Mission Report

NOAA/NOS/NCCOS/CCMA/Biogeography Team

October 17 – October 27, 2005

Characterization and monitoring of reef fish populations within and around Buck Island Reef National Monument, USVI:
A cooperative investigation between NOAA, the National Park Service, and the Virgin Islands Department of Planning and Natural Resources

NOAA
National Ocean Service
National Centers for Coastal Ocean Science
Center for Coastal Monitoring and Assessment
Biogeography Team
Silver Spring, MD 20910

April 2006

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Mission Purpose:

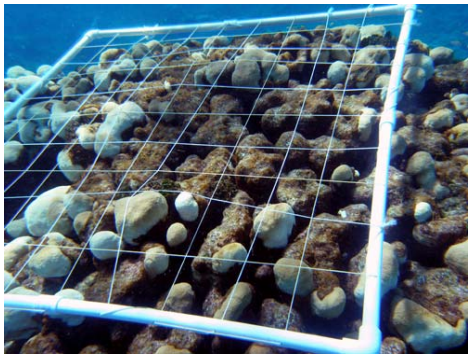
The intent of this field mission was to continue ongoing efforts: (1) to spatially characterize the distribution, abundance and size of both reef fishes and conch within and around the waters of Buck Island Reef National Monument (BUIS) and the East End Marine Park (EEMP) of St. Croix, (2) to correlate this information to *in-situ* data collected on associated habitat parameters, (3) to use this information to establish the knowledge base necessary for enacting management decisions in a spatial setting and to establish the efficacy of those management decisions.

Information collected thus far is being extensively utilized by NOAA, NPS, DPNR and others. Examples include NPS' use of NOAA-produced habitat maps in monitoring efforts, The Ocean Conservancy's use of maps and fish data in efforts to assist EEMP with zonation designations within the Park, and USGS/University of Miami's and NOVA Southeastern University's use of habitat maps for cryptic fish inventories. Information is also used to develop protocols, detailing how, where, and when to monitor nearshore fish assemblages. The data collected will aid NPS managers in understanding and making informed decisions regarding the resources of the South Florida / Caribbean Network.

A major bleaching event occurred throughout the Caribbean during the September – December months. In early October, NOAA issued Coral Reef Watch bleaching alerts for the US Virgin Islands and Puerto Rico- locations where thermal stress reached record levels (NOAA News Release, 2005)[1]. During the October mission, researchers took the opportunity to characterize the extent, by species, of this event throughout the study area. Results and observations from the bleaching study are described in a separate report, which is attached as an appendix to this trip report.

Operational Accomplishments:

- 121 sites were surveyed within the study area (Figure 1), and information on fish distribution, abundance and size (Table 2), benthic habitat composition (Table 1), bleaching, and conch abundance and distribution was collected. The project team consisted of 1 NPS and 5 NOAA scientific divers. NPS and NOAA dive logs were maintained.
- Two NPS boats were used each day of the mission.
- Air and Nitrox (32 %) tanks were used at approximately 73 and 48 dive sites respectively.



[1] "Major Coral Bleaching Event Expands Across Caribbean, Severe in Puerto Rico and US Virgin Islands: NOAA's New Coral Reef Watch Satellite Bleaching Alerts Aiding Managers." NOAA News Release: NOAA05-R499-04. National Oceanic and Atmospheric Administration. 24 October 2005. http://www.publicaffairs.noaa.gov/releases2005/oct05/noaa05-r499-04.html.

