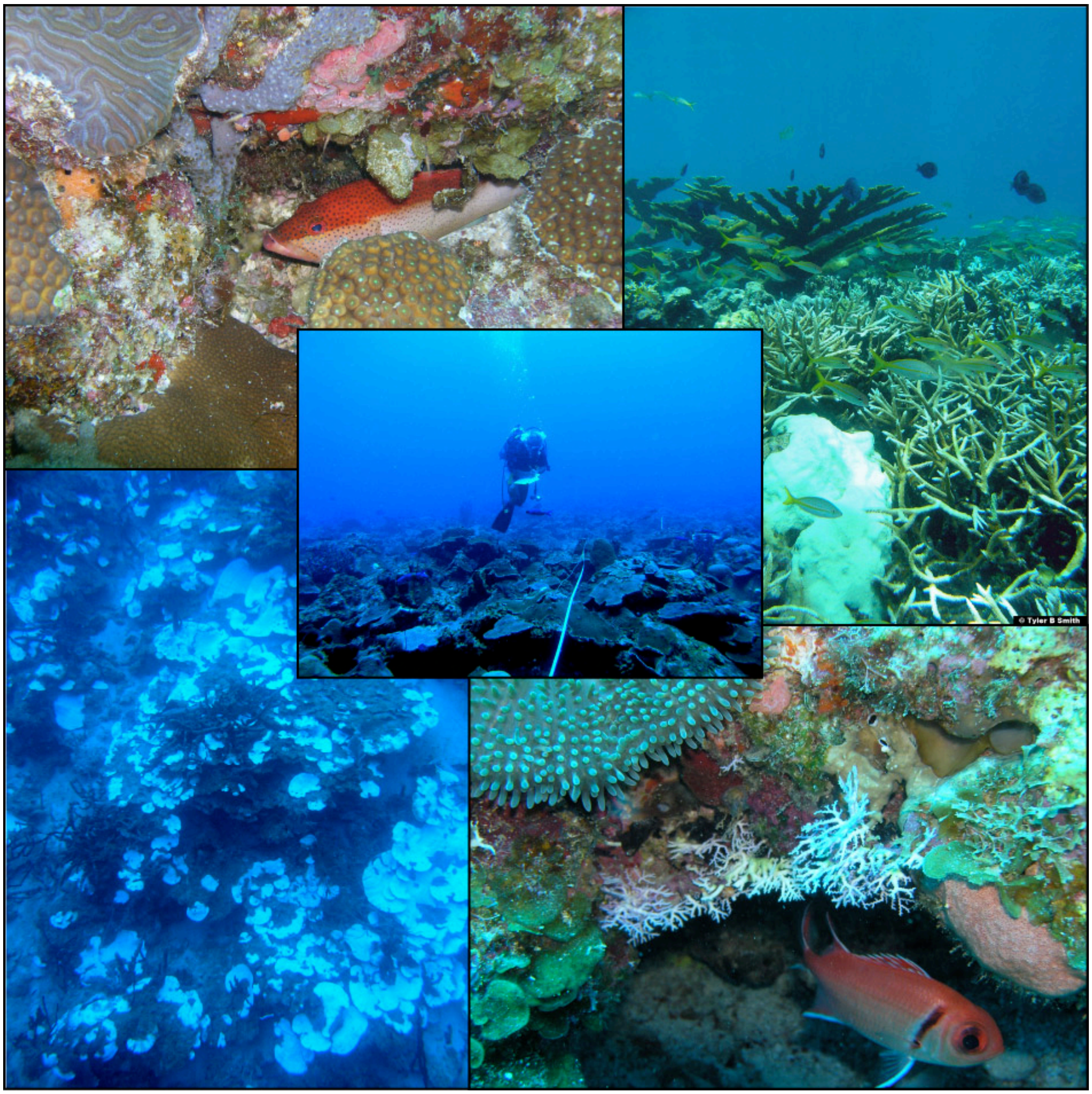
Coral Reef Monitoring

United States Virgin Islands



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Coral Reef Monitoring

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Executive Summary

Coral reefs in the Caribbean are facing a dramatic decline. To effectively manage and maintain these important ecosystems, the government of the United States Virgin Islands (USVI), in coordination with federal agencies and the University of the Virgin Islands, implemented the Territorial Coral Reef Monitoring Program in 2001. This long-term coral reef monitoring and assessment program encompasses sites in territorially and federally managed waters across the insular shelf of the USVI. The Territorial Coral Reef Monitoring Program has established a baseline condition and temporal trends of coral reefs and fish populations for determining the effectiveness of various management initiatives on the sustainability of these important resources. This program will also allow natural resource managers to gauge the impacts of natural disturbances and human activities on coastal habitats and their rates of recovery. This report presents results from the seventh year of monitoring in St. Croix and the fifth year of monitoring in St. Thomas, with comparisons to previous years. St. Thomas monitoring and assessment employed a stratified design based upon the position of reefs along the insular platform (mid-shelf and shelf-edge). This design was implemented to complement other ongoing monitoring studies and to facilitate a systematic evaluation of the effects of natural and human-induced stresses influencing the decline or recovery of coral reef systems.

Digital video and diver surveys were used to quantify coral diversity, coral recruit density, the percent cover of corals, algae and other organisms, incidence of coral bleaching and disease, sea urchin density, and fish community structure at eight permanent sites surrounding the island of St. Croix (Buck Island, Cane Bay, Great Pond, Jacks/Isaacs Bay, Long Reef/Eagle Ray, Mutton Snapper, Salt River, and Sprat Hole) and six permanent sites surrounding the island of St. Thomas (Seahorse Cottage Shoal, South Capella, South Water Island, the Grammanik Bank, the Red Hind Bank, and College Shoal East).

Introduction

The U.S. Virgin Islands consists of three large islands, St. Thomas, St. John and St. Croix, and numerous smaller islands surrounded by a diverse, tropical marine environment that includes coral reefs, seagrass beds, and mangrove forests. The islands of St. Thomas and St John are joined by an extensive shallow water platform that connects them to Puerto Rico and the British Virgin Islands. Sixty-five kilometers to the south of St. Thomas and St. John, St. Croix lies on a separate platform. St. Croix is separated from St. Thomas and St. John by the Virgin Islands Trough (over 3,000 m deep).

Tourism drives economy of the Virgin Islands. The marine environment with its clean, clear water and fringing sandy beaches is the major tourist attraction. The waters of the Virgin Islands are ideal for sailing because of the persistent trade winds and the numerous bays that provide protected anchorages. The diverse marine life of the coral reefs and other habitats attracts thousands of skin and scuba divers each year. Sport fishing also makes an important contribution to the economy, especially on St. Thomas.

In addition to their tourist appeal, the coral reefs and other habitats in the Virgin Islands are essential to the lives of hundreds of thousands of species including the economically important queen conch, whelk, snapper and grouper. Over three hundred full-time or part-time commercial fishermen fish in territorial and federal waters on all three islands (Tobias 1997). Recreational and artisanal fishing by islanders are poorly cataloged but frequent activities in nearshore waters (Authors, personal observation). In tough economic times, fishing is an important means of supplemental income for many people.

Over the past 20 years, eight major hurricanes, numerous outbreaks of disease and episodic bleaching events have caused extensive coral mortality to the coral reefs surrounding the Virgin Islands (Gladfelter 1982: Edmunds and Witman 1991; Rogers et al. 1991; Causey et al. 2000, Rothenberger et al. 2008, Woody et al. 2008, Miller et al. 2010). Recovery from these natural disturbances is hindered by a multitude of human impacts that affect coral reefs such as overfishing, ship groundings, anchor damage, and non-point source pollution (Roberts 1993; Sebens 1994; Rogers and Garrison 2001, Rothenberger et al. 2008). Moreover, rapid development of inland and coastal areas has dramatically increased soil erosion and sedimentation onto many of these coral reefs (Rogers 1990; MacDonald et al. 1997; Anderson and MacDonald 1998, Smith et al. 2008). Chronic sedimentation may affect the abundance and diversity of corals and other reef organisms, increase coral stress and susceptibility to diseases and bleaching, and reduce the ability of corals and other reef organisms to recover and regenerate after natural disturbances such as hurricanes (Acevedo and Morelock 1988; Rogers 1990; Rice and Hunter 1992). The cumulative effects of these human impacts reduce coral abundance and larval recruitment and may make corals more susceptible to disease and bleaching (Nemeth and Sladek Nowlis 2001, Smith et al. 2008).

Most research around the Virgin Islands has focused on fringing reefs (5 – 30 m depth) located along the shoreline of the three main islands, St. Thomas, St. John, and St. Croix. In contrast, very little information exists for other reef systems, which can be quite extensive. Surrounding St. Thomas and St. John, these other reef systems include mid-shelf reefs (5 – 30 m depth) located 2 to 10 km from the shore of the main islands and shelf-edge reefs (>30 m depth) located 10 to 15 km offshore along the edge of the insular platform (Smith et al. 2010). Distance from shore may be a factor in the historical degeneration of coral reef systems in the Virgin Islands (Herzlieb et al. 2005, Smith et al. 2008, Calnan et al. 2008). A systematic approach to investigating these cross-shelf coral reef systems allows us to evaluate the variable impacts and synergistic effects of natural impacts and human-induced stress that influence the decline or recovery of Caribbean coral reef systems. The first two years of this project (2001 and 2002) concentrated on the fringing reefs surrounding St. Croix (Nemeth et al. 2002; Nemeth et al. 2003a). In 2003, monitoring continued at St. Croix reefs and began at reef systems distributed across the insular platform surrounding St. Thomas (Nemeth et al, 2004a). In 2004, 2005 and 2006 monitoring continued at reefs surrounding both islands, with additional reefs surrounding St. Thomas added in 2004 and 2005 (Nemeth et al. 2004b, Nemeth et al. 2005, Smith et al. 2007).

Objectives for Monitoring Coral Reefs

Effective management is necessary to maintain the resources in the territorial and federal waters of the Virgin Islands in an ecologically and economically sustainable manner. Monitoring programs are essential for successful management because they provide managers with fundamental information with which to make and enforce decisions. Standards for resource protection can be measured by comparison to baseline data established by monitoring. Monitoring also provides the means to assess the status and trends of ecological resources, allowing managers to determine the effectiveness of current management and to develop effective management plans for the future. The intent of this project is to monitor the condition of coral reefs throughout the U.S. Virgin Islands to better manage these ecosystems. This will be accomplished by continuing to monitor previously established reef sites surrounding St. Croix and St. Thomas. This report presents results from the seventh year of monitoring in St. Croix and the fifth year of monitoring in St. Thomas. For both islands, temporal changes from year to year in the conditions of the reef communities are assessed. In addition, biotic and abiotic parameters are compared among the mid-shelf and shelf-edge reefs of St. Thomas.

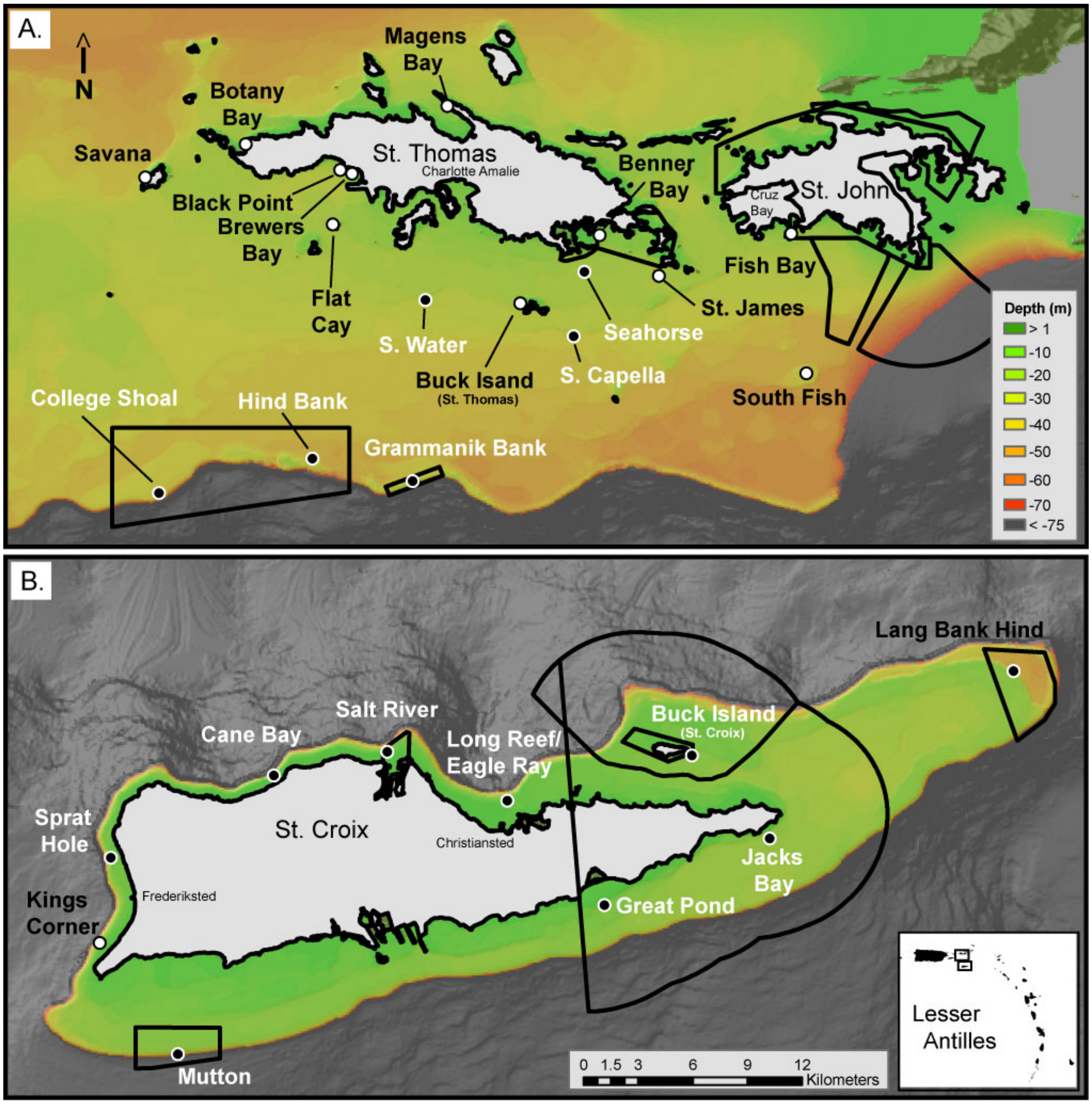

Figure 1. Locations of Territorial Coral Reef Monitoring Sites in the US Virgin Islands, 2007. NOAA Coral Reef Conservation Program funded sites are indicated with black circles and white lettering. All other monitoring sites assessed in 2007 are indicated with white circles and black lettering. Boundaries indicate federal and territorial marine protected areas.

