.

Skeletal colony = continuous skeleton
- May have one or more patches of live tissue
- Overall dimensions (length, width, height measured)

Physiologic colony = patch of continuous live tissue
- Overall dimensions (length, width, height) measured
- Individual branch measurements (length, diameter)
Figure C-4. Disease, disease-like conditions, and predation of *Acropora* corals.

- **White band type II in *Acropora***
- **White pox**
- **Damselfish bites**
- **Damselfish bites**
- **Coralliophila snail predation**
- **Possible snail predation or white pox**
Table C-1. *Acropora* population metrics for Level 3, 4, 6, and 7. Levels 1 and 2 deal with presence-absence at the site and transect levels, respectively. Level 5 measurements include branch and patch sizes and numbers for colony surface area estimates. Level 7 metrics might also include cover, branch density and branch diameter. Clumps, thickets, and stands are arbitrary terms that we are evaluating for longer-term usage, and could change before the 2012 field season. Acrv = *A. cervicornis*, Apal = *A. palmata*.

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Size Parameters Level 3-4</th>
<th>Condition Measurements Levels 3-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Diameter</td>
<td>Second Diameter</td>
</tr>
<tr>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrv &lt; 25 cm</td>
<td>Tape/Ruler</td>
<td>Tape/Ruler</td>
</tr>
<tr>
<td>Apal &lt; 1 m</td>
<td>Tape/Ruler</td>
<td>Tape/Ruler</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrv 25-100 cm</td>
<td>Tape/Ruler</td>
<td>Tape/Ruler</td>
</tr>
<tr>
<td>Apal 1-3 M</td>
<td>Tape/Ruler</td>
<td>Tape/Ruler</td>
</tr>
<tr>
<td>Clump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrv 1-5 m</td>
<td>Tape</td>
<td>Tape</td>
</tr>
<tr>
<td>Apal 3-10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thicket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrv 5-30 m</td>
<td>Tape/GPS</td>
<td>Tape/GPS</td>
</tr>
<tr>
<td>Apal 10-30 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrv &gt;30 m</td>
<td>Tape/GPS</td>
<td>Tape/GPS</td>
</tr>
<tr>
<td>Apal &gt;30 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
D. Anemones and Corallimorpharians

Quantitative surveys of other benthic cnidarians in the Florida Keys during 2011 were conducted at 280 sites in the middle and upper Florida Keys, with a Keys-wide effort planned for 2012. These surveys target anemones (O. Actiniaria) and corallimorpharians (O. Corallimorpharia) known to occur in the Florida Keys, with a particular focus on the larger and conspicuous or field-identifiable members of both orders. Similar surveys were conducted in the study area during 1999-2001 (211 sites), 2005 (195 sites), 2008 (145 sites), 2009 (160 sites), and 2010 (120 sites), as well as in the Dry Tortugas region during 2000, 2006, and 2008. Because some species of anemones and corallimorpharians are collected for the marine aquarium trade, these surveys are designed to quantify differences in distribution, density, and abundance among habitats and management zones in the Florida Keys.

Since 1999, we have encountered five conspicuous anemone species, all of which tend to have solitary and larger polyps compared to other cnidarians: the giant Caribbean or pink-tipped anemone Condylactis gigantea in the Family Actiniidae, the ringed or corkscrew anemone Bartholomea annulata in the Family Aiptasiidae, the speckled anemone Epicystes (=Phymanthus) crucifera in the Family Phymantididae, Bunodosoma granulifera (first record since study inception), and Lebrunia danae. Two other anemones, the knobby anemone (Heteractis lucida) and the sun anemone Stichodactyla (=Stoichactis) helianthus, are rarely encountered, but are still searched for during the benthic surveys. Tube-dwelling anemones and very cryptic species (e.g. L. coralligens) are not included in these surveys. Figure D-1 shows six of the seven anemone species (S. helianthus not shown) that are targeted in belt transect surveys. Three corallimorpharians are also included for sampling: Discosoma (=Paradiscosoma) carlgreni and D. sanctithomae in the Family Actinodiscidae and Ricordea florida in the Family Corallimorpharidae (Figure D-2). Corallimorpharians, sometimes called false corals, differ from anemones in the arrangement of the tentacles, and may be solitary, but are typically found in clusters.