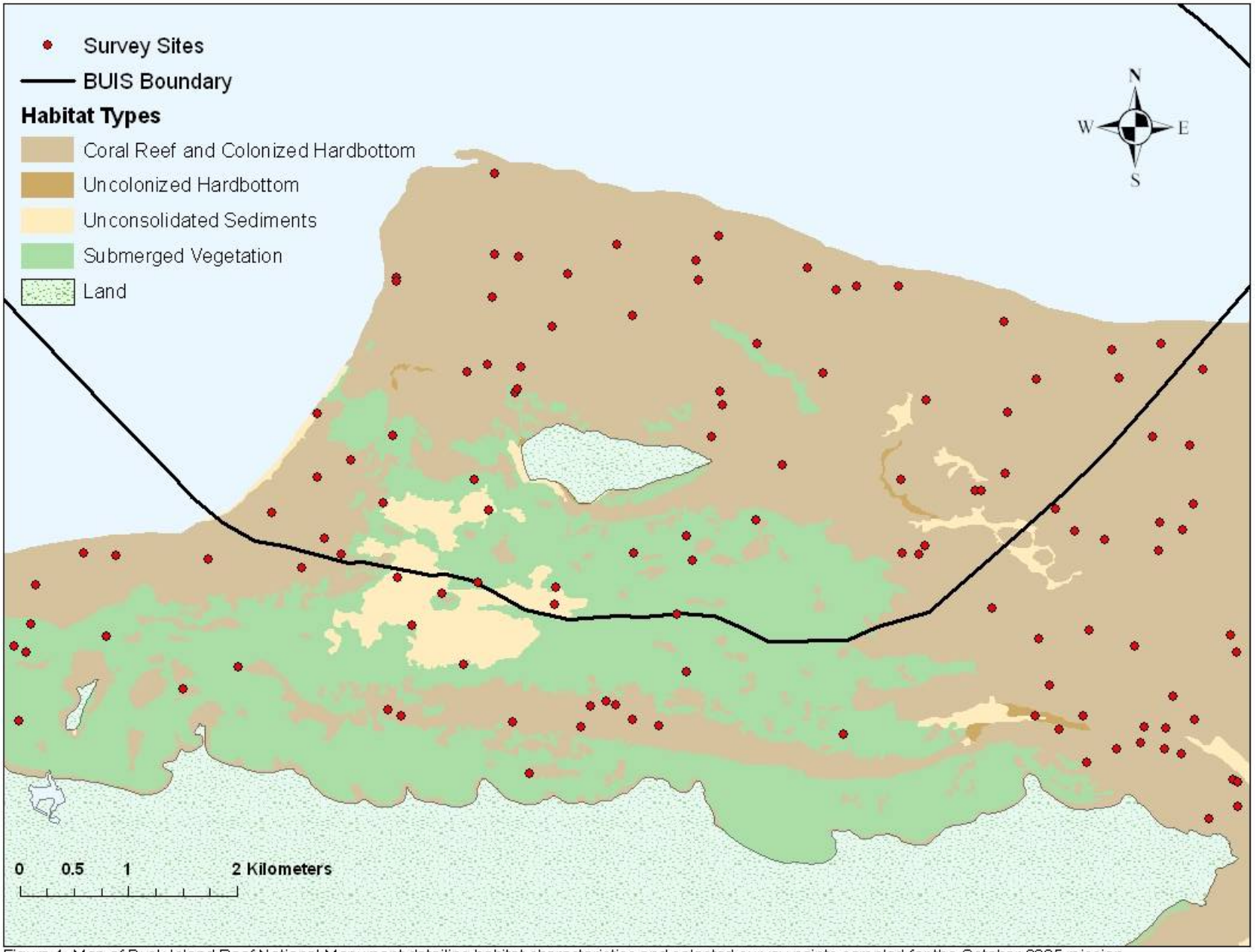


Figure 1. Map of Buck Island Reef National Monument detailing habitat characteristics and selected survey points sampled for the October 2005 mission.

Summary of Surveys:

Fish

- Fish species abundance, size and distribution were characterized using the belt transect survey method (http://biogeo.nos.noaa.gov/projects/reef_fish/protocols.shtml) at 121 sites. The data are summarized in table 1.

Table 1. Fish abundance, richness and biomass (all per 100m^2). Data are from the October 2005 St. Croix mission.

Location	Habitat Type	Number of Surveys	# indiv / 100m^2		biomass (g) /100m^2		# species / 100m^2		Mean Diversity*	
			Mean	(± SE)	Mean	(± SE)	Mean	(± SE)	Mean	(± SE)
Inside	Hard	48	229.90	15.30	4745.45	493.92	18.5	0.7	2.06	0.06
	Soft	11	52.00	11.46	792.75	358.73	6.7	0.8	1.24	0.12
	OVERALL	**59**	**188.89**	**9.67**	**3834.41**	**311.53**	**15.82**	**0.45**	**1.87**	**0.04**
Outside	Hard	46	201.33	13.16	2996.04	342.38	19.0	0.7	2.06	0.05
	Soft	16	48.94	12.63	418.15	109.13	5.9	0.9	1.13	0.13
	OVERALL	**62**	**129.62**	**8.46**	**1783.10**	**208.54**	**12.87**	**0.46**	**1.62**	**0.04**
Both	Hard	94	217.51	7.38	3987.06	222.85	18.75	0.35	2.06	0.06
	Soft	27	49.87	7.16	532.70	86.13	6.18	0.49	1.17	0.13
	OVERALL	**121**	**157.69**	**3.78**	**2754.28**	**75.69**	**14.26**	**0.22**	**1.74**	**0.03**

*Shannon Diversity Index
**Taxonomic Diversity takes into account family, order, and class

Habitat

- Data were collected at 121 sites for habitat characterization. Detailed methodology can be found at http://biogeo.nos.noaa.gov/projects/reef_fish/protocols.shtml. Hardbottom habitat characterization is summarized in table 2.

Table 1. Average percent cover of habitat types for 94 hardbottom sites for October 2005 St. Croix mission.

Location	Number of Surveys	%Coral / 100m^2		% Macroalgae / 100m^2		%Turf / 100m^2		% Gorgonians / 100m^2		% Sponges / 100m^2	
		Mean	(± SE)	Mean	(± SE)	Mean	(± SE)	Mean	(± SE)	Mean	(± SE)
Inside	48	5.01	0.72	20.94	3.80	28.56	3.43	2.06	0.47	1.79	0.29
Outside	46	1.88	0.28	19.57	2.89	32.45	3.96	0.92	0.19	1.87	0.27
Both	**94**	**3.65**	**0.28**	**20.34**	**1.76**	**30.25**	**1.84**	**1.57**	**0.19**	**1.82**	**0.14**

Conch

- A total of 174 conch, *Strombus gigas*, (123 inside, 51 outside) were observed during hard and soft-site transects on this mission. Of the 174 conch observed, 120 were recorded as immature and 54 mature.

Events of Note:

- A coral bleaching event was widespread and occurred all around Buck Island but with no obvious spatial patterns. Four species of coral had 90% or greater of total cover bleached (*Diploria labyrinthiformis*, *Agaricia* spp., *Mycetophillia* spp., *Montastrea annularis*). Bleaching was observed in 53% of total coral cover at 91 of 94 randomly selected sites ranging in depth between 9 and 91 ft (2.7 and 27.5 m). A weak but significant correlation ($r^2 = 0.159$, $P = 0.0023$) occurred between bleaching and depth, such that corals at shallower sites had higher rates of bleaching than those at deeper sites.