Section I: St. Croix

Methods

Benthic Assessments

In September of 2007, the University of the Virgin Islands determined the benthic composition at eight long-term monitoring sites previously established off the island of St. Croix (Figure 1, Table 1). Two of the sites (Great Pond and Jacks Bay) are within the East End Marine Park Boundary. Details on site selection and prior sampling methodology can be found in Nemeth *et al*. (2004a). Sampling began in 2002 for Great Pond and Mutton Snapper and 2001 for all other sites. Permanent transects numbered 6 for all sites, except for Buck Island, St. Croix in 2001 and 2002 (3 transects) and Mutton Snapper and Sprat Hall in 2002 (transects = 5).

Table 1. St. Croix site location information and number of benthic transects at each site. Dates are for benthic cover and coral health/Diadema assessments.

Site	Date Sampled	GPS Coordinates	Depth (m)	No. of Transects
Buck Island	9/25/07	N 17° 47.122, W 64° 36.550	14	6
Cane Bay	9/28/07	N 17° 46.433, W 64° 48.810	9	6
Great Pond	9/27/07	N 17° 42.668, W 64° 39.148	4	6
Jacks/Isaac Bay	9/27/07	N 17° 44.588, W 64° 34.309	11	6
Long Reef/Eagle Ray	9/25/07	N 17° 45.688, W 64° 41.929	9	6
Mutton Snapper	9/26/07	N 17° 38.217, W 64° 51.683	23	6
Salt River West Wall	9/30/07	N 17° 47.116, W 64° 45.564	6	6
Sprat Hole	9/25/07	N 17° 44.038, W 64° 53.722	12	6

Benthic Cover. Video sampling consisted of one diver traversing each transect videotaping the benthic cover using a Sony TRV-950 digital camcorder in a Light and Motion Stingray II underwater housing. The diver swam at a uniform speed, pointing the camera down and keeping the lens approximately 0.4 m above the substrate at all times. A guide wand attached to the camera housing was used to help the diver maintain the camera a constant distance above the reef. After taping, approximately 20 - 30 non-overlapping images per transect were captured and saved as JPEG files on a computer using a Sony video capture card. Captured images represented an area of reef approximately 0.31 m^2 (0.64 m x 0.48 m). Microsoft Excel and Adobe Photoshop were used to superimpose ten randomly located dots on each captured image. The substrate type located under each of the dots was then identified to the most descriptive level possible and entered into a database. For each transect, the percent cover of coral, dead coral with turf algae, macroalgae, sponges, gorgonians, and sand/sediment were calculated by dividing the number of random dots falling on that substrate type by the total number of dots for that transect. Mean values for percent cover were calculated for each site and coral diversity was measured by using the Shannon-Weaver diversity index.

Repeated measure tests were performed to determine if there were significant differences in the percent cover of these benthic categories at each site between years after meeting assumptions of normality and homogeneity of variance. Percent cover values were arcsine transformed prior to testing.

Coral Health. Coral health assessments follow methodologies outlined in Calnan et al. (2008) and Smith et al. (2008) and are briefly described here. All coral colonies 10 cm or greater in diameter or height that were located directly under the transect lines were assessed in situ for signs of mortality and disease following a modified Atlantic and Gulf Rapid Reef Assessment protocol (Kramer et al. 2005). Partial mortality of coral colonies was broken into two categories. Recent partial mortality, skeleton not eroded (fine corallite structure still intact) and bare or with a thin veneer of sheeting or filamentous algae, is typically visible for up to three months following tissue loss. Old partial mortality, skeleton eroded and covered with turf or macroalgae, is a transition from recent mortality and typically lasts up to 1–4 years (Smith et al. 2008, also see http://www.agrra.org/method/methodcor.html).

Diseases were conservatively categorized into recognized Caribbean scleractinian diseases and syndromes that included bleaching, black band disease, dark spots disease, white plague, and yellow blotch (band) disease (following Bruckner 2007). Acroporid corals were extremely rate at the study sites; thus, their associated diseases (white band and white pox) are not presented. Bleaching was assessed as abnormal paling of the colony, and, when present, the severity of the bleaching (paling or total whitening) and the area of the colony affected were assessed.

For each transect, the prevalence of coral impairment categories was calculated as the number of colonies with partial mortality, disease, or bleaching divided by the number of colonies assessed. Also, for affected colonies in each transect the average three-dimensional surface area (%) of the colony affected was also estimated for each impairment category.

The monitoring site Mutton Snapper was not sampled for coral health in 2004.

Divers also counted the number of *Diadema antillarum* sea urchins within 1 m on either side of each transect at all sites. The mean number of sea urchins per 10 m^2 was calculated for each site.

Fish Census

Due to loss of personnel at the USVI Division and Fish and Wildlife, Fish assemblages were not surveyed on St. Croix in 2007.

Physical Measurements

At each coral monitoring site a temperature probe (Hobotemp v2, Onset Computer Corp., Bourne, MA) was affixed to the benthos near permanent transects and set to record temperature at 15-minute intervals. Data is not presented in this report but is available upon request.

Results and Recommendations

Detailed summaries of the benthic data from each of the St. Croix sites are included in Appendix I: Summary of Coral Video Data, Appendix II: Summary of Non-coral Video data, and Appendix III: Summary of Urchin, Bleaching, and Disease Data.

Benthic Assessments

In 2007, the percent cover of living coral at the St. Croix sites ranged from a low of 3% at Jacks Bay to a high of 12% at Cane Bay. Five out of the eight sites (Cane Bay, Great Pond, Long Reef/Eagle Ray, Mutton, and Salt River West) showed increases in coral cover from 2006-2007 (Figure 2A). Dead coral covered with turf algae (DCA) was the most dominant substrate type in 2007. Salt River had the highest cover of DCA at 69% while the lowest cover was seen at Sprat Hall at 25% (Figure 2B). Macroalgae cover was highest at Jack's Bay at 61% and lowest at 12% at Salt River (Figure 2C). There was 4% sponge cover at Salt River and only 0.2% cover at Great Pond (Figure 3A). Gorgonian cover was highest at Buck Island and Long Reef/Eagle Ray with 8% cover while Great Pond had 0% cover (Figure 3B). Sand/sediment cover was observed at all sites in 2007 except for Jacks and was highest at 33% at Buck Island (Figure 3C).

The coral reefs of St. Croix were generally dominated by coral species in the genus *Montastraea* (Figure 4). From 2001-2006, *Montastraea spp*. were the most abundant corals at seven out of eight sites (Figure 5A-H). Great Pond was not dominated by *Montastraea* species but instead was composed of mostly three species; *Porites astreoides*, *Millepora complanata* and *Diploria strigosa* (Figure 5C). *P. astreoides* was the most dominant species at 48%. Species composition at each of the sites varies between years. Sprat Hole, Mutton and Salt River all showed slight increases in the *Montastraea annularis* complex from 2006-2007. Relative *Montastraea cavernosa* cover at Buck Island doubled from 9% in 2006 to 20% in 2007. Great Pond also showed a large relative increase of *Millepora complanata* from 14% to 47%, but had a decline in *Diploria strigosa* cover from 29% to 5%. Most of these changes in relative percent cover likely represent variability inherent in the transect sampling protocol.

The Shannon – Weaver Diversity Index (H') for coral ranged from a high of 2.05 at Salt River to a low of 1.21 at Great Pond (Figure 6). Coral diversity increased at four out of the eight sites between 2006 and 2007 (Buck Island, Jacks, Long Reef/Eagle Ray, Mutton and Salt River). Salt River experienced the greatest increase in coral diversity increasing from 1.82 to 2.05 (Figure 6).

Coral Health

Coral health on St. Croix showed a decrease and bleaching and disease following mass coral reef bleaching in 2005 and the subsequent disease outbreaks in 2006. The year 2007 was marked by moderately high levels prevalence of bleaching at all of the sites on St. Croix. Cane Bay and Mutton Snapper showed the highest prevalence of bleaching at 50% and 56% respectively (Figure 7A). Salt River and Long Reef/Eagle Ray showed the lowest levels of bleaching at 16% and 14% (Figure 7A). Although not shown, most bleaching was low intensity (<10% extent on colonies) and likely represents low level seasonal bleaching associated with the seasonal thermal maximum and local stressors.

Prevalence of disease increased at five out of eight sites in 2007. Cane Bay showed the highest prevalence of disease at 6% (Figure 7B) with *Siderastrea siderea* most affected (Figure 7B). Dark spots disease was solely responsible for disease occurrences in *S. siderea* (Figure 8B). The incidence of each individual disease was calculated for each site during the years 2002 to 2007. Black band disease has only been observed on St. Croix during monitoring at Long Reef/Eagle Ray in 2005. Dark spots disease has been observed at four out of the eight sites but with the greatest prevalence occurring at Salt River (Figure 9). The highest prevalence of dark spots disease occurred in 2007 at four sites (Cane Bay, Long Reef/Eagle Ray, Salt River and Sprat Hall). Cases of white plague disease have been observed throughout monitoring at 5 out of the 8 sites with the greatest prevalence occurring in 2006 but only one occurrence in 2007 (Figure 9). Yellow blotch disease has also been observed at five sites; however, with fewer incidences of disease than white plague. Buck Island and Cane Bay both had colonies affected by yellow blotch disease in 2007 (Figure 9), and this was associated with *M. annularis*. Cases of unknown diseases were observed every year with the exception of 2003 and 2004 (Figure 9).

In addition to coral bleaching and disease, prevalence of old and recent partial mortality was assessed in 2007 for the previous years of monitoring; however, old and recent partial mortality were not consistently monitored until 2005. The prevalence of old partial mortality showed an increase at all sites from 2005 to 2007 and was highest at Mutton Snapper in 2007 (Figure 10A). The average percent surface area of individual colonies affected by old mortality was increasing at all sites with the exception of Great Pond and Salt River in 2007 (Figure 10B). The average extent of old partial mortality on colonies was variable, but tended to less than 8% (Figure 10B).

High prevalence of old partial mortality following the bleaching event in 2005 is a reflection of the high prevalence of recent mortality associated with disease outbreaks following bleaching. The prevalence of recent mortality in 2007 had declined since markedly high levels in 2005 following the bleaching event (Figure 11A). Average percent surface area of individual colonies affected by recent mortality has been declining since the 2005 bleaching event at all sites (Figure 11B). In 2007, Long Reef/Eagle Ray and Jack's Bay had 0% average recent mortality.

Assessment of the overall health of corals (i.e., "impairment") showed that the total combined prevalence of mortality and disease had increased from 2006 to 2007 ranging from a low of 71% at Sprat Hole to a high of 93% at Mutton Snapper (Figure 12). The majority factor contributing to high levels of impairment after the 2005 bleaching event was old partial mortality. The low levels of impairment prior to 2005 may be partly due to inconsistent reporting of partial mortality.

Abundance of **Diadema antillarum**

The sea urchin *Diadema antillarum* was present at two sites on St. Croix in 2007. Great Pond had the highest number of sea urchins (11.5 urchins/10m^2) although a few individuals were observed at Cane Bay (Figure 13).

Section II: St. Thomas

Methods

Benthic Assessments

In August and September of 2007, the University of the Virgin Islands assessed the benthic composition at six sites in St. Thomas, USVI (Figure 1, Table 2). Monitoring in St. Thomas was based upon a stratified design to test hypotheses involving differences between reef systems located at different points along the insular platform, as well as to fill gaps in existing knowledge on previously unstudied reef systems. Midshelf sites represent intermediate depths, while shelf edge site can be considered parts of contiguous Mesophotic Coral Ecosystems (MCE).; See Nemeth *et al.* (2003a and 2003b) for the rationale of site selection, and Smith et al. (2008) and Smith et al. (2010) for a detailed description of some of the survey areas and sites.

Sites were established in 2003, with exception of the South Water site, which was established in 2005. Although College Shoal was established in 2003, fish community structure was not assessed in 2003, no assessments were made in 2004, and full assessments of fish community, benthic structure, coral health, and *Diadema* abundance were initiated in 2005. Sites sampled in 2004 used 10 transects as a test of the sufficiency of sampling with 6 transects per site.