Anemones and corallimorpharians are surveyed in two 15-m x 1-m belt transect surveys per visited site. The procedures for sampling are as follows:

- Once transects are deployed, start at one end of the transect tape and search 0.5 m out from the left transect side using the 0.5-m scale bar. At the end of the 15-m transect, turn around and search the other side of the transect tape (similar to the belt transect surveys for physical data, urchins, mollusks, and Acropora corals).
- Any anemones or corallimorpharians that are encountered within the 0.5-m belt area on each side of the transect are identified and counted.
- Data recorded on the slate includes the abbreviation for the species and the number of individuals encountered.
The abbreviations used for these organisms are as follows and consist of a four-letter code with the first letter of the genus and generally the next three letters of the scientific name:

- Bartholomea annulata = BANN
- Bunodosoma granulifera = BGRA
- Condylactis gigantea = CGIG
- Epicystes crucifera = ECRU
- Lebrunia danae = LDAN
- Stichodactyla helianthus = SHEL
- Discosoma carlgreni = DCAR
- D. sanctithomae = DSAN
- Ricordea florida = RFLO
Figure D-1. Anemones (Cnidaria, Anthozoa) surveyed for presence-absence, density, and habitat distribution in the Florida Keys. Not pictured is *Stichodactyla helianthus* (sun anemone), which is rarely encountered.

<table>
<thead>
<tr>
<th><strong>Bartholomea annulata</strong> (corkscrew anemone)</th>
<th><strong>Epicystes crucifera</strong> (speckled anemone)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Bartholomea annulata" /></td>
<td><img src="image2" alt="Epicystes crucifera" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Bunodosoma granulifera</strong></th>
<th><strong>Heteractis lucida</strong> (knobby anemone)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Bunodosoma granulifera" /></td>
<td><img src="image4" alt="Heteractis lucida" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Condylactis gigantea</strong> (giant pink-tipped anemone)</th>
<th><strong>Lebrunia danae</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Condylactis gigantea" /></td>
<td><img src="image6" alt="Lebrunia danae" /></td>
</tr>
</tbody>
</table>
Figure D-2. Corallimorpharians (Cnidaria, Anthozoa, Corallimorpharia) surveyed for presence-absence, density and habitat distribution.

*Discosoma carlgreni*  

*Ricordea florida*  

*D. sanctithomae*  

*R. florida*  

*Discosoma carlgreni*  

*Ricordea florida*  

*D. sanctithomae*  

*R. florida*
**E. Urchins**

Beginning in 1999, we have conducted large-scale surveys of urchin abundance and size in a diversity of habitats across the south Florida shelf encompassing now over 1,100 sites. We recently described the population status of *Diadema antillarum* based upon surveys of 235 sites along ~200 km of the Florida reef tract during 2007. Additional surveys were conducted Keys-wide in 2008 (145 sites), 2009 (160 sites), and 2010 (120 sites). Urchin surveys include all echinoids encountered, in addition to *D. antillarum*, and to our knowledge, these efforts represent the only large-scale, repeated, surveys for urchins being conducted in the Florida Keys.

Quantitative surveys in the upper and a portion of the middle Florida Keys during May-September 2011 targeted echinoids known to occur coral reef and hard-bottom habitats throughout the Florida Keys; thus, our surveys do not include sand dollars and sea biscuits, which tend to occur in soft-sediment habitats and not in reef environments. The accompanying figure shows each of the six echinoids commonly encountered (Figure E-1). Urchins are surveyed in two 15-m x 1-m belt transect surveys per site. The procedures for sampling are as follows:

- Once transects are deployed, start at one end of the transect tape and search 0.5 m out from the left transect side using the 0.5-m scale bar. At the end of the 15-m transect, turn around and search the other side of the transect tape (similar to the belt transect surveys for physical data, cnidarians, mollusks, and *Acropora* corals).
- Any urchins that are encountered within the 0.5-m belt area on each transect side are counted and measured for test diameter (not including the spines) to the nearest mm (0.1 cm) using plastic calipers or a ruler.
- Data recorded on the slate includes the abbreviation for the species and the test sizes of the of individuals encountered for each species.
- The abbreviations used for these organisms are as follows and consist of a four-letter code with the first letter of the genus and generally the next three letters of the scientific name:
  - *Arbacia punctulata* = APUN
  - *Diadema antillarum* = DANT
  - *Echinometra lucunter* = ELUC
  - *Echinometra viridis* = EVIR
  - *Eucidaris tribuloides* = ETRI
  - *Lytechinus variegatus* = LVAR
  - *Tripneustes ventricosus* = TVEN
Figure E-1. Urchin (echinoid) species surveyed for habitat distribution, density, and size (test diameter) in the Florida Keys. Not shown is *Arbacia punctulata*.