Figure 2. Pictures taken during the October 2005 mission to St. Croix of bleached coral (*Acropora palmata, Diploria strigosa*, *Montastraea* spp., and another *Montastraea* spp.).

- Due to the extensive bleaching observed during the October mission, a subsequent mission was undertaken in December 2005 to continue the documentation of the coral bleaching event. The regularly scheduled Spring 2006 mission will provide further information on the extent of the bleaching/recovery. Attached as an appendix to this report is the interim bleaching report that includes data summarized from the October and December trips.

- Both dive teams were visited by a pod of dolphins and an individual dolphin on separate days. A few dolphins from the pod and the individual were inquisitive and came in close proximity to the divers (Figure 3). They swam around the divers for a few minutes and then swam away.

Figure 3. The divers from both boats were visited by dolphins on two separate occasions.

- The blackfin snapper (*Lutjanus buccanella*) was recorded for the first time in St. Croix during this mission

Logistics of Note:

- Sample size within strata was determined by optimizing the number of fish species and community metrics that would be captured within 10% precision. These metrics included: fish diversity (Shannon and taxonomic), total fish and family abundance and richness, habitat substrate, etc. This was the first mission where sampling design was set by precision for fish richness, size, and biomass. A corollary was a decrease in lagoon sites. Although this decision was strongly supported statistically, it proved logistically difficult. With several days with rough, rainy weather, the divers had difficulty completing the minimum number of sites per day and worked the first Saturday to complete the number of dives needed.

APPENDIX

Coral bleaching and recovery observed at Buck Island, St. Croix, US Virgin Islands, October and December, 2005

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Summary

Researchers from NOAA's Biogeography Team and the National Park Service's South Florida Caribbean Network (NPS-SFCN) recently observed widespread bleaching in 22 species of hard corals at Buck Island Reef National Monument (BIRNM) and the Virgin Islands East End Marine Park (EEMP) in St. Croix, U.S. Virgin Islands (USVI) (Table 1). The observed bleaching was part of a larger event occurring throughout the tropical western Atlantic (Coral Reef Watch). Bleaching, or the loss of symbiotic algae from coral tissue, commonly occurs when corals are exposed to 1 ^{o}C above annual maximum water temperature for an extended amount of time (Houegh-Guldberg, 1999). Satellite information and water quality data provided by NESDIS' Coral Reef Watch have shown that water temperatures in the northeastern Caribbean exceeded the bleaching threshold (29.5°C, 83.3 ^{o}F) for approximately 12 weeks prior to November 12, 2005 (Figure 1). Data on bleaching were collected as part of NOAA's biannual monitoring of coral reef ecosystems in St. Croix, which is part of a larger program to monitor coral reef ecosystems in the U.S. Caribbean.

During October 16-30, 2005, bleaching occurred in 53% of the coral cover observed at 91 of 94 randomly selected hard bottom sites, which ranged in depth from 9 to 91 ft (2.7 and 27.5 m). Twelve coral species had bleaching greater than 50%, with four species being more than 90% bleached (*Diploria labrynthiformis, Agaricia* spp., *Mycetophyllia* spp., and *Montastraea annularis*) (Table 1). Several abundant corals also were severely bleached; four corals (*M. annularis*, *D. strigosa*, *Porites astreoides*, and *Agaracia* spp.) had cover greater than 9,850 cm^2 and experienced bleaching from 40 – 95%. Fire corals (*Millepora* spp.) comprised 11,400 cm^2 of cover of which 60% were bleached. *Acropora palmata* covered 21,800 cm^2 of the sampled area but was less severely bleached (23%). Some corals had bleaching less than 20% (*Stephanocoenia interceptis*, *Madracis* spp., *Dichocoenia stokesii*, *Meandrina meandrites*), whereas other corals had no bleaching (*Acropora cervicornis*; *Dendrogyra cylindricus*, *Eusmilia* spp., and *Scolymia* spp., Table 1).

In general, the October 2005 coral bleaching event was widespread and occurred all around Buck Island but with no obvious spatial patterns (Figure 2). Also, no spatial patterns were observed in the occurrence of bleaching for four abundant coral species (Figure 3). A weak but significant correlation (r^2 = 0.159, P = 0.0023) occurred between overall bleaching and depth, such that corals at shallower sites had higher rates of bleaching than those at deeper sites (Figure 4). If coral bleaching is temperature related, the observed correlation between depth and bleaching suggests that water temperature at depth would be lower than at the surface. However, water temperature, measured with a dive computer (Oceanic ProPlus 2) was not significantly lower at deeper sites than at shallower sites (r^2 = 0.004, P = 0.633, F = 0.230, df = 60). Overall, the water temperature ranged from 82 to 95 ^{o}F with a mean = 88.9 ± 0.19 ^{o}F (from 27.7 to 35 ^{o}C, mean = 31.6 ± 0.1 ^{o}C).

A follow-up study was conducted during December 12-14, 2005 to evaluate possible coral recovery or mortality. Data were collected on coral cover and condition at 18 randomly selected hardbottom sites within and adjacent to the BIRNM and the EEMP (hereafter protected areas, Figure 5). Bleaching was observed at 15 of the 18 sites in only 8% of the observed coral cover (Table 1). Most corals were unbleached (67%), but 20% exhibited abnormal coloration and were mottled or pale in appearance (Table 1). About 4% of the observed coral were colonized by Cyanobacteria or algae and were considered dead. Sixteen of 22 coral species were less than 10% bleached. *Porites porites*, *Manicina aereolata*, and *favia fragum* were 32-33% bleached, but these species had low abundance (< 0.2% total cover, Table 1). *Agaricia* coral occurred at 13 of 18 sites, had total cover of 0.24%, of which 80% was bleached. *Dendrogyra cylindrus* was 100% bleached but only occurred at one site (Table 1).