Table 2. St. Thomas site location information and number of benthic transects at each site. Dates are for benthic cover and coral health/*Diadema* assessments.

Site	Date Sampled	GPS Coordinates	Depth (m)	No. of Transects
Seahorse Cottage Shoal[1]	8/30/07	N 18° 17.680, W 64° 52.050	20	6
South Capella[1]	9/7/07	N 18° 15.760, W 64° 52.342	24	6
South Water[1]	8/31/07	N 18° 16.841, W 64° 56.755	23	6
Grammanik Bank[2]	9/13/07	N 18° 11.468, W 64° 57.019	38	6
Red Hind Bank[2]	9/5/07	N 18° 12.130, W 65° 00.095	40	6
College Shoal East[2]	9/20/07	N 18° 11.141, W 65° 04.606	29	6

[1] Mid-shelf Sites – Intermediate Depths
[2] Shelf-edge Sites – Mesophotic Depths

Methods for video transects, health assessments, sea urchin counts and physical measurements were as described for St. Croix monitoring. Prior to 2007, transects for benthic cover, coral health, and *Diadema antillarum* abundance were laid along new random compass directions each sampling period within the same general area defined by georeferenced positions. This methodology was required because of limited diving times at deeper depths. In 2007, using technical NITROX and Closed Circuit Rebreather, all transects were made permanent by laying transects along randomly determined compass paths and marking end points with steel rods. Transect locations are relocated with detailed site maps.

Fish Census

The six sites surveyed for benthic composition were also surveyed for fish abundance and assemblage between 24 July and 28 August 2007 (Table 3). As outlined above and in previous reports, the sites were stratified based on proximity to the island of St. Thomas and the Puerto Rican shelf edge. Three sites, South Water Island (WI), Seahorse Cottage Shoal (SCS) and South Capella (SCP) were midshelf sites, all located between 2 and 5 km from St. Thomas, while the other three sites, College Shoal East (CSE), the Grammanik Bank (GB) and the Red Hind Bank (RHB) were on the southern edge of the Puerto Rican shelf, at least 10 km from land. All six sites were surveyed in 2005 and 2006 (Nemeth et al. 2005, Smith et al. 2007), four of the six in 2004 (Nemeth et al. 2004b) and three of the six in 2003 (Nemeth et al. 2004a). In addition to proximity to shore, the three midshelf sites differ from the shelf edge sites in that they are in areas open year round to commercial fishing. The shelf edge sites are closed at least seasonally to fishing; RHB and CSE are closed year round to all but surface trolling and GB is closed from February through May.

Fish census methods were consistent with those used on St. Thomas from 2004 through 2006. Both random belt transects and roving diver surveys (RDS's) were conducted at each site (see Nemeth et al. 2004 for detailed methodology). Belt transects were 30 m x 2 m and were conducted in 7-8 min per replicate. RDS replicates were either 45 min (sites < 28 m; WI, SCS, SCP) or 15 min (sites >28 m; CSE, GB, RHB). Ten replicate belt transects and three replicate RDSs were conducted at each site. All fish encountered were recorded except blennys and gobies. Data from all fish surveys were transcribed to Microsoft Excel spreadsheets and analyzed for descriptive statistics of reef fish assemblage structure.

Table 3. Summary of fish census efforts on St. Thomas, 2007.

Survey Method	Site	Survey Date	Total No. of Replicates	Cumul. Survey Time (min)	Ave. Time per Replicate (min)
Belt Transect	WI	6-Aug-07	10	75	7.5
	SCS	24-Jul-07	10	75	7.5
	SCP	16-Aug-07	10	75	7.5
	CSE	28-Aug-07	10	75	7.5
	RHB	27-Aug-07	10	75	7.5
	GB	21-Aug-07	10	75	7.5
Roving Diver	WI	26-Jul-07	3	135	45
	SCS	24-Jul-07	3	135	45
	SCP	16-Aug-07	3	135	45
	CSE	28-Aug- 07	3	45	15
	RHB	27-Aug-07	3	45	15
	GB	10-Aug-07	3	45	15

Results and Recommendations

Detailed summaries are included in Appendix I: Summary of Coral Video Data, Appendix II: Summary of Non-coral Video data, and Appendix III: Summary of Urchin, Bleaching, and Disease Data.

Benthic Assessments

In 2007, the St. Thomas sites had percent cover of living coral that ranged from a low of 3% at South Water to a high of 37% at College Shoal East (Figure 14A). The percent of dead coral covered with turf algae ranged from 19% at the Red Hind Bank to 34% at South Water (Figure 14B). Macroalgae ranged from 26% at the Grammanik Bank to 38 % at South Water (Figure 14C). Sponge cover was highest at South Water at 6% while lowest at College Shoal East at less than 1% (Figure 15A). Gorgonian cover comprised less than 10% cover at all sites with highest cover observed at Seahorse Cottage Shoal and South Capella at 3% while no gorgonians were observed at the Red Hind Bank (Figure 15B). Sand/sediment cover was highest at Red Hind Bank, where the percent cover was 9% (Figure 15C).

Intermediate and mesophotic coral reefs surveyed in St. Thomas were dominated by coral species in the *Montastraea annularis* species complex (Figure 16). Coral species composition was similar between mid-shelf and shelf-edge sites and between years for all sites (Figure 16A and B). Corals within the *M. annularis* complex were the most abundant corals at all sites (Figure 17), with the exception of South Water that was dominated by *Montastraea cavernosa*, *Porites astreoides* and *Siderastrea siderea* (Figure 17C).

In 2007, the Shannon – Weaver Diversity Index (H') for coral ranged from a high of 1.9 at Seahorse Cottage Shoal to a low of 1.45 at the Red Hind Bank. Diversity increased at all three shelf-edge sites from 2006 to 2007 and only declined at Seahorse Cottage Shoal from 1.99 to 1.62 (Figure 18).

Coral Health

Coral bleaching decreased markedly since the 2005 bleaching event but was high at some sites (Figure 19A). South Water showed the highest level of bleaching at 53% while Seahorse Cottage Shoal showed the lowest level at 21%. All shelf-edge sites (Grammanik Bank, Red Hind Bank, and College Shoal East) along with South Water showed modest increases in bleaching from 2006 to 2007 (Figure 19A). In general the extent of bleaching on colonies was low (Appendix II), suggesting the majority of bleaching was related seasonal bleaching related to the seasonal thermal maximum or localized stressors. The extent of colony bleached for the twelve most common species across sites was highest for *Colpophyllia natans*, *Diploria strigosa*, and *Montastraea annularis* (Figure 20A).

Prevalence of coral disease increased at three out of six sites in 2007 and was generally high at all high coral cover mesophotic sites (Figure 19B). Seahorse Cottage Shoal and South Water showed no cases of disease. *Siderastrea siderea* and *M. annularis* species complex showed the highest number of disease cases on St. Thomas in 2007. Similarly to St. Croix, dark spots disease was solely responsible for disease outbreaks in *S. siderea* (Appendix II). The occurrence of each individual disease was calculated for each site during the years 2003 to 2007 (Figure 21). Black band disease has been observed on St. Thomas at Seahorse Cottage Shoal in 2003, 2004, and 2006. It was also observed at the Grammanik Bank in 2004. Dark spots disease has been observed during every year of monitoring in a total of five out of the six sites. Dark spots disease most commonly occurred at Seahorse Cottage Shoal. Cases of white plague disease have been observed at all six sites with the greatest number of cases occurring in 2006. In 2007 all mesophotic shelf edge sites showed cases of white plague. Yellow blotch disease has been observed at three out of the six sites but only occurred at Seahorse Cottage Shoal in 2007 (Figure 21). Unknown diseases were most prevalent in 2006 following the bleaching event in 2005 (Appendix II).

The prevalence of old partial mortality has increased at all sites from 2006 to 2007 with the exception of South Water (Figure 22A). The highest prevalence of old partial mortality was seen at Seahorse College Shoal at 85 %. The average percent surface area of individual colonies affected by old mortality increased at all sites from 2006 to 2007 but was highest at South Water at 6% (Figure 22B). The prevalence of recent partial mortality has decreased at all sites from 2006 to 2007 with the exception of Red Hind Bank where it has remained at approximately the same level of 14% (Figure 23A). The highest prevalence of recent mortality occurred at the Grammanik Bank at 22%. Average recent mortality of individual colonies was more variable than old mortality, increasing the most at Red Hind Bank by 2% (Figure 23B).

Assessment of the overall health of corals showed that the total combined prevalence of mortality and disease (i.e., impairment) has increased from 2006 to 2007; ranging from 75% impairment at College Shoal East to 88% at the Grammanik Bank (Figure 24).

Abundance of **Diadema antillarum**

D. antillarum sea urchins were not present at any of the sites during the 2007 monitoring.

Fish Census

A total of 8,803 fish representing 91 species and 29 families were recorded during belt transects across all sites in 2007 (Appendix IV). Using RDS, 103 species representing 36 families were observed (Appendix V). As expected species richness was greater in RDS, designed to capture rare and cryptic species, than belt transects (Table 4).

Table 4. Comparison of species richness across sites off St. Thomas in 2007 using belt transects and roving diver surveys (RDS).

Site	Belt Transects			RDS		
	Total Survey Time (min)	Total No. Species	Ave. Species Richness (+/-SD)	Total Survey Time (min)	Total No. Species	Ave. Species Richness (+/-SD)
WI	75	47	17.8 (4.2)	135	69	58.3 (5.0)
SCS	75	55	20.9 (3.5)	135	58	52.0 (6.0)
SCP	75	52	20.6 (2.3)	135	74	52.0 (9.9)
CSE	75	54	18.3 (3.8)	45	59	40.3 (4.5)
RHB	75	43	16.7 (4.1)	45	47	30.0 (4.5)
GB	75	51	17.4 (4.2)	45	50	32.7 (9.5)

Fish smaller than 10cm TL predominated within belt transects (Appendix V). Twenty-seven percent of the individuals counted were less than 5 cm TL and 71.0% were less than 10cm TL. Large fish (30-40 cm TL) constituted 1.6% (139 fish) of the numeric total, and very large fish (> 40 cm) made up less than 1% (65 fish). Similar to 2006 surveys, the most abundant fish on all shelf edge sites and SCP was the creole wrasse (*Clepticus parrae,* Appendix IV). The abundance of creole wrasse on shelf edge sites and SCP ranged from a mean of 28.5 ± 9.0 fish/transect (GB) to 71.0 ± 25.8 fish/transect (CSE). Creole wrasse were uncommon at SCS and absent in transects at WI. The second and third most common fish across St. Thomas sites were the blue chromis (*Chromis cyanea*, mean = 23.9 ± 11.4 fish/transect) and bicolor damselfish (*Stegastes partitus,* mean = 16.2 ± 9.5 fish/transect), respectively. These fish were ubiquitous and occurred at all sites in relatively large numbers (Appendix IV).

Total fish abundance in 2007 was similar to earlier years across all sites, especially 2006 (Figure 25A). Fish abundance was highest on midshelf sites and CSE, and lowest on the two off-shore sites GB and RHB. Species richness determined by belt transects was less variable between sites and strata; however, as in previous years, species richness was slightly higher at the mid-shelf sites SCS and SCP (Figure 25B). Higher species richness was also reflected in RDS (Table 4). As discussed in the previous report (Smith et al. 2007), the bleaching event that occurred in the late summer of 2005, and the subsequent coral die-off, was not reflected in fish biodiversity or abundance in 2006 or 2007, even at the mid-shelf sites that were hardest hit by disease and mortality.

The abundance of fish by family for St. Thomas sites is shown in Figure 26 A-J. A summary table (Table 5) is presented with notable changes in abundance by family between 2006 and 2007. Overall, increases and decreases in fish abundance were results of natural variation or seasonality. Creole wrasse (*C. parrae*), both juvenile and adult, were present at CSE in 2005 and 2007 surveys, but were uncommon during the 2006 survey. Increases in abundance of pomacanthids at SCP and GB, chaetodontids at WI, and haemulids at SCS are probably also a result of natural variation as well as a small sample size. Scarids, represented primarily by juvenile princess (*Scarus taeniopterus*), striped (*S. iserti*) and redband parrotfish (*Sparisoma aurofrenatum*), are relatively abundant on all three midshelf sites. The abundance of this family as well as the other major herbivorous group, the acanthurids, have been variable over the last five years on midshelf sites, however the overall trend of both families does not appear to be increasing or decreasing. As in previous years, abundance and variability of scarids and acanthurids was low on the deep shelf-edge sites in 2007. Lutjanids were less abundant at GB and RHB in 2007, due to seasonality of the fish and the days surveys were conducted. In 2006 inflated numbers of cubera snapper (*Lutjanus cyanopterus*) were recorded at GB because those fish were present to spawn. Likewise schoolmaster snapper (*L. apodus*), rare in 2007, were present at RHB to spawn in 2005 and in more limited numbers in 2006. This was a function of the sampling calendar and lunar cycle; both cubera and schoolmaster snapper were observed in large numbers at other times in 2007.

Table 5. Observed trends in fish assemblages in St. Thomas from 2006 to 2007.

