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Spatial and temporal patterns of coral bleaching around Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands

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Abstract. 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 Buck Island Reef National Monument (BUIS) St. Croix, USVI. The bleaching event was preceded by 10 weeks of higher than average water temperatures (28.9-30.1°C). Random transects (100 m^2) over hard bottom habitats (N=94) revealed that approximately 51% of live coral cover was bleached. Nineteen of 23 coral species within 16 genera and two hydrocoral species exhibited signs of bleaching; species-specific bleaching patterns were variable throughout the study area. Coral cover for *Montastraea annularis* and species of the genus *Agaricia* were the most affected, while other species exhibited variability to bleaching. Although a weak but significant negative relationship (r^2=0.10, P=0.0220) was observed, bleaching was evident at all depths (1.5-28 m). Bleaching was spatially autocorrelated (P=0.001) and hot-spot analysis identified a cluster of high bleaching stations northeast of Buck Island. Bleaching was significantly reduced within all depth zones and habitat types upon subsequent monitoring during April (15%) and October (3%) 2006.

Key words: Coral Reef, Coral Bleaching, USVI, Buck Island.

Introduction

During June to October 2005, a significant coral bleaching event took place ranging throughout the Caribbean and the southeastern U.S. Satellite sea surface temperature data indicated that the thermal stress associated with this warm water was the highest experienced during the previous 20 years (NOAA Coral Reef Watch, http://coralreefwatch.noaa.gov/caribbean2005/, accessed 7/02/2008). In October 2005, data on extent and severity of the coral bleaching were recorded during the biannual monitoring of coral reefs in St. Croix, US Virgin Islands conducted by scientists from NOAA's Center for Coastal Monitoring and Assessment's Biogeography Branch (CCMA-BB) and the National Park Service's Buck Island Reef National Monument.

This study quantifies spatial patterns of coral bleaching observed along the northeastern shore of St. Croix comprised of habitats within and adjacent to BUIS and the northern portion of the East End Marine Park (EEMP) during October 2005 through October 2006 (Fig. 1.). Specific objectives include:

1) describing the extent, severity and spatial patterns of coral bleaching before, during and after the 2005 bleaching event
2) correlating coral bleaching with environmental factors such as *in situ* temperature and depth
3) describing taxonomic differences in the severity of bleaching experienced by different coral species.

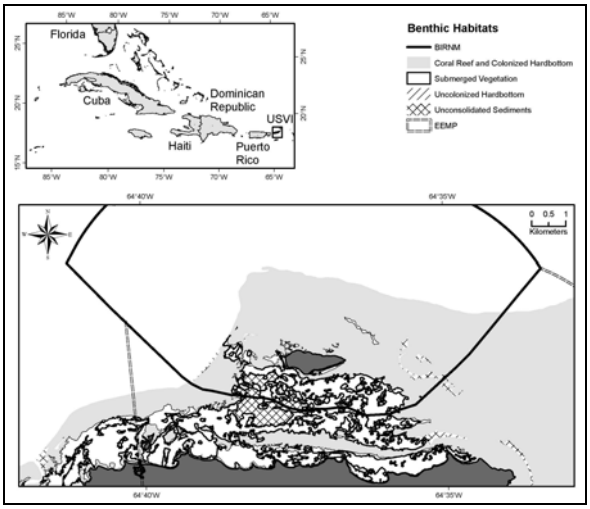

Figure 1: Map of study area around Buck Island Reef National Monument. BIRMN = Buck Island Reef National Monument; EEMP = East End Marine Park.