Overall, bleached coral cover decreased by 44.7% in areas from October to December 2005, however, bleaching and apparent recovering corals were still evident (Table 1). Bleached cover decreased by 60% or more in several abundant corals (e.g., *Diploria strigosa, Porites porites, Montastraea annularis, Mycetophyllia spp. and Millepora spp.*). These corals also showed an increase in the occurrence of unbleached colonies between October and December 2005 (Table 1). Less abundant corals such as *D. labyrinthiformis* and *Mycetophyllia spp.* showed a decrease in bleached coral cover and a corresponding increase in normal coral cover (unbleached coloration).

Prolonged bleaching can be lethal to corals and, along with disease and pollution, may have contributed to the loss of about 16% of the world's coral reefs within the past decade (Houegh-Gulberg 1999; Wilkinson 2000). A causal link between bleaching and coral death may not be quite obvious in this study because the effects of bleaching were not monitored through time at permanently marked coral heads. However, estimates of species' coral cover and total coral cover were very similar between October and December 2005 when compared to the differences in the estimates of bleached and unbleached corals. These data suggest that more corals may be recovering than dying as a result of the September-October, 2005 bleaching event. Recent coral death (i.e. overgrowth by Cyanobacteria or algae) was observed in only a few species (Table 1). *Porites porites and Millepora spp*. had the highest occurrence of dead coral and may have been the species most affected by the bleaching event (see Table 1). Continued monitoring of BIRNM and EEMP corals is necessary to determine recovery and the overall impact of such extreme natural events on coral reef ecosystems.

Researchers from the NPS-SFCN and US Geological Survey (USGS) also observed widespread coral bleaching at both the BIRNM and the Virgin Islands Coral Reef National Monument (VICRNM) at permanent sites in St. John, where they have been monitoring reefs with video since 1999 (J. Miller, pers. comm.). Analyses of data collected (during bleaching maxima and at present) are still being conducted, but preliminary results indicate most sites had over 90% of coral cover bleached. NPS-SFCN researchers have noted also that mean monthly sea temperature (at depth) during September was the warmest seen in 15 years. Bleaching of *A. palmata* occurred much later than most other scleractinian corals; however mortality of bleached areas happened within weeks (J. Miller, pers. comm.). Bleaching severity and mortality from bleaching differed between individual colonies within a site. Most of the colonies that survived have regained previous pigmentation levels, with only a few colonies still having bleached tips (J. Miller, pers. comm.).

Methods used to estimate bleached coral cover

From October 16 to 30, 2005, coral bleaching was documented at 94 hard bottom sites during a biannual survey of benthic habitats at the BIRNM. During December 12-14, 2005, only 18 sites were randomly selected for documentation of bleaching during benthic surveys because of limited logistical support. The goals of the December sampling mission were to (1) to spatially characterize the extent of coral bleaching that occurred September/October 2005 within and around the waters of the BIRNM and the EEMP, and (2) to determine the mortality or recovery of corals from bleaching observed during October 2005. A stratified random sampling method was chosen instead of a repeated measures design at permanently marked locations to fully characterize 1) the spatial extent and occurrence of bleaching and 2) ecosystem levels of mortality or recovery from coral bleaching. Additionally, corals sampled during October 2005 were unmarked. Therefore, it was impossible to re-survey specific corals as would be required by a repeated measures design.

Documentation of bleaching occurred on hard bottom areas within and outside of protected areas, which were likely to have coral. At each site, the cover of bleached and unbleached coral within five 1-m^2 quadrats [along a 25 m-transect] was estimated visually and recorded for each species. Coral cover is reported in **cm^2** and was converted to those units using the relationship: 1% cover = 100 cm^2. The amount of bleaching of each species was calculated with the equation: **bleached cover / [bleached cover + unbleached cover]) X 100%**. The biannual benthic habitat survey is part of the Caribbean Coral Reef Ecosystem Monitoring project. The detailed methodology for the benthic habitat survey is located on line at http://www8.nos.noaa.gov/biogeo_public/Metadata/Habitat_Metadata/st_croix_hab_metadata.pdf.

Next steps

During October, 2005, managers from the NPS-SFCN and the EEMP requested that the Biogeography Team explicitly collect data on coral bleaching during its annual monitoring of coral reef ecosystems in the U.S Caribbean. Plans are to continue future monitoring of coral bleaching and recovery during benthic surveys planned for April 2006, when the Biogeography Team's next biannual monitoring of coral reef ecosystems will occur.

During December 2005, NOAA's Biogeography Program also partnered with NASA Ames Research Center and provided diving support for the collection of spectroradiometer measurements and data for the

calibration of hyperspectral imagery (Airborne Visible Infrared Imaging Spectrometer, AVIRIS). Plans are to continue working closely with NASA to provide this information to park managers, thus further developing the knowledge base necessary to better respond to large-scale bleaching events. Ultimately, the data collected on reef habitats will provide information to address primary resource management questions of the Park and Monuments, and will aid NPS and local management in assessing the effectiveness of marine protected area regulations.

References

Houegh-Gulberg, O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. Marine and Freshwater Research 50:839-866

Wilkinson, C. 2000. Status of Coral Reefs of the World. 2000. IOC/UNESCO-UNEP-IUCN- World Bank.

Miller, J. Personal Communication. National Park Service – South Florida/Caribbean Network http://www1.nature.nps.gov/im/units/sfcn/.