Site	Fish Family	Affected Species	Observed Trend: 2006 to 2007	Affected Size Class	Most Probable Explanation (see text)
CSE	Labridae	creole wrasse	increase	5-20 cm	natural variation
WI, SCS, RHB	Pomacanthidae	rock beauty, queen angel	increases	20-30 cm	natural variation, small sample size
WI	Chaetodontidae	butterflyfish	increase	0-5 cm	natural variation, small sample size
WI, SCS	Haemulidae	tomtate, white grunt	decrease	10-20 cm	natural variation, small sample size
WI, SCS, SCP	Scaridae, Acanthuridae	Princess and striped parrotfish, doctorfish	Increases and decreases	0-20 cm	natural variation
GB, RHB	Lutjanidae	schoolmaster cubera snapper	decrease	30-40 cm >40 cm	seasonality

RDS Observations of Rare Species. The RDS method was incorporated into the annual fish surveys to provide greater detection of commercially important, rare and/or vulnerable fishes. Results from 2007 RDS surveys are presented in Appendix VI and observations of rare species from these surveys as well as belt transects are summarized in Table 6.

Five species of grouper, including the red hind (*Epinephelus guttatus*), yellowfin (*Mycteroperca venenosa*), yellowmouth (*M. interstitialis*), tiger (*M. tigris*) and Nassau (*E. striatus*), were observed in either RDS surveys or on belt transects in 2007. All of the larger grouper species were very rare, and three, the yellowfin, yellowmouth and tiger, were only observed on the offshore sites. Red hind were observed at all six sites and Nassau grouper at four, including all midshelf sites and CSE. Large snappers were observed at several sites in both belt transects and RDS. Cubera (*Lutjanus cyanopterus*), dog (*L. jocu*) and mutton snapper (*L. analis*) were seen on GB, a site where these species spawn between March and October. Dog and mutton snapper were also observed in small numbers at SCP and SCS. As noted in previous reports, the occurrence of large groupers and snappers on the edge of the shelf off St. Thomas is probably due to the two reserves that protect grouper spawning aggregation areas and over 10 linear km of the shelf edge from fishing. Although declines in large snappers and groupers have been documented around the territory in the past 30 years, it is encouraging to observe some of these species, especially the Nassau grouper on the more inshore reefs.

Table 6. Abundance of nine commercially important, rare and/or vulnerable fish species, St. Thomas 2007.

			Relative fish abundance*								
Site	Method	Total Survey Time (min)	Nassau grouper	yellowfin grouper	yellowmouth grouper	tiger grouper	red hind	cubera snapper	mutton snapper	dog snapper	hogfish
WI	belt	75	1	-	-	-	6	-	-	-	-
	RDS	135	0.3 (1,0)	-	-	-	2.0 (2,2)	-	-	-	-
SCS	belt	75	-	-	-	-	-	-	1	1	1
	RDS	135	0.3 (1,0)	-	-	-	1.6 (2,1)	-	2.0 (3,1)	1.3 (2,0)	2.0 (2,2)
SCP	belt	75	-	-	-	-	-	-	-	-	-
	RDS	135	0.3 (1,0)	-	-	-	1.0 (2,0)	-	0.6 (2,0)	1.3 (2,0)	2.0 (2,2)
CSE	belt	75	1	1	-	-	-	-	-	5	1
	RDS	45	0.3 (1,0)	0.3 (1,0)	1.3 (2,0)	0.3 (1,0)	1.3 (2,0)	-	-	2.0 (2,2)	0.3 (1,0)
RHB	belt	75	-	-	-	1	9	-	-	-	-
	RDS	45	-	-	-	-	0.3 (1,0)	-	-	-	-
GB	belt	75	-	1	1	2	1	10	-	2	2
	RDS	45	-	-	0.3 (1,0)	0.7 (2,0)	-	1.6 (3,0)	0.7 (2,0)	0.3 (1,0)	-

*Belt transects occurrences reported as the total number of fish observed over 10 repetitive surveys. RDS occurrences reported as mean Abundance Index (AI) over 3 repetitive surveys with maximum and minimum AI in parentheses. AI: 0=no fish, 1=fish, 2=2-10 fish, 3=11-100 fish, 4=101-1000 fish, 5>1000 fish.

Summary of St. Thomas Fish Data. As in previous years, total fish abundance was variable between sites. However, there was a pattern of higher abundance on mid-self sites than shelf-edge sites, with the exception of CSE. Species richness was less variable between sites, strata, and sampling years but was also slightly lower at shelf-edge sites. Planktivorous labrids, (*C. parrae*) and pomacentrids (*C. cyanea*) numerically dominated most sites, with the notable exception of WI and SCS, which were dominated by omnivorous pomacentrids (*Stegastes partitus*) and scarids (*S. iserti*). Large serranids were rare, and except for the red hind and Nassau grouper, were observed only on shelf-edge sites. Nassau grouper were observed on all midshelf sites during RDS, but were very rare. Lutjanids were most common at GB and RHB, protected sites on which the cubera, mutton and schoolmaster snapper form aggregations to spawn. No changes that could not be attributed to natural variation or seasonality were noted in fish abundance or species composition between 2007 and the previous four years. The effects of coral bleaching and subsequent coral mortality observed in 2006 were not reflected in the fish data that was collected in 2007.

Summary

St. Croix

On St. Croix, turf algae covering dead coral was the dominant substrate at most sites sampled, ranging from 24% to 67%. The percent cover of other benthic organisms ranged from 3% to 12% for living hard coral, 0% to 8% for gorgonians, 0.2% to 4% for sponges and 12% to 61% for macroalgae. Coral species composition was similar between most sites with the exception of Great Pond. Coral diversity (H') varied between 1.21 and 2.05. Diversity declined at four sites (Cane Bay, Great Pond, Eagle Ray and Mutton Snapper) but increased at the other four (Buck Island, Jack's Bay, Salt River, and Sprat Hole). Coral health varied between sites. Prevalence of coral disease ranged from 0% to 6% with no signs of disease at Great Pond, Jack's Bay and Mutton Snapper, and the highest values at Cane Bay. Coral bleaching ranged from a low of 14% at Salt River to a high of 55% at Mutton Snapper. Diadema sea urchins were observed at two sites with the highest number recorded at Great Pond.

Annual comparisons show slight increases in 2007 at most sites in percent cover of live coral compared to 2006. The largest increase of coral was seen at Cane Bay with a gain of 2% cover. Species in the Montastraea genus remained the most dominant coral with the exception of Great Pond, where *Porites astreoides, Diploria strigosa and Millepora complanata* are the most dominant species.

Levels of disease and bleaching were both relatively high in 2007 after having dropped slightly in 2006. Bleaching was most severe at the Mutton Snapper Site, with 55% prevalence. Salt River showed the lowest degree of bleaching at 15%. Disease was most prevalent at Cane Bay at 6% and was evident at five out of the eight sites.
Despite slight increases in coral cover at some sites, overall health of St. Croix coral reefs appears to continue to be declining. This is most likely a lasting effect of the 2005 bleaching event.

St. Thomas

On St. Thomas in 2007, macroalgae and live coral cover were the most predominant substrates with averages of 38% and 37% respectively. South Capella had the highest cover of macroalgae while College Shoal East had the highest cover of coral. Living coral cover increased at all sites from 2006 to 2007 with the exception of Seahorse Cottage Shoal. These findings are similar to those for coral diversity (H'). Coral diversity increased at all sites except for Seahorse Cottage Shoal and ranged from 1.45 to 1.9. Gorgonian cover ranged from 0%-3% while percent cover of sponges ranged from 0.1%-6%. Dead coral with turf algae ranged from 19% to 34%.

In previous years, species in the genus *Montastraea* have remained the dominant coral species on St. Thomas reefs; however, in 2007 South Water showed dominance by

Montastraea cavernosa, *Porites astreoides* and *Siderastrea siderea*. The sea urchin *Diadema antillarum* was not observed at any sites in 2006.

Coral disease was evident at four of the six sites and at all three shelf edge sites. College Shoal East had the highest prevalence of disease at 12% due primarily to outbreaks of white plague. Bleaching was also observed at four out of six sites at levels higher than in 2006. Seahorse Cottage Shoal and South Cappella were the only two sites that did not show increases in bleaching, with approximately 50% reductions from 2006.

Assessment of the overall health of corals shows that the total combined prevalence of mortality and disease has increased from 2006 to 2007. This is troubling considering much of the decline is occurring at shelf-edge sites, located miles offshore, far from the direct impact of anthropogenic factors.

Acknowledgments

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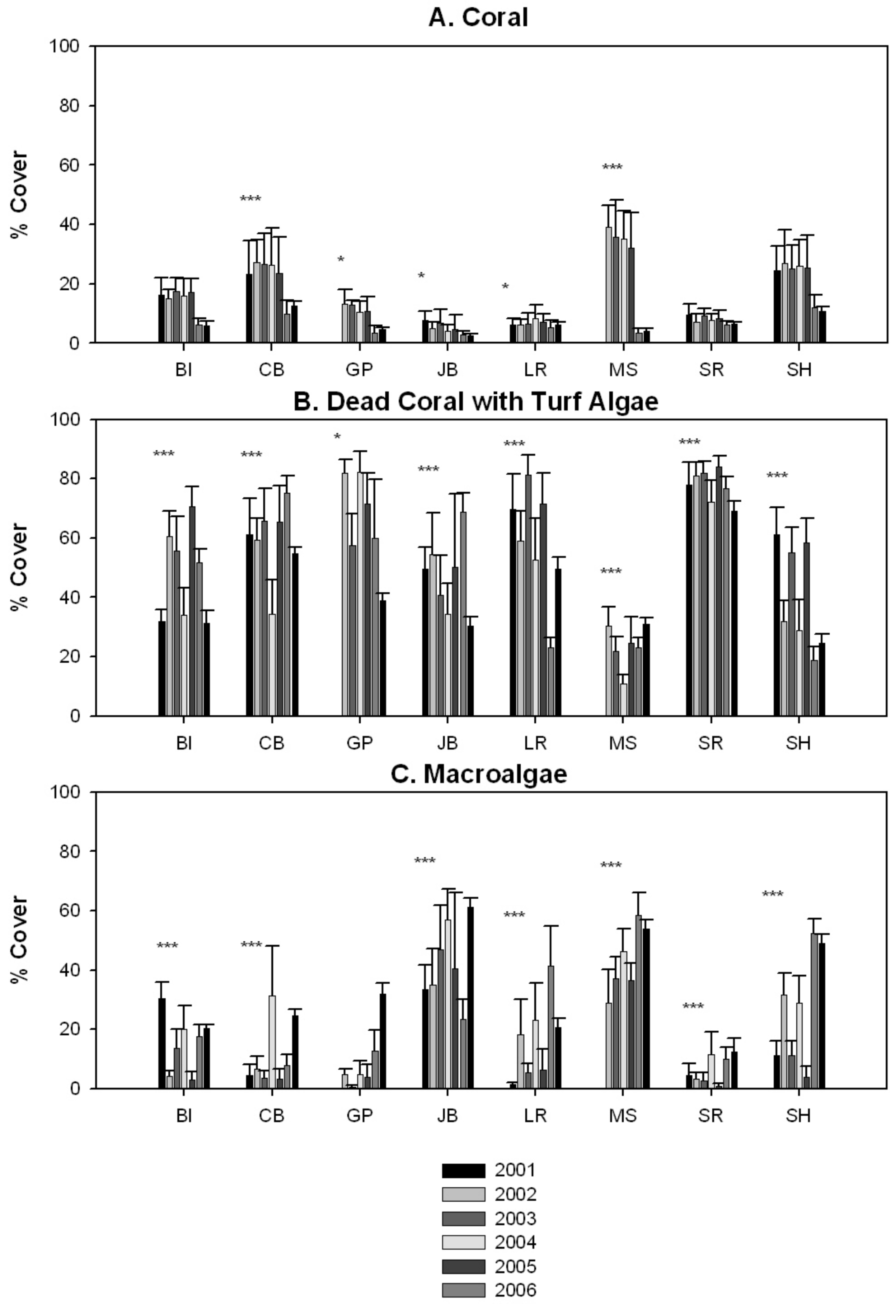


Figure 2. Mean percent cover ± SE of A. scleractinian corals, B. dead coral with turf algae, and C. macroalgae for 2001 - 2007 at eight monitored sites. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River; SH Sprat Hole. Significant difference in repeated measures ANOVA: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Figure 3. Mean percent cover ± SE of A. Sponges, B. Gorgonians, and C. Sand/Sediment for 2001 - 2006 at eight monitored sites. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SRW Salt River; SH Sprat Hole. Significant difference in repeated measures ANOVA: *p < 0.05; **p < 0.01; ***p < 0.001.