<table>
<thead>
<tr>
<th>Diadema antillarum</th>
<th>Eucidaris tribuloides</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diadema antillarum" /></td>
<td><img src="image2" alt="Eucidaris tribuloides" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Echinometra lucunter</th>
<th>Lytechinus variegatus</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Echinometra lucunter" /></td>
<td><img src="image4" alt="Lytechinus variegatus" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Echinometra viridis</th>
<th>Tripneustes ventricosus</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Echinometra viridis" /></td>
<td><img src="image6" alt="Tripneustes ventricosus" /></td>
</tr>
</tbody>
</table>
The Florida Keys marine ecosystem supports a diverse fauna of mollusks belonging to several orders. Opisthobranch mollusks, for example, are represented by at least 30 species of sea slugs (Sacoglossa) and 23 species of nudibranchs (Nudibranchia), including at least three endemic species. Data on the status and trends of mollusk populations and habitat utilization patterns in the Florida Keys are generally limited, with the exception of queen conch (*Strombus gigas*). Since 2001, we have conducted intermittent surveys of various gastropod mollusk species in conjunction with assessments of other benthic coral reef organisms (Figure F-1). In 2007, 2010, and most recently in 2011, we surveyed *Coralliophila* snail predation on *Acropora* corals and quantified the density of two other Neogastropoda species (*Leucozonia nassa* and *Thais deltoidea*) that were particularly abundant on high-relief spur and groove reefs. During 2001 and 2008-2009, we surveyed *Cyphoma* abundance, size, and gorgonian host occupation patterns.

During 2011, replicate 15-m x 1-m belt transects per site were surveyed for the following sacoglossan, nudibranch, and Neogastropoda mollusks:

- The lettuce sea slug, *Elysia (Tridachia) crispata*, Class Gastropoda, Subclass Opisthobranchia, Order Sacoglossa, Family Elysiidae;
- All nudibranchs encountered, including *Hypselodoris edenticulata* (Florida regal sea goddess), *H. bayeri* (black-spotted sea goddess), *Chromodoris kempfi* (purple-crowned sea goddess), *C. nyalya* (red-line blue sea goddess), and *Glossodoris sedna* (red-tipped sea goddess) of the Class Gastropoda, Subclass Opisthobranchia, Order Nudibranchia; and
- The Neogastropoda mollusks *Thais deltoidea* (Lamarck) of the Family Thaididae, *Coralliophila* sp. of the Family Coralliophilidae, *Leucozonia nassa* (Gmelin) of the Family Fasciolariidae, and the queen conch (*Strombus gigas*) of the Family Strombidae.

Of the targeted species, members of the genera *Chromodoris* and *Hypselodoris* are generally very rare. However, all of the targeted mollusks encountered are quantified to determine transect frequency of occurrence, density, shell or total length, and substratum occupancy patterns. An accompanying figure (Figure F-1) shows the more common mollusks that are included in the belt transect surveys. Mollusks are surveyed in two 15-m x 1-m belt transect surveys per visited site. The procedures for sampling mollusks are as follows:

- Once transects are deployed, start at one end of the transect tape and search 0.5 m out from the left transect side using the 0.5-m scale bar. At the end of the 15-m transect, turn around and search the other
side of the transect tape (similar to the belt transect surveys for physical data, cnidarians, urchins, and *Acropora* corals).

- Any of the targeted mollusk species that are encountered within the 0.5-m belt area on each transect side are counted and measured for total or shell length. The type of substratum the mollusk is found occupying, such as coral (indicate species) or algae (indicate by functional group) should also be noted.

- For queen conch, shell lip thickness is measured with plastic calipers, in addition to total shell length.