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US Geological Survey Florida Caribbean Science Center

Table 1. Condition of corals in the Buck Island Reef National Monument, St. Croix during October 16-30 and December 12-14, 2005. Coral species are ranked by observed coral cover (Column 2). Photos of bleached coral are available at: **http://ccma.nos.noaa.gov/products/biogeography/coral_bleaching/oct_rpt.html**. Source of data and photos: NOAA NCCOS Biogeography Team, unpublished data.

Coral	Observed coral cover (cm^2)*		Bleached coral (%)[1]		Unbleached coral (%)[2]		Abnormal coral (%)[3]	Dead coral (%)[4]	Number of sites		Total coral cover (%)	
	Oct 2005	*Dec 2005*	*Oct 2005*	*Dec 2005*	*Oct 2005*	*Dec 2005*	*Dec 2005*	*Dec 2005*	*Oct 2005*	*Dec 2005*	*Oct 2005*	*Dec 2005*
Total cover	171,275	**35,000**	53	**8.32**	47	**67.18**	**20.46**	**4.04**	94	**18**	5.57	**3.89**
Diploria strigosa	28,665	**5,180**	60.5	**0.4**	39.5	**51.4**	**43.4**	**4.8**	63	**16**	0.98	**0.58**
Porites astreoides	26,740	**2,800**	43.6	**0.9**	56.4	**89.6**	**9.5**	**0**	67	**15**	0.82	**0.31**
Acropora palmata	21,800	**100**	22.8	**0**	77.2	**100**	**0**	**0**	8	**1**	0.57	**0.01**
Montastraea annularis	21,295	**6,125**	93.1	**4.6**	6.9	**48.9**	**46.5**	**0**	34	**7**	0.87	**0.68**
Millepora spp.	11,400	**3,500**	60.2	**0**	39.8	**84.9**	**0.3**	**14.9**	69	**11**	0.39	**0.39**
Agaricia spp.	9,850	**2,170**	95.9	**80**	4.1	**0.7**	**10.4**	**9**	58	**13**	0.41	**0.24**
Montastraea cavernosa	9,650	**2,970**	27.4	**0**	72.6	**93.3**	**6.7**	**0**	42	**7**	0.26	**0.33**
Siderastrea siderea	9,155	**1,520**	54	**9.9**	46	**76**	**14.1**	**0**	43	**10**	0.30	**0.17**
Siderastrea radians	8,290	**5,470**	25.3	**1.8**	74.7	**80.4**	**16.5**	**1.3**	56	**14**	0.22	**0.61**
Diploria clivosa	6,605		33.3		66.7				27		0.19	
Pories porites	5,790	**1,365**	81.3	**32.2**	18.7	**37.4**	**2.6**	**27.8**	41	**7**	0.22	**0.15**
Meandrina meandrites	3,050	**895**	0.8	**1.1**	99.2	**98.9**	**0**	**0**	26	**9**	0.07	**0.10**
Stephanocoenia spp.	1,910	**860**	16	**0**	84	**100**	**0**	**0**	31	**4**	0.05	**0.10**
Colpophyllia natans	1,575	**755**	49.2	**0**	50.8	**98.7**	**1.3**	**0**	10	**2**	0.05	**0.08**
Diploria labyrinthiformis	1,275	**300**	96.1	**0**	3.9	**100**	**0**	**0**	7	**1**	0.05	**0.03**
Dichocoenia stokesii	1,175	**410**	6	**0**	94	**70.7**	**29.3**	**0**	21	**6**	0.03	**0.05**
Mycetophyllia spp.	960	**230**	93.8	**8.7**	6.3	**60.9**	**30.4**	**0**	18	**4**	0.04	**0.03**
Madracis spp.	455	**60**	11	**0**	89	**100**	**0**	**0**	8	**1**	0.01	**0.01**
Isophyllia spp.	415		77.1		22.9				8		0.02	
Solenastrea spp.	325		56.9		43.1				5		0.01	
Acropora cervicornis	320	**100**	0	**0**	100	**100**	**0**	**0**	2	**1**	0.01	**0.01**
Manicina areolata	210	**60**	57.1	**33.3**	42.9	**50**	**16.7**	**0**	5	**2**	0.01	**0.01**
Dendrogyra cylindrus	200	**100**	0	**100**	100	**0**	**0**	**0**	1	**1**	0.00	**0.01**
Favia fragum	115	**30**	69.6	**33.3**	30.4	**66.7**	**0**	**0**	5	**3**	0.00	**0.01**
Scolymia spp.	30		0		100				1		0.00	
Eusmilia fastigata	20		0		100				2		0.00	