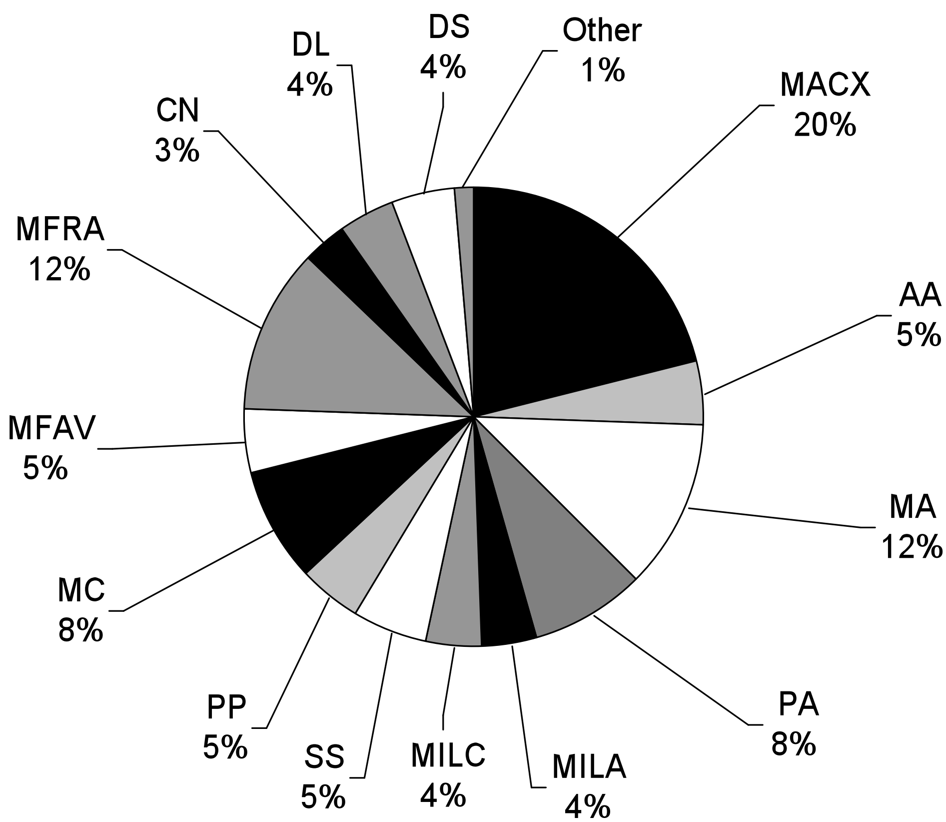


Figure 4. Relative coral species composition as a function of cover for St. Croix USVI. MACX *Montastraea annularis* species complex; MC *M. cavernosa*; PA *Porites astreoides*; SS *Siderastrea siderea*; AA *Agaricia agaricites*; AL *A.lamarcki*; AF *A. fragilis*; CN *Colpophyllia natans*. Other denotes percent of all other coral species combined and includes: *Acropora cervicornis, Agaricia grahamae, Diploria labyrinthiformis, D. strigosa, Eusmilia fastigiata, Madracis decactis, M. formosa, M. mirabilis, Millepora alcicornis, Mussa angulosa, Mycetophyllia aliciae, My. ferox, My. lamarckiana, Porites furcata, P. porites*.

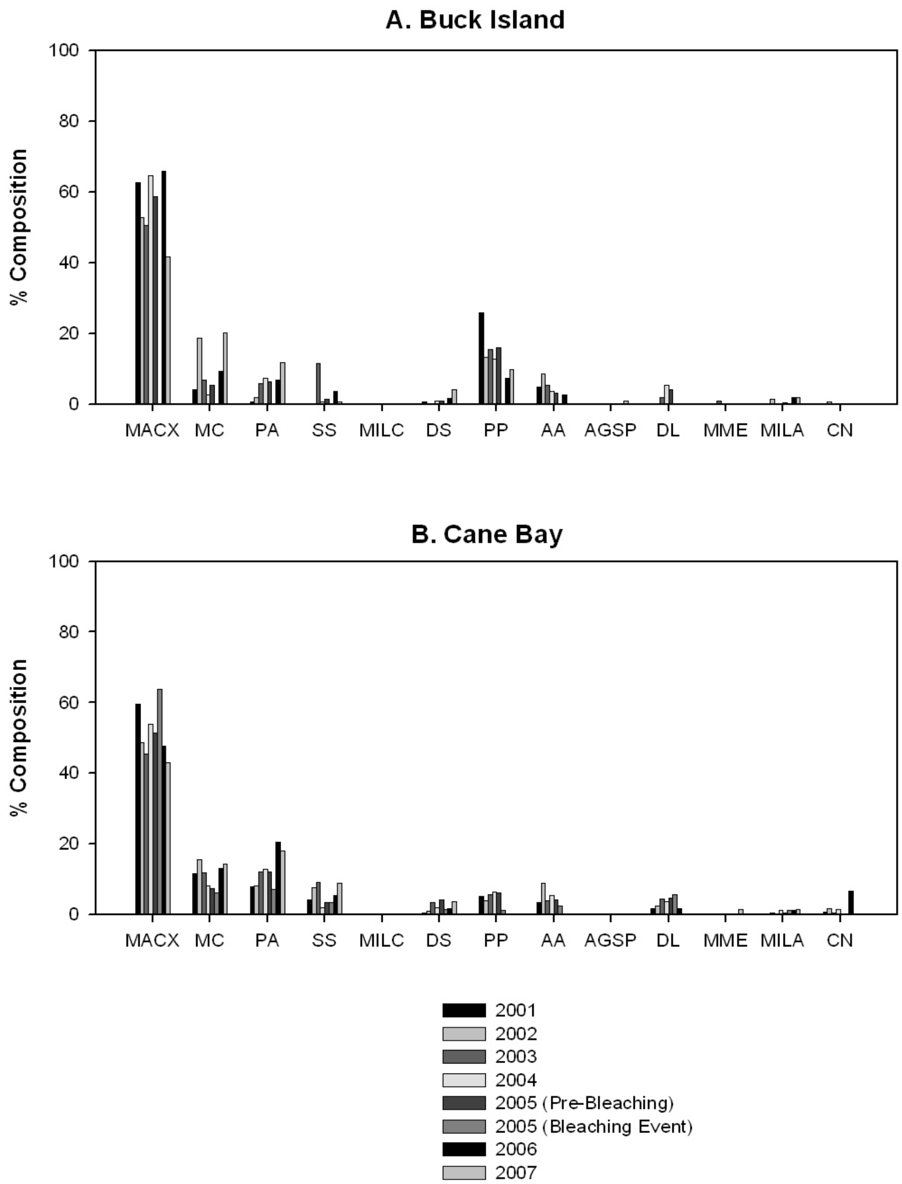
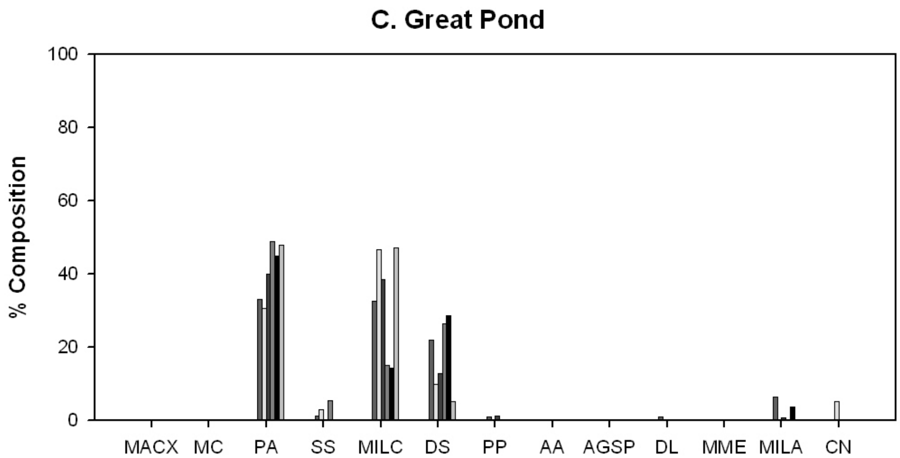
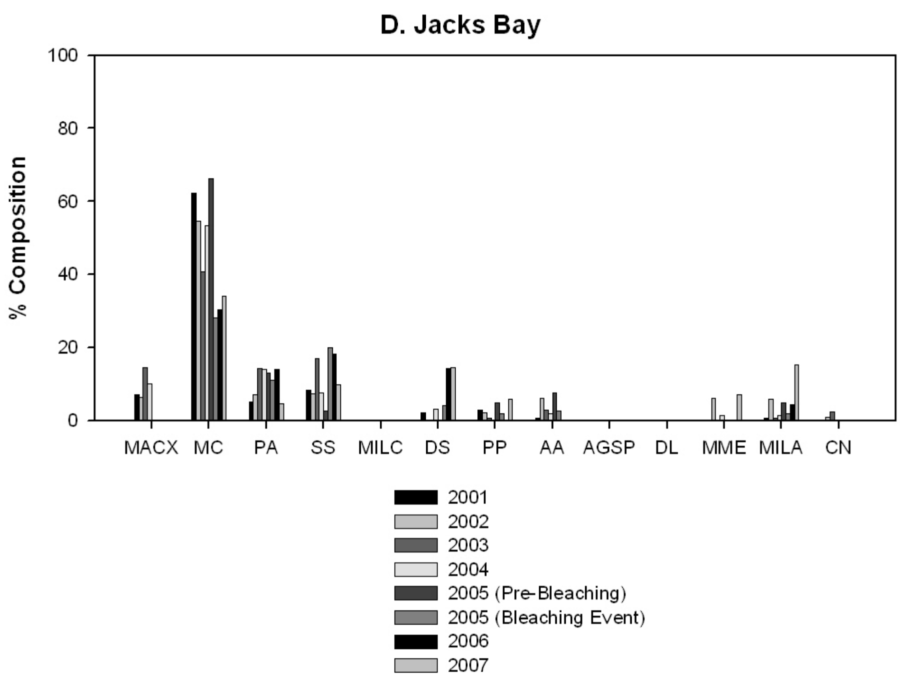
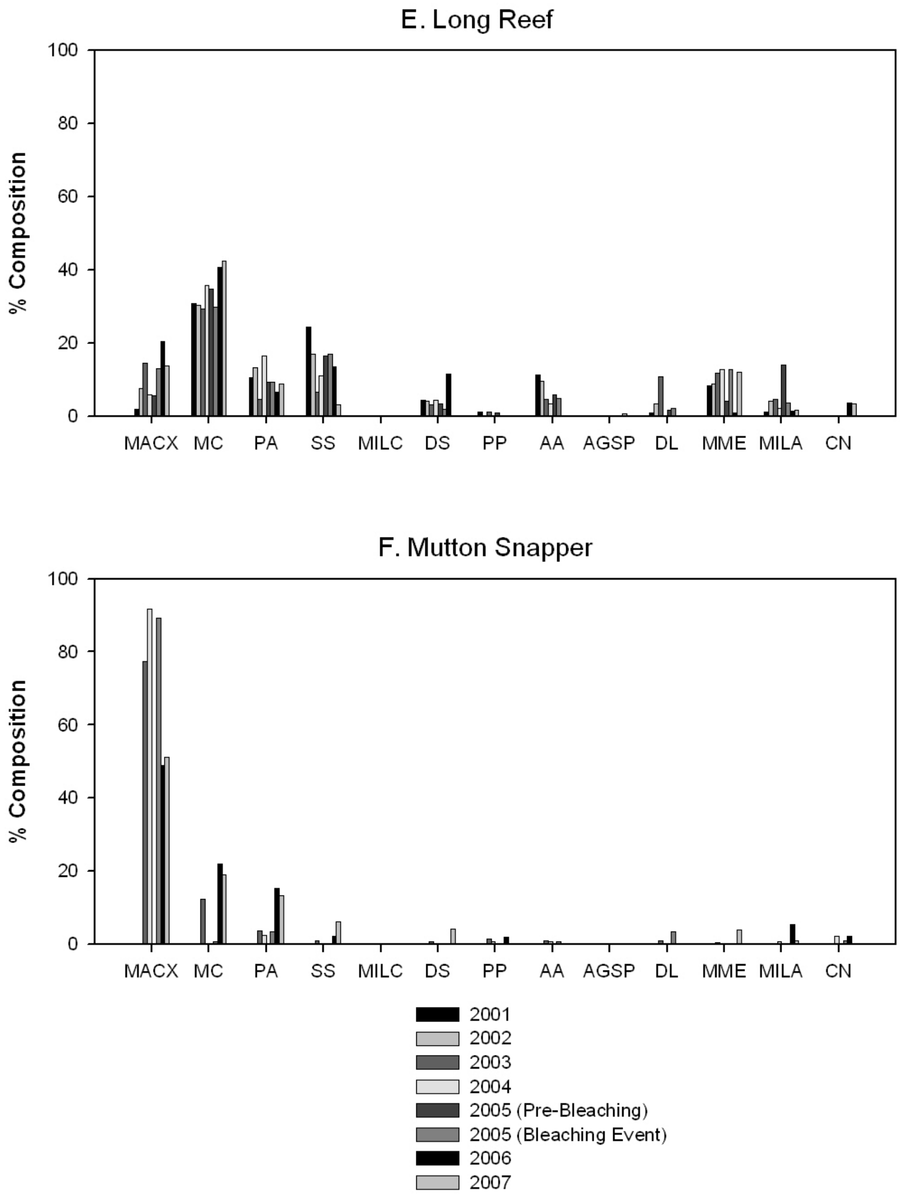
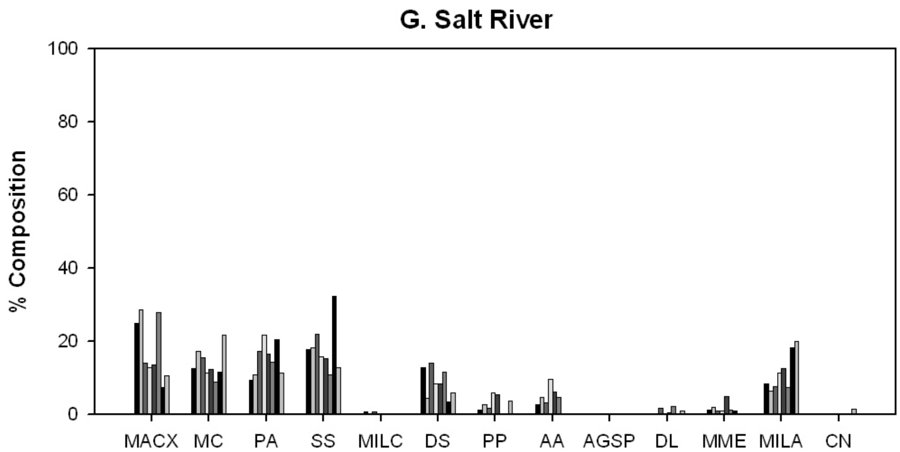