- Data recorded on the slate includes the abbreviation for the species, the shell or total length of each individual, and the substratum type where the mollusk was found (e.g. algal turf, crustose coralline algae, and coral species).

- The abbreviations used for these organisms are as follows and consist of a four-letter code with the first letter of the genus and generally the next three letters of the scientific name:
  
  - *Chromodoris kempfi* = CKEM
  - *Chromodoris nyalya* = CNAY
  - *Flabellina* sp. = FLAB
  - *Glossodoris sedna* = GSED
  - *Hypselodoris bayeri* = HBAY
  - *Hypselodoris edenticulata* = HEDE
  - *Hypselodoris olgae* = HOLG
  - *Hypselodoris picta* = HPIC
  - *Elysia (Tridachia) crispata* = TCRI
  - *Coralliophila* sp. = CABB
  - *Leucozonia nassa* = LNAS
  - *Thais deltoidea* = TDEL
  - *Strombus gigas* = SGIG (surveyed for shell lip thickness and total shell length)
Figure F-1. Selected mollusks (sacoglossans, nudibranchs, gastropods) surveyed for habitat distribution, density, and size in the Florida Keys. Not pictured are certain nudibranchs of the genera *Hypselodoris* and *Chromodoris* that are infrequently encountered, as well queen conch (*Strombus gigas*).
G. Marine Debris

Baseline data on marine debris and the biological impacts to coral reef benthic organisms were collected by our program during 2000, 2001, and 2008 (Chiappone et al. 2002c, 2004, 2005). Earlier surveys consisted of quantitative surveys of debris at 45 sites in the lower Keys from inshore to offshore during 2000, followed by surveys of 63 platform margin sites Keys-wide in 2001. These initial efforts addressed several questions pertaining to marine debris and its impacts to benthic organisms. First, what is the spatial extent and frequency of remnant fishing gear at multiple spatial scales in the Florida Keys? Second, what factors, such as habitat type (depth) or management regime (closed or open to fishing) affect the spatial variability of marine debris occurrence? Third, what are the biological impacts of marine debris, especially from remnant commercial and recreational fishing gear, on reef biota such as hard corals and sponges? As a follow-up to these initial surveys, a major effort was expended during 2008 to document the different debris types, length (where applicable), weight, and impacts to benthic coral reef organisms (e.g. abrasion damage) at 145 sites partitioned by habitat type, regional sector, and management zone from northern Key Largo to SW of Key West. To our knowledge, these data represent the most comprehensive site-level assessment of marine debris and its corresponding impacts in the Florida Keys. These data demonstrate the ubiquitous and damaging characteristics of marine debris, particularly derelict fishing gear, even within “protected” no-fishing zones in the Sanctuary. In 2010, we were able to incorporate marine debris surveys in our upper Keys sampling design to document the frequency of occurrence and biological impacts of marine debris encountered in the course of belt transect surveys for other benthic variables. During 2011, these surveys were continued at 280 sites in the upper Keys and included measurements of debris length and debris collection per transect for weight determinations.

Marine debris is surveyed along both 15-m transects, but an area 1-m out from each transect side is searched instead of 0.5 m, thus yielding a total belt transect area of 30 m². Along each belt transect, any marine debris encountered is identified, counted, measured (if applicable), and collected (Figures G-1 and G-2). The number of organisms impacted by marine debris is also noted, where a marine debris impact is considered where an item is causing abrasion damage to Millepora and scleractinian corals, gorgonians, sponges, and the colonial zoanthid Palythoa. For entangled hook-and-line angling gear, measurements of total length of monofilament, wire leaders, wire, and hooks are made either underwater or on-board the research vessel. For trap gear, total length of trap rope is measured, not including plastic pot openings, plastic trap grating, wooden slats, and cement used to weight the traps. For each transect, all marine debris encountered is recovered from the bottom and placed into labeled mesh gear bags to determine total wet weight per transect once on-board the research vessel. A digital 50-pound scale is used (we use the Rapala® model RSDS-50) to obtain the wet weight of marine debris collected along each transect. Debris items are also categorized according to whether it was biologically fouled or not. In cases where the entangled debris is either too large or too difficult to remove due to incorporation into the substrate, the debris
may be left behind, but a note is made of its occurrence, size, and any abrasion damage to benthic organisms. In addition, intact lobster/crab traps, whether buoyed or not, are not disturbed.