Material and Methods

Data on benthic composition were recorded from five $1m^2$ quadrats along randomly selected 25×4 m belt transects (100 m^2) as part of a larger project that surveyed 2,790 sites to characterize and monitor fishes and benthic composition in coral reef ecosystems in the US Virgin Island and Puerto Rico between 2001 and 2006. Survey sites were selected using a stratified random sampling design (Menza et al, 2006). Colonies were considered entirely bleached if they contained white, blotchy/mottled, or pale tissue (Fig. 2.). In situ water temperature data were obtained for January 1999 - December 2006 from a single data logger located at 10 m on the fore-reef at BUIS. Linear regression was used to examine the relationship between depths of sites and proportion of total coral cover bleached at each site. Autocorrelation of spatial bleaching patterns was tested using Moran's Index and Geary's C statistic. Time series plots of the proportion of live coral that was 'normal' or 'bleached' from October 2005 through October 2006 examined temporal trends in coral bleaching.

Figure 2: Bleached colony of *Acropora palmata* observed in the study area during October 2005. Quadrat in frame is $1m^2$, with 10cm x 10cm divisions.

Results

From October 2005 through October 2006, 27 scleractinian coral species within 21 genera and two species of fire coral were observed within 294 transects. Water temperatures were consistently higher during the study period when compared with the eight year mean (Fig. 3.).

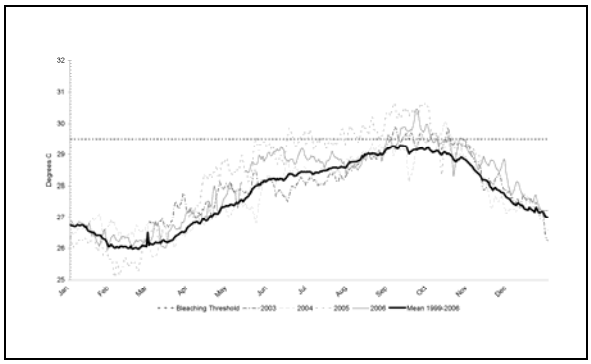

Figure 3: In situ water temperature from the forereef (10m) of BUIS 2003 – 2006. Flat dashed line is bleaching threshold (29.5^0C). Data provided by NPS.

During 2005, mean water temperature was significantly greater ($p<0.0001$) for each summer/fall month (Jun-Oct) than all other years.

October 2005

Mean percent of live scleractinian and fire coral cover (per 100 m^2) ranged from 0.96% on reef rubble to ~ 6% on linear and patch reefs. Surveys (n=94) identified 23 scleractinian coral species (16 genera) and two hydrocoral species. Bleached corals were observed at 91% of all transects (Fig. 4.). Bleached colonies were completely white, with few being mottled or pale. Fifty-one percent of the total coral cover within transects was bleached, and species-specific bleaching proportions ranged from 15.8-100%.

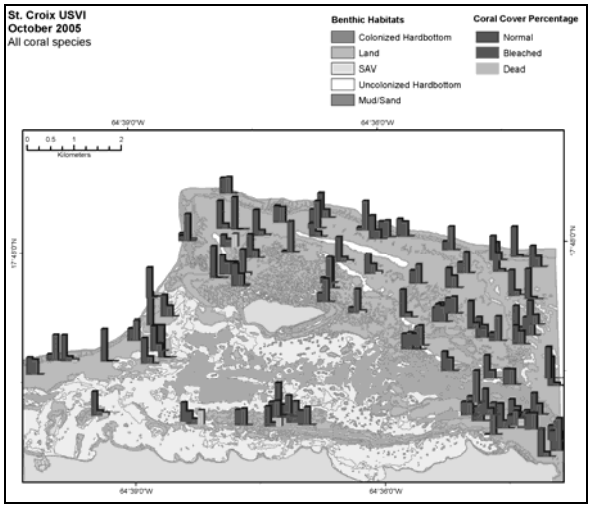

Figure 4: Coral cover percentages of all coral species that were observed as normal (showing no signs of bleaching or discoloration), bleached or dead at each site during October 2005.