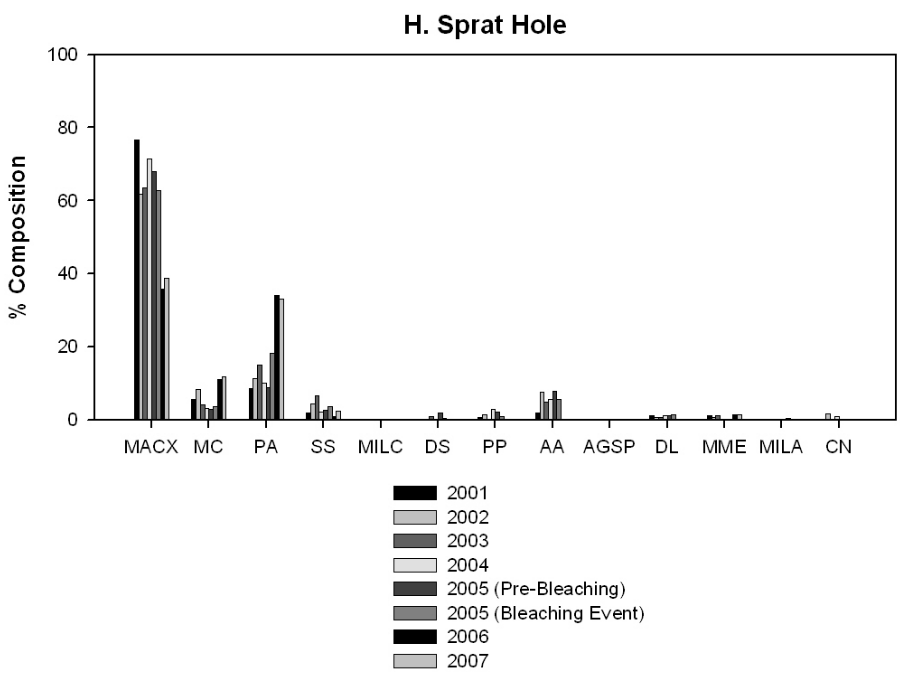
Figure 5. Species composition of living coral cover of the most common coral species. A. Buck Island, B. Cane Bay, C. Great Pond, D. Jacks Bay, E. Long Reef, F. Mutton Snapper, G. Salt River, H. Sprat Hall for years 2001-2006. MACX *Montastraea annularis* complex; MC *Montastraea cavernosa*; PA *Porites astreoides*; SS *Siderastrea siderea*; MILC *Millepora complanata*; DS *Diploria strigosa*; PP *Porites porites*; AA *Agaricia agaricites*; DL *Diploria labyrinthiformis*; MME *Meandrina meandrites*; MILA *Millepora alcicornis*; CN *Colpophylia natans*. n = 6 transects for all samplings, except n = 3 transects for Buck Island in 2001 and 2002; n=5 transects for MS and SH in 2002. Sampling of GP and MS began in 2002.


C. Great Pond
100
80
60
40
20
0
% Composition
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN


D. Jacks Bay
100
80
60
40
20
0
% Composition
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
2001
2002
2003
2004
2005 (Pre-Bleaching)
2005 (Bleaching Event)
2006
2007


E. Long Reef
% Composition
100
80
60
40
20
0
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
F. Mutton Snapper
% Composition
100
80
60
40
20
0
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
2001
2002
2003
2004
2005 (Pre-Bleaching)
2005 (Bleaching Event)
2006
2007


G. Salt River
% Composition
100
80
60
40
20
0
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN


H. Sprat Hole
% Composition
100
80
60
40
20
0
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
2001
2002
2003
2004
2005 (Pre-Bleaching)
2005 (Bleaching Event)
2006
2007

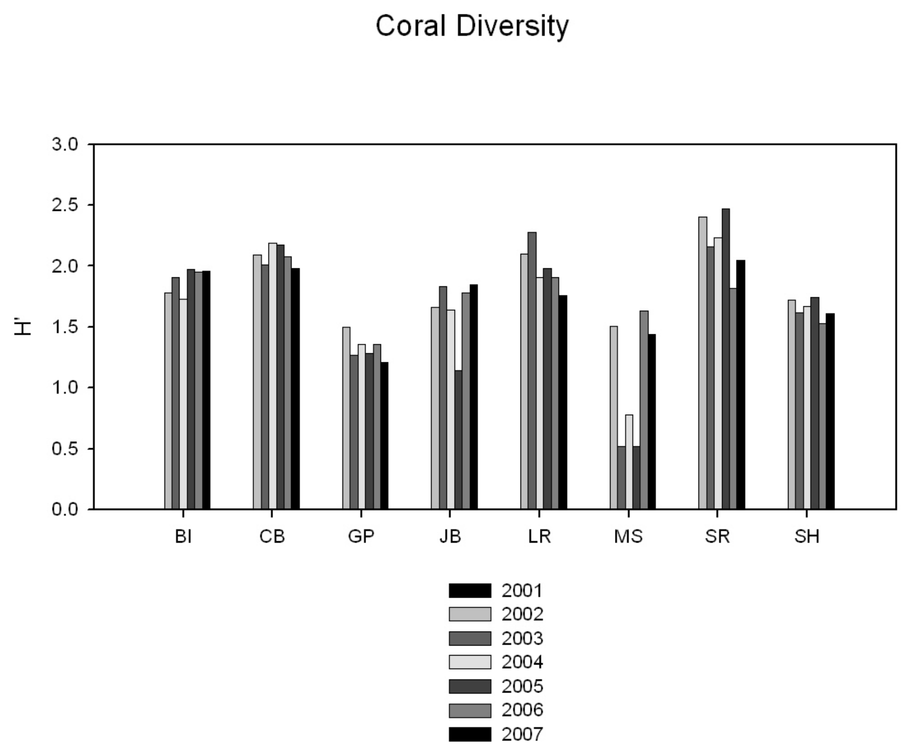


Figure 6. Shannon - Weaver Diversity Index (H') for corals at eight monitored sites in St. Croix, USVI for years 2001- 2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River; SH Sprat Hole

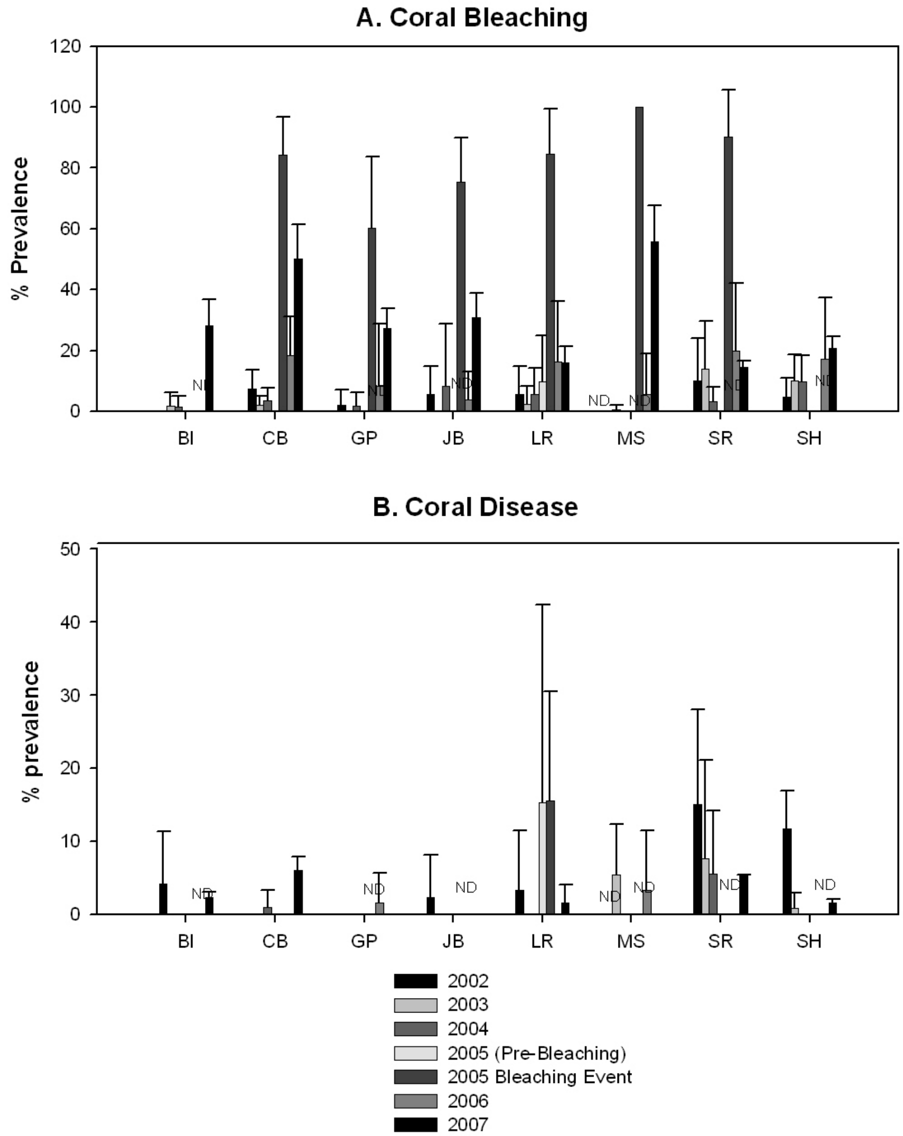


Figure 7. Mean prevalence ± SE of A. colonies with bleaching and B. colonies with disease by sampling site for years 2001-2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River; SH Sprat Hole.

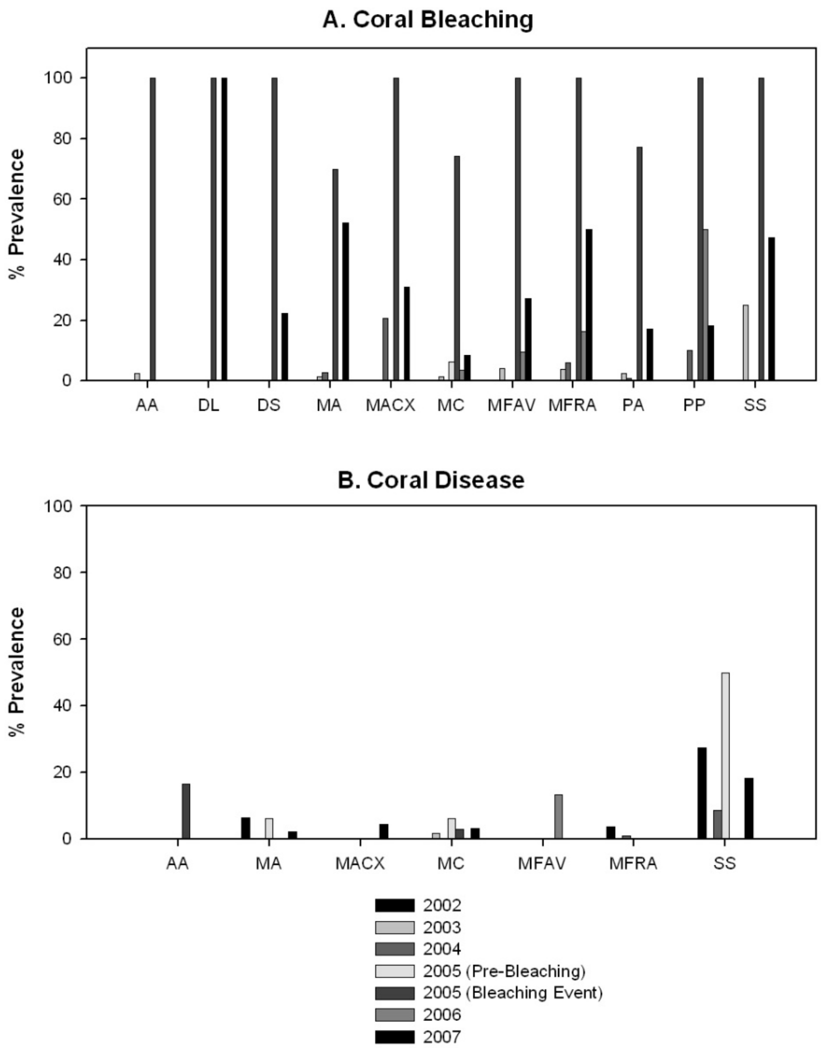


Figure 8. Mean prevalence of A. bleached colonies and B. diseased colonies by seven most common species, with the exception of Mutton Snapper for year 2002-2006. AA Agaricia agaricites; DL *Diploria labyrinthiformis*; DS *Diploria strigosa*; MA *Montastraea annularis*; MACX unidentified species belonging to the *Montastraea. annularis* complex; MC *Montastraea cavernosa*; MFAV *Montastraea faveolata*; MFRA *Montastraea franksii*; PA *Porites astreoides*; PP *Porites porites*; SS *Siderastrea siderea*.