Of the debris entangled on the seabed, we divide entangled items into three major categories: angling gear, lobster/crab trap gear, and other debris. Angling gear consists of monofilament with or without lead sinkers and hooks, wire leader (including piano wire), lead sinkers, and fishing rods with or without intact reels. Lobster/crab trap gear can include: intact traps, rope with or without attached buoys, wooden slats, plastic trap grating, plastic pot openings (trap throats), and cement. Other debris encompasses everything else that is not angling or trap gear related, including metals, glass, and plastics.

The procedures for sampling marine debris are as follows:

- Once transects are deployed, start at one end of the transect tape and search 0.5 m out from the left transect side using the 1-m scale bar. At the end of the 15-m transect, turn around and search the other side of the transect tape (similar to the belt transect surveys for physical data, cnidarians, urchins, mollusks, and *Acropora* corals). Note that a wider search area is used for marine debris compared to all of the other benthic variables.
- If debris is encountered within the belt transect boundaries, the item is identified, recorded as fouled or clean, measured for total length to the nearest cm (only angling gear and trap rope).
- The observer should note if the debris item is in contact with any benthic coral reef invertebrates and count and identify the organisms impacted by tissue/skeletal abrasion.
- For each transect, all debris encountered is placed into a collection bag and brought back on-board for the determination of wet weight. Note that debris weight for each transect includes all debris items encountered along a transect.
- Data recorded on the slate include the debris type, length (if applicable), whether the item is fouled or not, the number of individuals or colonies of each type of organism exhibiting abrasion damage, and the wet weight for all items encountered along the transect.
Figure G-1. Surveys of marine debris consist of 1-m search areas out on each side of a 15-m transect. Any debris encountered on a transect is identified, measured (applicable to angling gear such as monofilament line and lobster/crab trap gear such as trap rope) and collected for weighing. If the debris consists of angling gear or trap rope, each individual item is measured to the nearest cm, either while underwater or once back on the boat. Any milleporid hydrocoral, scleractinian coral, gorgonian, sponge, or colonial zoanthid (*Palythoa*) in contact with debris and exhibiting tissue/skeletal abrasion is noted.
Figure G-2. Examples of marine debris commonly encountered on the seabed in the Florida Keys.

<table>
<thead>
<tr>
<th>Monofilament</th>
<th>Trap rope debris</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Monofilament" /></td>
<td><img src="image2" alt="Trap rope debris" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trap rope debris</th>
<th>Trap rope debris</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Trap rope debris" /></td>
<td><img src="image4" alt="Trap rope debris" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intact lobster trap</th>
<th>Trap grating</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Intact lobster trap" /></td>
<td><img src="image6" alt="Trap grating" /></td>
</tr>
</tbody>
</table>
References


Benaka, L. R. (1999) Fish habitat: Essential fish habitat and rehabilitation. AFS Symposium 22, Bethesda, MD


Bursey CR, Harmer JA (1979) Induced changes in the osmotic concentration of the coelenteron fluid in the sea anemone _Condylactis gigantea_. Comp. Biochem Physiol 64A:73-76


Clark KB (1994) Ascoglossan (=Sacoglossa) molluscs in the Florida Keys: Rare marine invertebrates at special risk. Bull Mar Sci 54:900-916
DeMaria K (1996) Changes in the Florida Keys marine ecosystem based upon interviews with experienced residents. The Nature Conservancy, Key West and Center for Marine Conservation, Washington DC, 134 p

[43]
FWCC (Florida Fish and Wildlife Conservation Commission) (2000) Fishing lines. Division of Marine Fisheries, Tallahassee, 8 p
Hartog JC den (1977) The marginal tentacles of *Rhodactus sanctithomae* (Corallimorpharia) and the sweeper tentacles of *Montastrea cavernosa* (Scleractinia): their cnidom and possible function. Proc Third Intl Coral Reef Symp 1:463-469
Kier PM, Grant RE (1965) Echinoid distribution and habits, Key Largo Coral Reef Preserve, Florida. Smithsonian Misc Coll 149:1-68


Rutten LM, Chiappone M, Swanson DW, Miller SL (In press) Stony coral species diversity and cover in the Florida Keys using design-based sampling. Proc 11$^{th}$ Intl Coral Reef Symp


Appendix

Appendix 1. Example data slates used for benthic surveys in the Florida Keys.