*** 1 percent coral cover = 100 cm^2**

1. Bleached: coral appeared white

2. Unbleached: coral had normal color

3. Abnormal: coral was mottled or pale

4. Dead: coral was colonized by cyanobacteria or algae

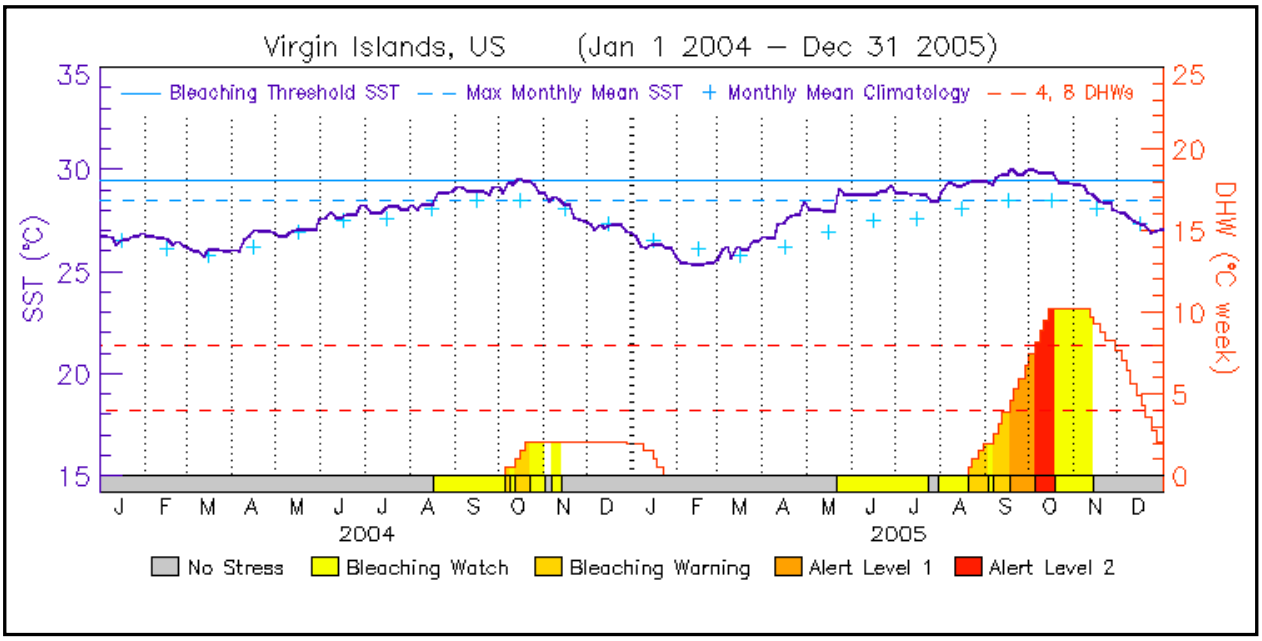

Figure 1. Sea surface temperature (SST) time series (solid dark-blue line) and coral bleaching Degree Heating Weeks (DHW) time series (solid red line) from January 2004 to December 2005 for the U.S. Virgin Islands. The corresponding thermal condition related to coral bleaching is color-coded and plotted below the time series. The thermal condition is categorized in the five bleaching alert levels defined by Coral Reef Watch's Satellite Bleaching Alert. Source: http://coralreefwatch.noaa.gov/satellite/current/sst_dhw_series_usvirgin_cur.html.

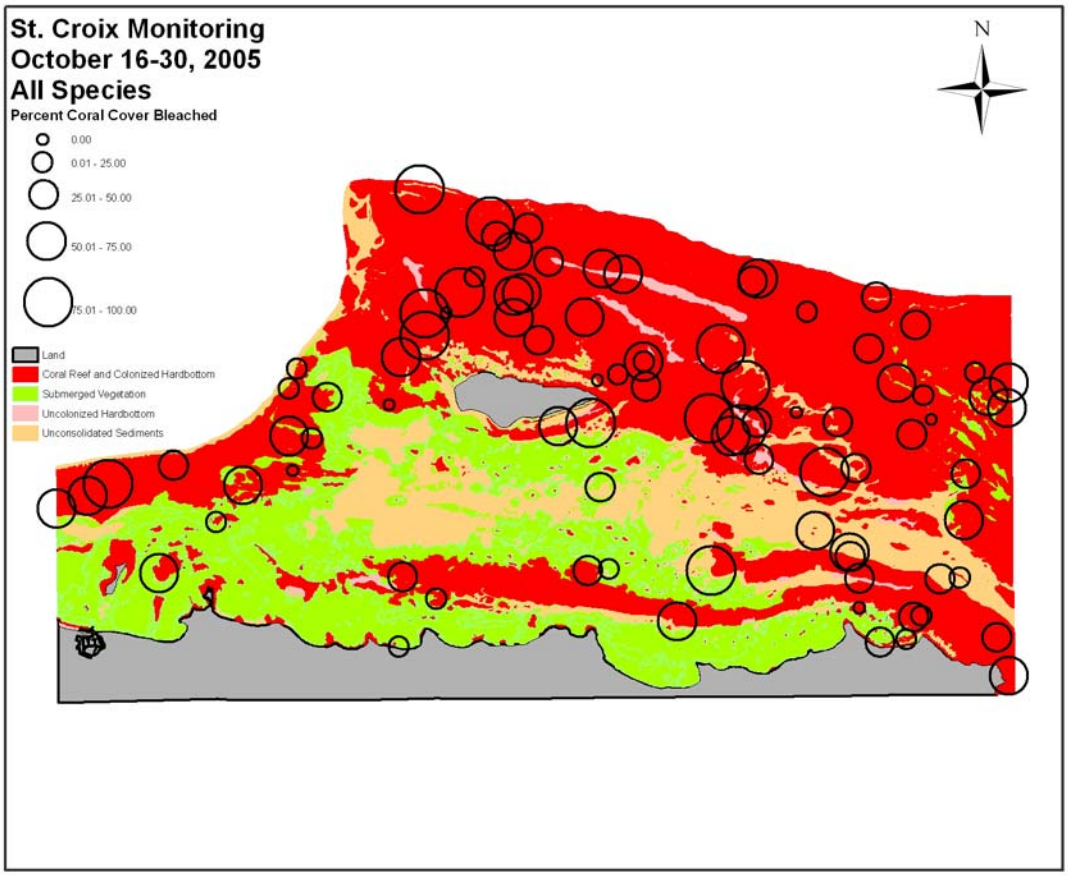

Figure 2. Spatial distribution of bleached coral determined from 94 sampled hardbottom sites at Buck Island, St. Croix, U.S. Virgin Islands in October 2005.