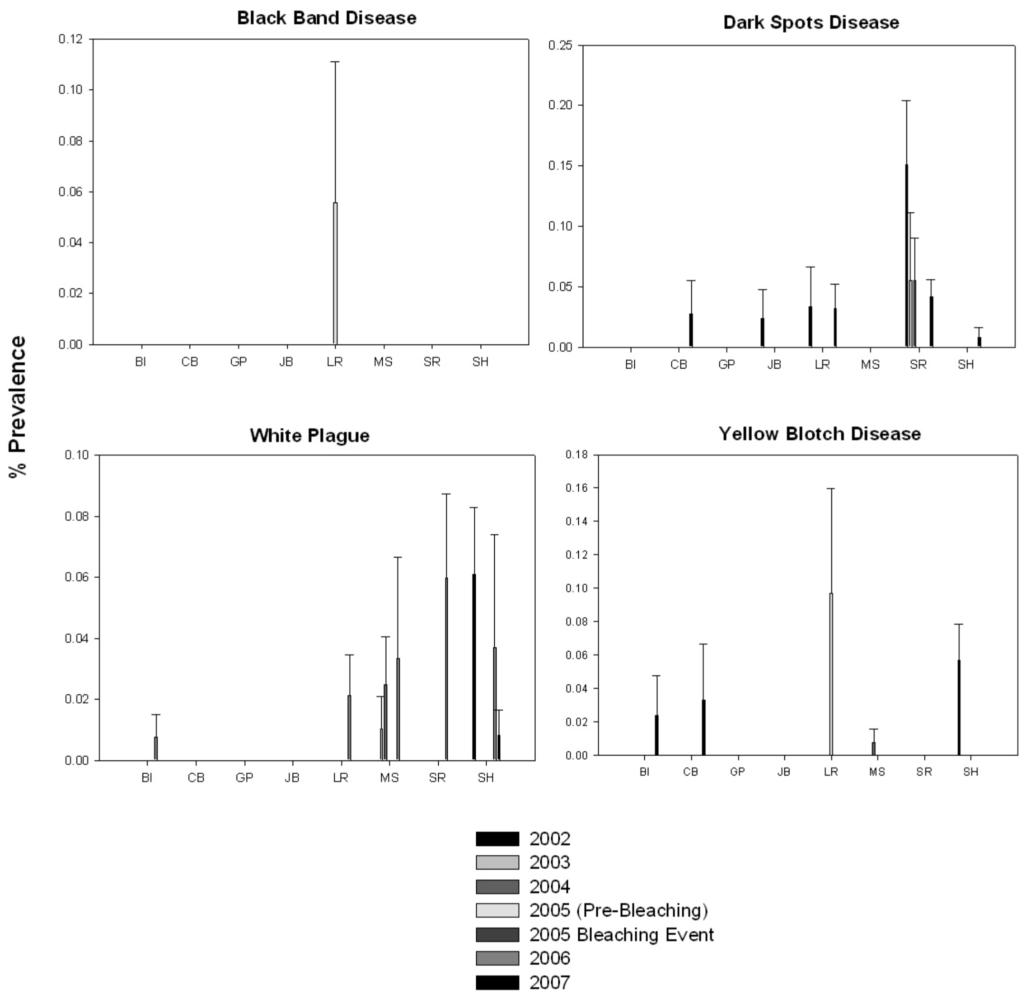


Figure 9. Mean prevalence of diseases ± SE at 8 sites on St. Croix from 2001-2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River. DCOR represents unknown diseases.

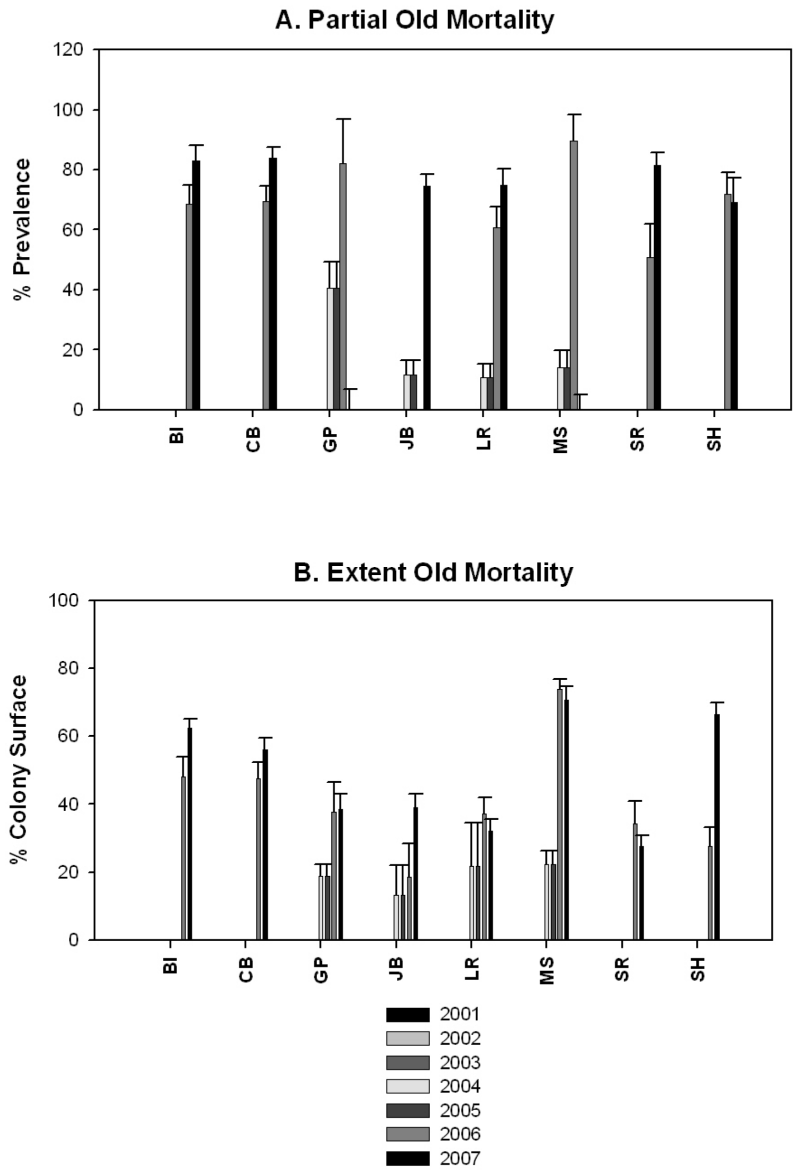


Figure 10. A. Prevalence and B. extent of colony affected by old mortality ± SE at eight sites on St. Croix from 2005-2008. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River.

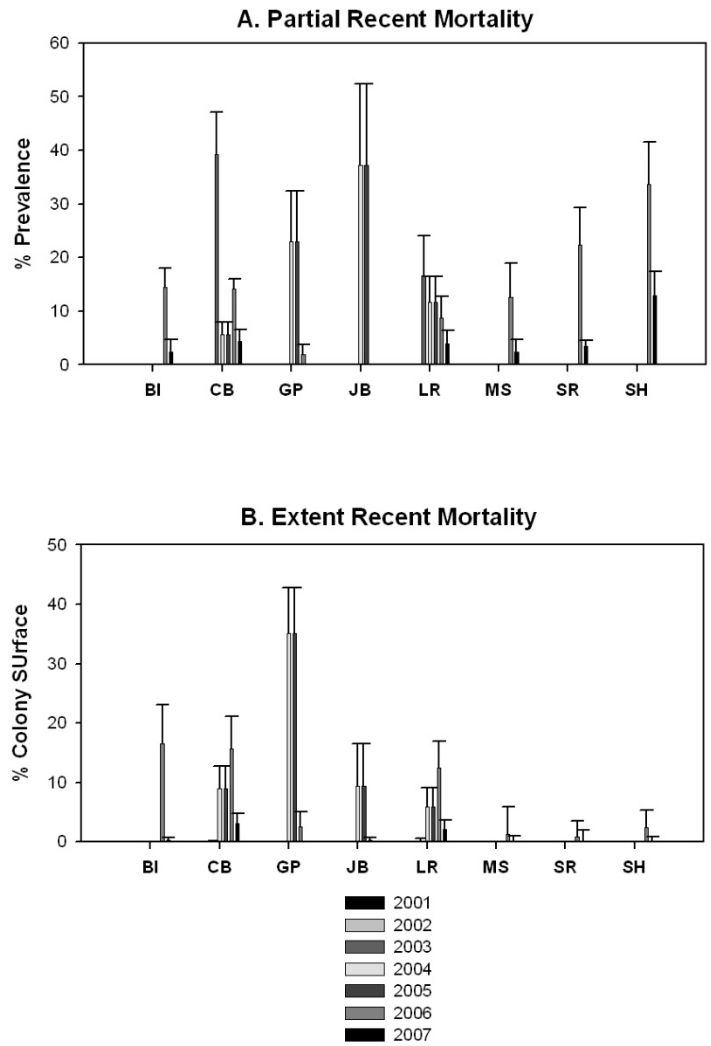


Figure 11. A. Prevalence and B. extent of colony affected by recent mortality ± SE for eight sites on St. Croix from 2003-2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River.

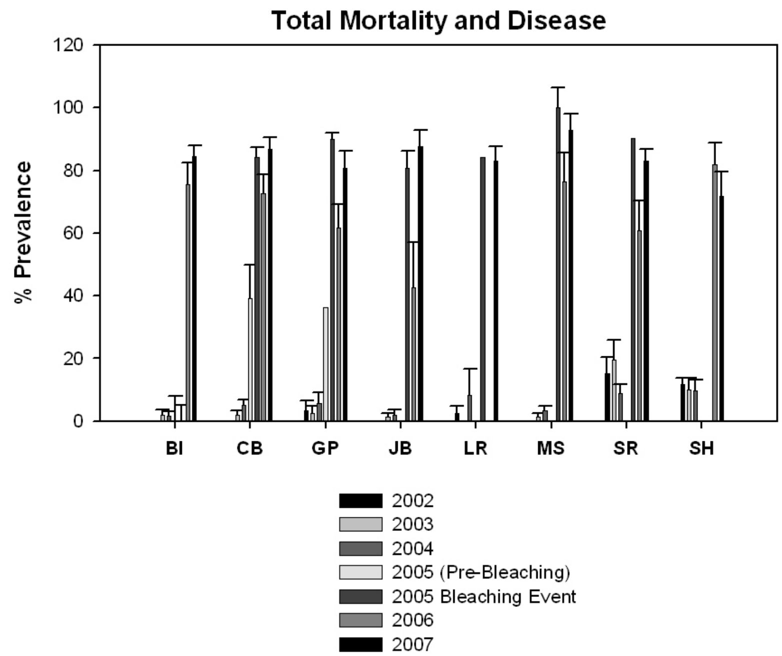


Figure 12. Total mortality and disease (Impairment) ± SE for 8 sites on St. Croix from 2001- 2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River.

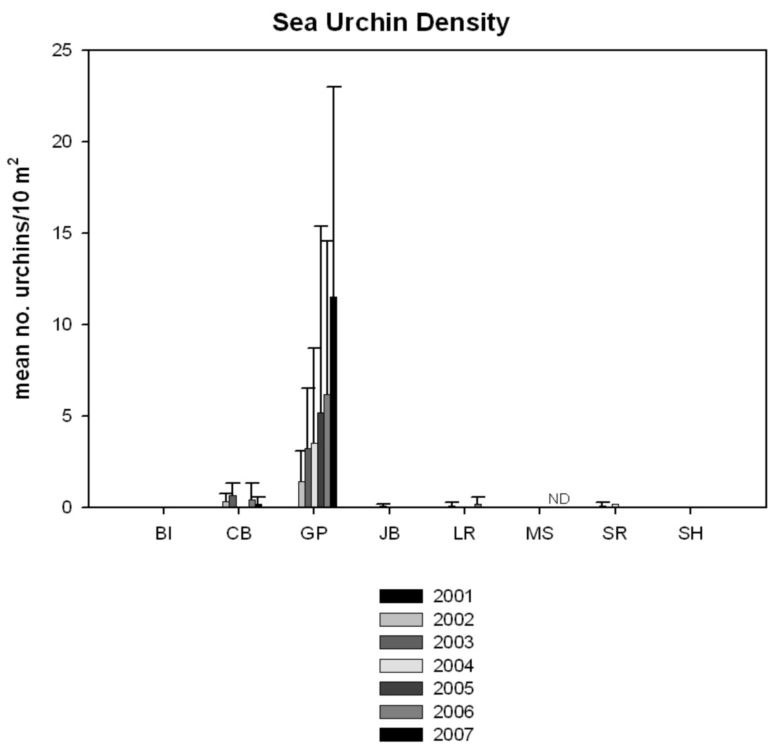


Figure 13. Mean sea urchin density ± SE at each St. Croix monitoring site for years 2001-2007. BI Buck Island; CB Cane Bay; GP Great Pond; JB Jacks Bay; LR Long Reef/Eagle Ray; MS Mutton Snapper; SR Salt River; SH Sprat Hole. GP and MS sampling began in 2002. No urchins were observed at any site in 2001. n = 6 transects for all sites except for n = 3 transects at BI 2001 and 2002 and n = 5 transects at MS and SH in 2002. No urchin assessments were performed at MS in 2004.