Appendix 1A. Dive log data slate used to record the dive #, site #, time up and down, maximum depth (z), bottom time, tank pressure at the beginning and end of the dive, and water temperature.

<table>
<thead>
<tr>
<th>Diver</th>
<th>Date:</th>
<th>Sampling Location:</th>
<th>Scanned:</th>
<th>Entered:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dive</th>
<th>Site</th>
<th>Time ↓</th>
<th>Time ↑</th>
<th>Z</th>
<th>BT</th>
<th>PSI ↓</th>
<th>PSI ↑</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diver</th>
<th>Date:</th>
<th>Sampling Location:</th>
<th>Scanned:</th>
<th>Entered:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dive</th>
<th>Site</th>
<th>Time ↓</th>
<th>Time ↑</th>
<th>Z</th>
<th>BT</th>
<th>PSI ↓</th>
<th>PSI ↑</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[47]
Appendix 1B. Example data slate used to record the site #, habitat, station or transect #, along with physical and biological variables. MinZ = minimum transect depth, measured in feet using a digital depth gauge. MaxZ = maximum transect depth. MVR-ID = maximum vertical relief measured along a transect, along with the identification of the relief feature. Under the ACRV and APAL columns, a “+” indicates a species is present within a belt transect boundary. ANEM = anemones, which are identified and counted. CMOR = corallimorpharians, which are identified and counted. Targeted mollusks are identified, measured for total or shell length to the nearest 0.1 cm, along with the substratum type occupied (e.g. algal turf, coralline algae, coral) when encountered. Urchins are identified and measured for test diameter to the nearest 0.1 cm.
Appendix 1C. Example data slate used to record information on the size and condition of all colonies, both at the skeletal and physiologic levels, of *Acropora* corals. Skeletal-level measurements include overall colony dimensions (length, width, and height), along with visual assessments of live tissue vs. dead skeleton and condition (bleaching, disease, predation, and overgrowth). Physiologic colony-level measurements include overall dimensions, condition notes, as well as individual branch (branch length and diameter or width) and basal measurements.

<table>
<thead>
<tr>
<th>Date</th>
<th>Date: 8/27/2011</th>
<th>Observer: EMB</th>
<th>Data:</th>
<th>Station Size: 10 x 15 m</th>
<th>Scanned:</th>
<th>Entered:</th>
</tr>
</thead>
<tbody>
<tr>
<td>257</td>
<td>1</td>
<td>6</td>
<td>Acropora</td>
<td>257-1</td>
<td>2 Acrv 10gal</td>
<td>257-2</td>
</tr>
<tr>
<td>257</td>
<td>2</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>3</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>4</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>5</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>6</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>7</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>8</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>9</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>10</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>11</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>12</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>13</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>14</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>15</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>16</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>17</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>18</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>19</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>20</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>21</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>22</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>23</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>24</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>25</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>26</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>27</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>28</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>29</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
<tr>
<td>257</td>
<td>30</td>
<td>1</td>
<td>Acrv 10gal</td>
<td>257-2</td>
<td>4 Acrv 6gal</td>
<td>257-1</td>
</tr>
</tbody>
</table>

Dimensions:
- Overall colony dimensions (length, width, and height)
- Visual assessments of live tissue vs. dead skeleton and condition (bleaching, disease, predation, and overgrowth)
- Physiologic colony-level measurements:
  - Overall dimensions
  - Condition notes
  - Individual branch (branch length and diameter or width)
  - Basal measurements
Appendix 1D. Example data slate used to record information on the number, size (binned by max. diameter size classes), and condition of all scleractinian corals greater than 4 cm in maximum diameter. For each belt transect, all scleractinian corals > 4 cm encountered are identified, counted, binned into size class intervals (e.g. 4-10 cm, 10-15 cm, etc.), and noted for condition (bleaching, disease, overgrowth, and predation).

| Date: 28/1/201
| Observer: LMR
| Data: Stony Coral
| Station Size: m x 10 m
| Scanned: ✓ Entered: ✓