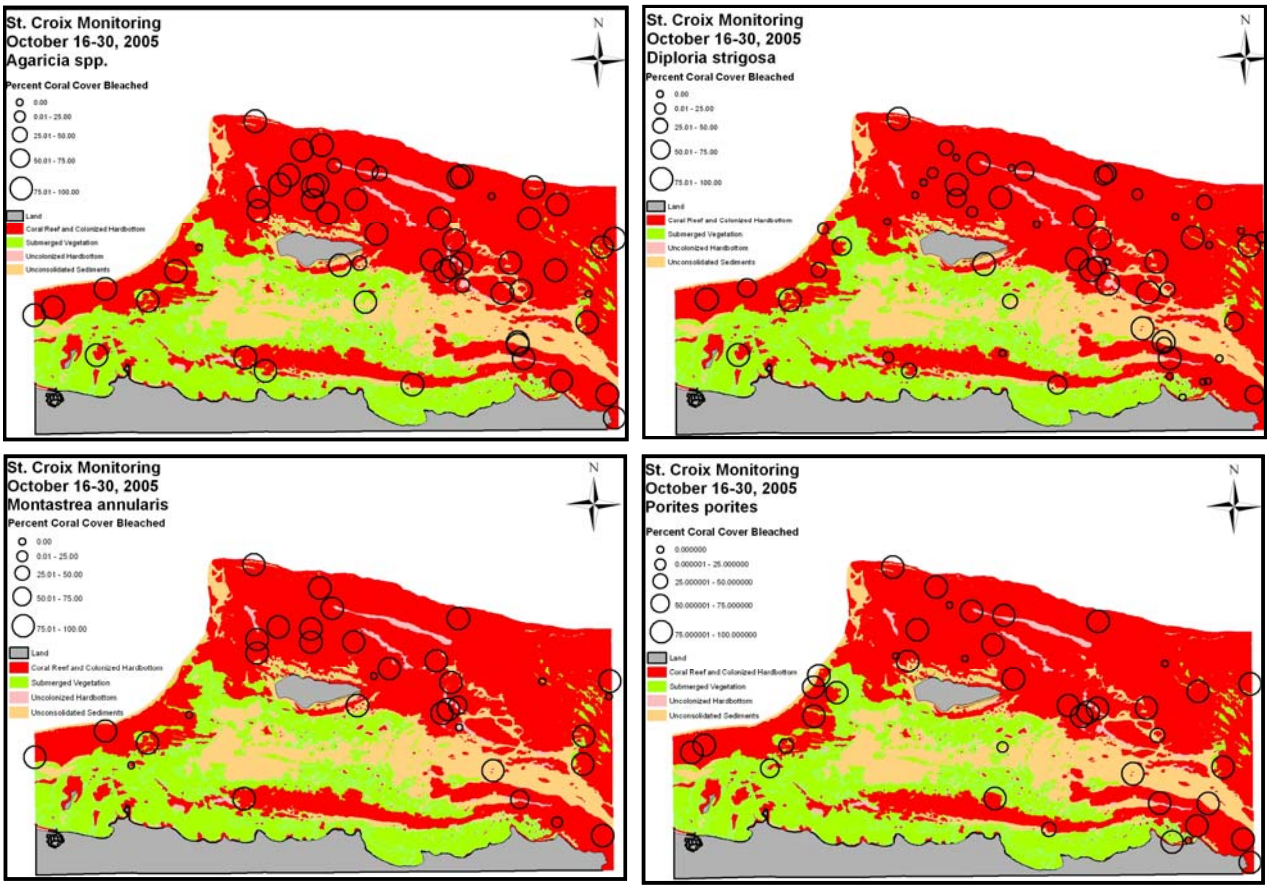

Figure 3. Spatial distribution of four abundant coral species that showed bleaching. The spatial distribution was determined from 91 hardbottom sites sampled at Buck Island, St. Croix, U.S. Virgin Islands in October 2005.