April 2006 – Post Bleaching

Bleaching was significantly reduced ($p<0.0001$) throughout the study area during April 2006 vs. October 2005. Surveys (n=89) identified 31 species of

coral where 15% of total coral cover exhibited bleaching (Fig. 5.). Most colonies were mottled/pale, except *Agaricia*, which were completely bleached. Fifteen species exhibited no bleaching affects. Colonies of *M. annularis* and *D. strigosa* were less bleached than those observed in October 2005. *Agaricia* cover was less bleached (16%) than observed in October 2005 (92%). Only two species had bleaching percentages greater than 50% (*Millepora complanata* and *D. labyrinthiformis*) but were infrequently encountered. Overall, nearly all species showed a dramatic decrease in bleached cover within all depth zones.

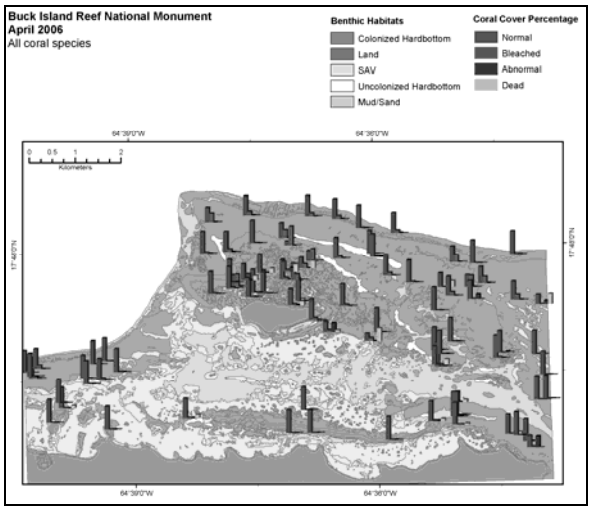

Figure 5: Coral cover percentages of all coral species that were observed as normal (showing no signs of bleaching or discoloration), bleached or dead at each site during April 2006.

October 2006 – One Year Post Bleaching

Bleaching was significantly lower ($p<0.0001$) than during the two previous sampling periods. Surveys (n=93) identified 20 scleractinian coral (5 genera) and two hydrocoral species. Bleaching was evident in 14% of transects with 3% of the total coral cover bleached. Most species exhibited significant declines in bleached cover within all depth zones compared to October 2005 and April 2006 (Fig. 6.). Dramatic decreases were observed for *M. annularis*, *P. asteroides*, *Agaricia*, *P. porites*, and *D. strigosa*.

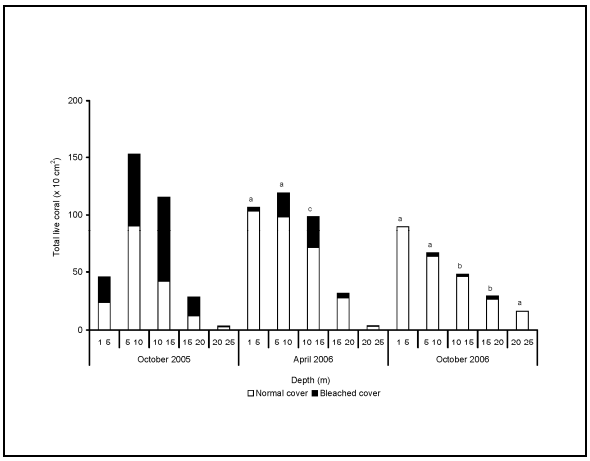

Figure 6: Normal and bleached coral cover within depth zones during study period. a=statistically different from Oct 2005; b=statistically significant from Oct 2005 and Apr 2006; c=statistically significant from Oct 2005 and Oct 2006. All at alpha=0.05.

Discussion

Bleaching events may alter the abundance of functional groups and their component species and have profound effects on the ability of local communities within the ecosystem to resist and recover from future disturbances. A better understanding of these indicators may help managers identify, design and manage protected areas to promote reef ecosystem survival. Results here provide evidence that bleaching has differential effects to the coral community; it is unknown what degree these effects have upon reef community structure. Understanding reef degradation (i.e. coral bleaching) at various scales and the potential for recovery should be a priority for scientifically based conservation and management plans.

Acknowledgement

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