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Post 2 A</td>
<td>SS 1 D 5 C</td>
<td>SS 1 D 5 C</td>
<td>SS 1 D 5 C</td>
<td>SS 1 D 5 C</td>
</tr>
<tr>
<td>Sid 1 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
<tr>
<td>Mcav 2 D</td>
<td>Ac 3 B 8 A</td>
<td>Ac 3 B 8 A</td>
<td>Ac 3 B 8 A</td>
<td>Ac 3 B 8 A</td>
</tr>
<tr>
<td>Mop 3 C</td>
<td>Side 1 A</td>
<td>Side 1 A</td>
<td>Side 1 A</td>
<td>Side 1 A</td>
</tr>
<tr>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
</tr>
<tr>
<td>Mop 1 B</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
<tr>
<td>Mop 2 C</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
<td>1 C 5 A</td>
</tr>
<tr>
<td>Mop 3 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
<tr>
<td>Mop 2 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
<tr>
<td>Side 4 A</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
</tr>
<tr>
<td>Mop 2 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
<tr>
<td>Side 2 B</td>
<td>4 B 5 A</td>
<td>4 B 5 A</td>
<td>4 B 5 A</td>
<td>4 B 5 A</td>
</tr>
<tr>
<td>Mop 2 A</td>
<td>2 B 5 A</td>
<td>2 B 5 A</td>
<td>2 B 5 A</td>
<td>2 B 5 A</td>
</tr>
<tr>
<td>Side 1 B</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
<td>3 B 5 A</td>
</tr>
<tr>
<td>Mop 2 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
<td>1 B 5 A</td>
</tr>
</tbody>
</table>

[50]
Appendix 1E. Example data slate used to record marine debris observations. Information collected includes the site #, habitat type, station # (transect #), the type of debris, length (cm, if applicable), the identification of benthic invertebrates experiencing abrasion damage, and the total wet weight of all debris items. For each debris item, the surveyor also notes whether the debris is fouled or clean. All debris items per transect are placed in a mesh bag and brought back to the surface to determine total weight.

<table>
<thead>
<tr>
<th>Date: 8/27/2011</th>
<th>Observer: NC</th>
<th>Station Size: 2m x 15 m</th>
<th>Scanned:</th>
<th>Entered:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Habitat</th>
<th>Station</th>
<th>Debris ID</th>
<th>Length</th>
<th>Impacts</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>(257)</td>
<td>MPR</td>
<td>1</td>
<td>wire leader</td>
<td>112</td>
<td>54.5</td>
<td>54 oz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>wire leader</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>wire leader</td>
<td>295</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>monofilament</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>metal grating</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>trap cement</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>trap leader</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>monofilament</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>plastic bag</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>glass bottle</td>
<td>88</td>
<td></td>
<td>28 oz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>174</td>
<td>pane-1 pdv-1</td>
<td></td>
</tr>
<tr>
<td>(258)</td>
<td>DPR</td>
<td>1</td>
<td>Trap rope</td>
<td>98.2</td>
<td>mcav-1</td>
<td>54 oz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>monofilament</td>
<td>60</td>
<td></td>
<td>1 oz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>wire leader</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(258)</td>
<td>LRMB</td>
<td>1</td>
<td>Trap rope</td>
<td>163</td>
<td>pfle-1 pdc-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>trap wood</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>metal ring</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>trap wood</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2. Equipment and supply list for benthic surveys in the Florida Keys.

Dive Flag/GPS Buoy:
Slic Pro-Bullet dive flag buoy (with extra 1 lb. weight)
Mesh bag (with wire handle and extra 3 lb. weight)
Polypropylene line (3/8” diameter, 50’ length)
Garmin GPSmap 76
Aquapak waterproof bag

Sampling Gear:
Two Keson fiberglass tapes (30m length)
Six PVC scale bars (modular 50cm lengths)
Assorted PVC slates (8 ½” x 11”, printed templates)
Pencils (usually Papermate Sharpwriter 0.7mm)
Measuring tools (rulers, calipers, and tapes)
Two mesh bags for (debris collection)
Canon SD1200IS Digital Elph Camera
Canon WP-DC29 Waterproof Case