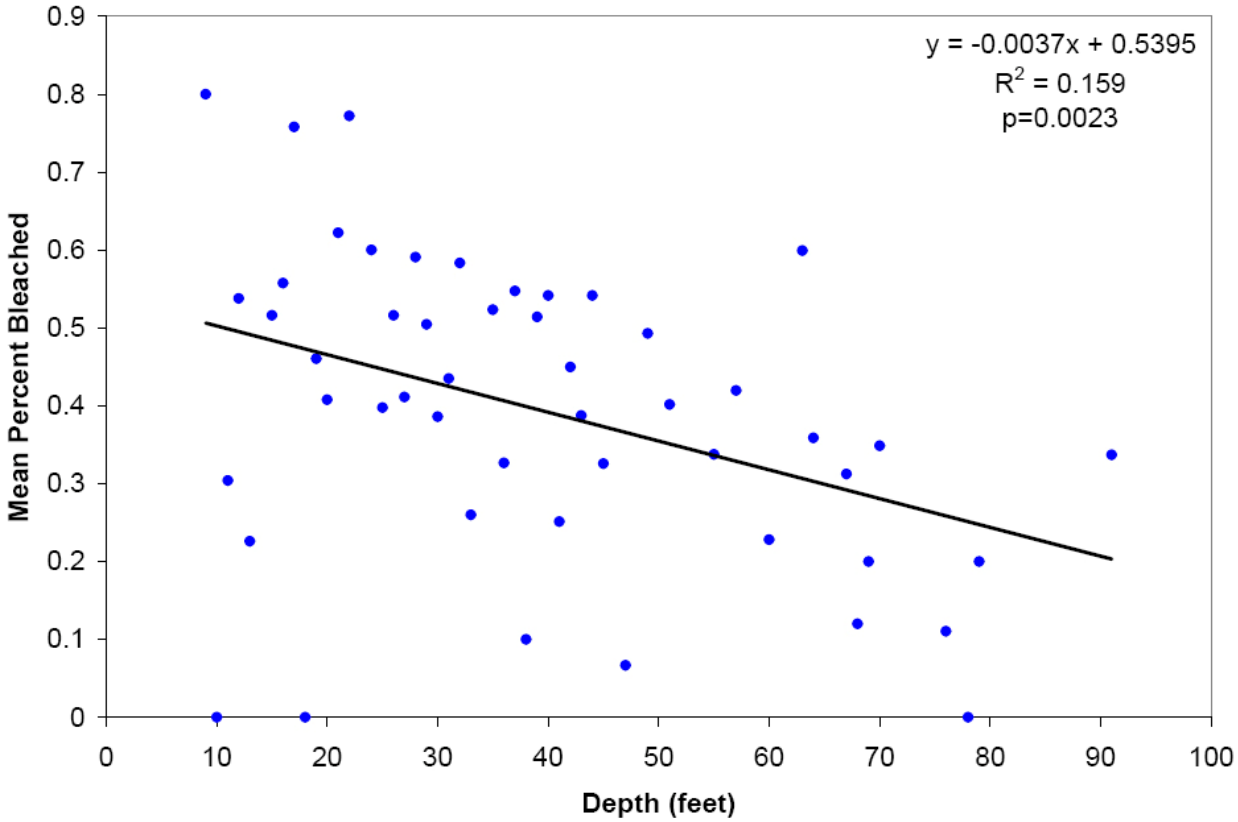

Figure 4. Linear regression of mean bleached coral (% cover) against depth for 91 hardbottom sites sampled at Buck Island, St. Croix, U.S. Virgin Islands from October 16-30, 2005.

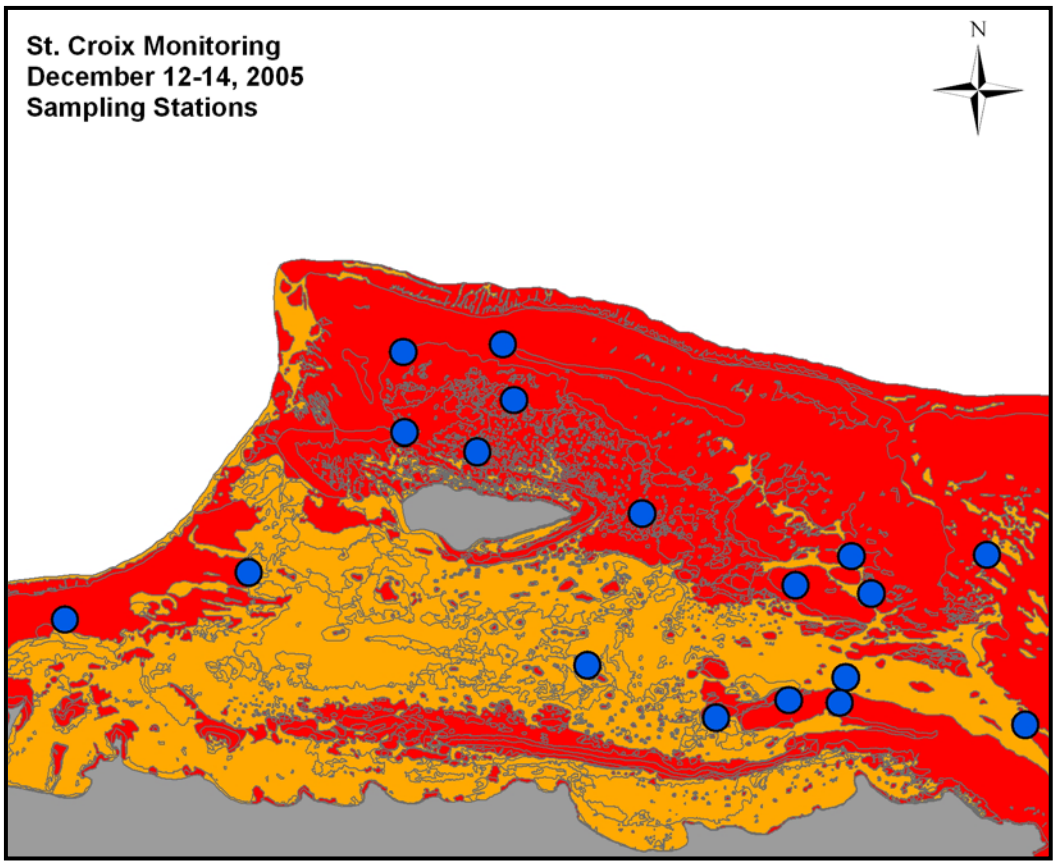

Figure 5. Sites (blue dots) selected for the follow-up bleaching study, December 12-14, 2005. Sites were randomly selected from hard bottom areas (red) from two strata: 1) within Protected Areas (Buck Island Reef National Monument and the Virgin Islands East End Marine Park) and 2) outside Protected Areas. Orange indicates soft bottom areas.