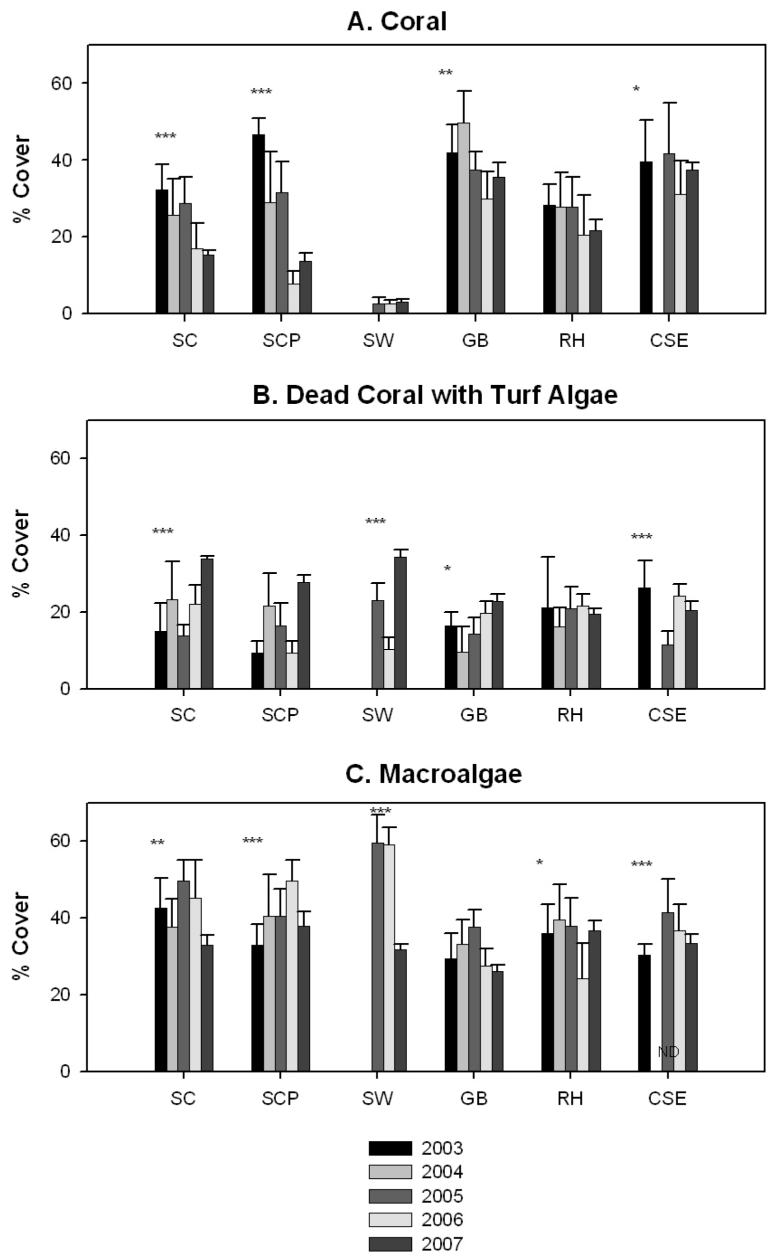


Figure 14. Mean percent cover ± SE of A. scleractinian corals, B. dead coral with turf algae, and C. macroalgae for 6 St. Thomas monitored sites. SC Seahorse Cottage Shoal; SCP South Capella; SW South Water; GB Grammanik Bank; RH Red Hind Bank; CSE College Shoal East.

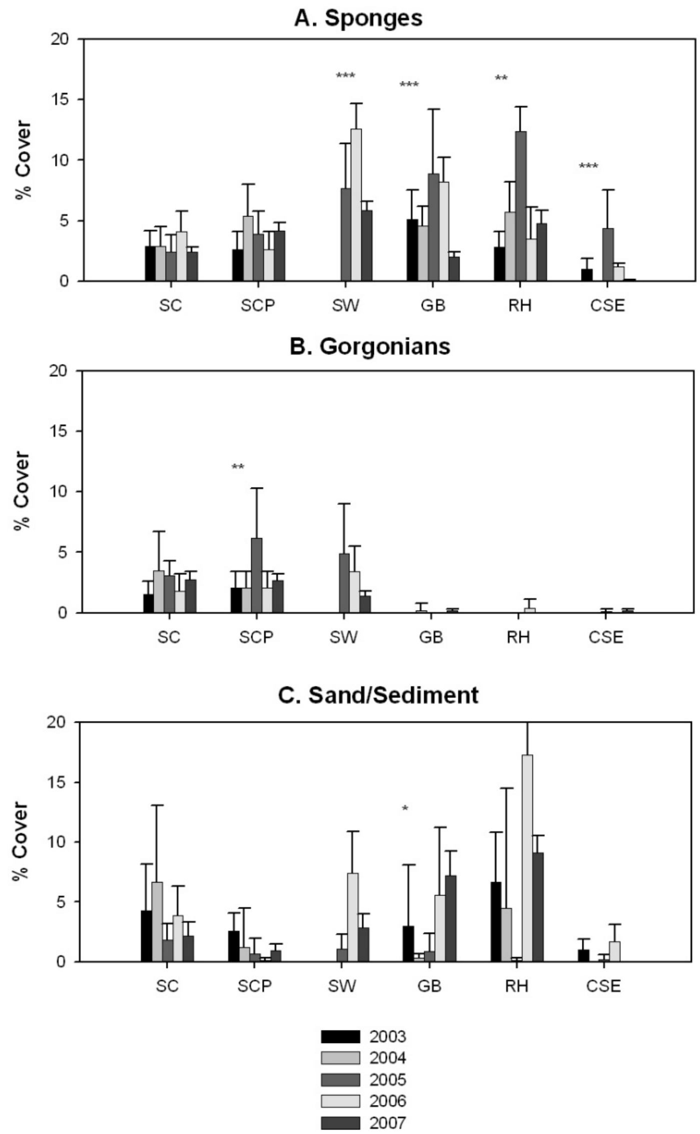
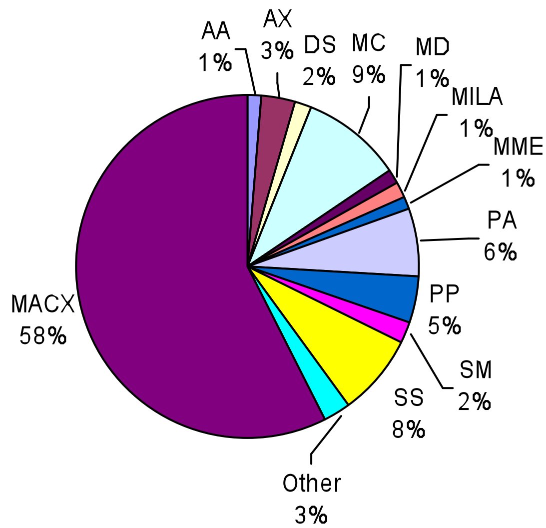


Figure 15. Mean percent cover ± SE of A. sponges, B. gorgonians, and C. sand/sediment for 6 St. Thomas monitored sites. SC Seahorse Cottage Shoal; SCP South Capella; SW South Water; GB Grammanik Bank; RH Red Hind Bank CSE College Shoal East. SC, SCP and SW are mid-shelf sites and GB, RH and CSE are shelf-edge sites. n = 6 transects for all sites sampled in 2003 and 2005, n = 10 transects for all sites sampled in 2004. Sampling for SCP began in 2004, sampling for SW and CSE began in 2005.

A. Mid-Shelf



B. Shelf-Edge

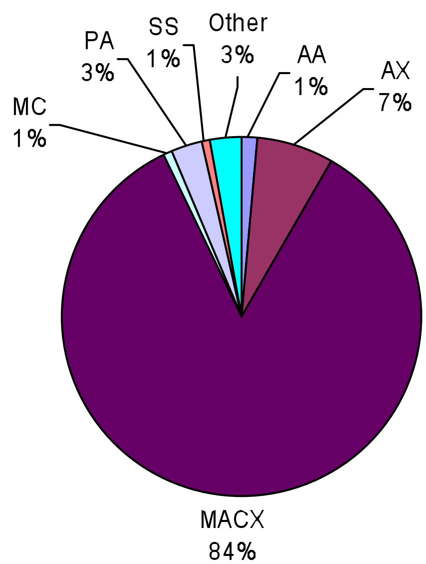


Figure 16 (Caption on following page)

C. Combined

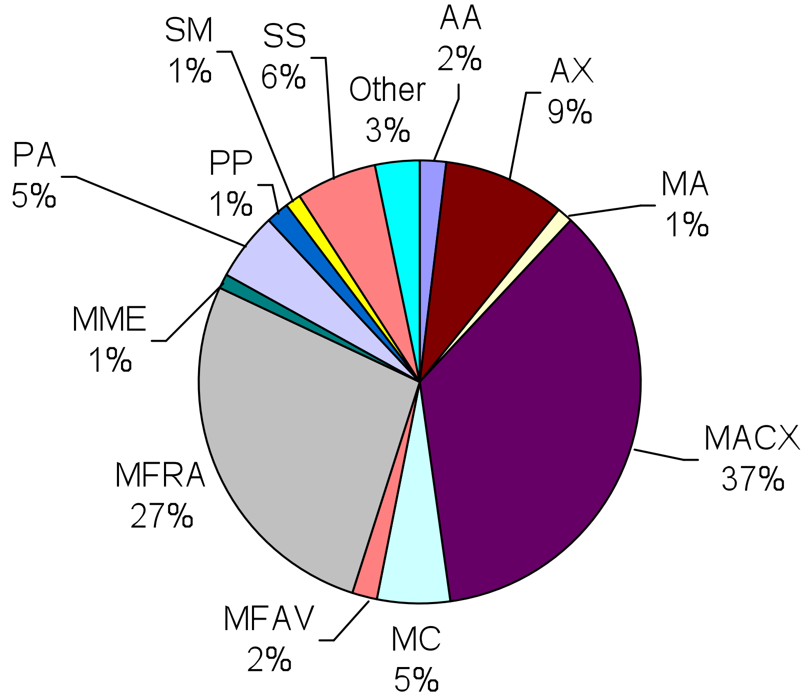


Figure 16. Relative coral species composition as a function of cover at A. mid-shelf sites and B. shelf-edge sites and C. all sites combined for St. Thomas, USVI 2007. MACX *Montastraea annularis* complex; MFAV *M. faveolata*; MFRA *M. franksi*; MC *M. cavernosa*; PA *Porites astreoides*; PF *P.furcata*; PP *P. porites* SS *Siderastrea siderea*; AA *Agaricia agaricites*; AL *A.lamarcki*; AF *A. fragilis*; CN *Colpophyllia natans; ,* DL *Diploria labyrinthiformis;* DS *D. strigosa;* MD *Madracis decactis,.* Other denotes percent of all other coral species combined and includes: *Acropora cervicornis, Agaricia grahamae Eusmilia fastigiata, M. formosa, M. mirabilis, Millepora alcicornis, Mussa angulosa, Mycetophyllia aliciae, My. ferox, My. Lamarckiana.*

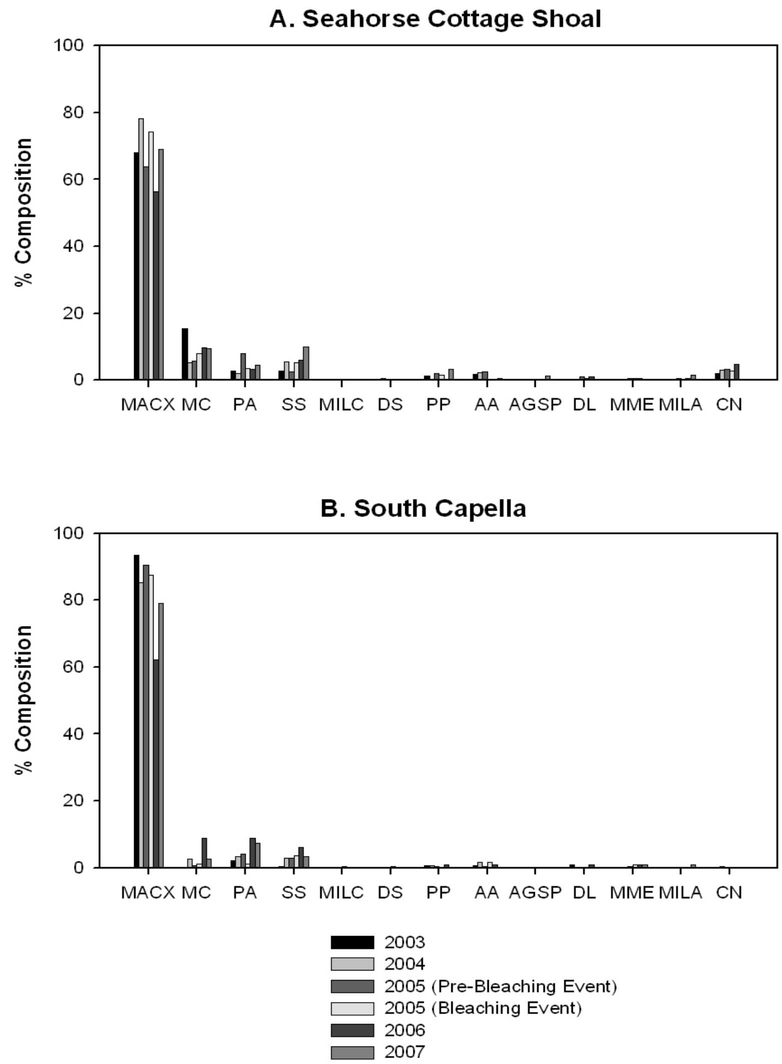
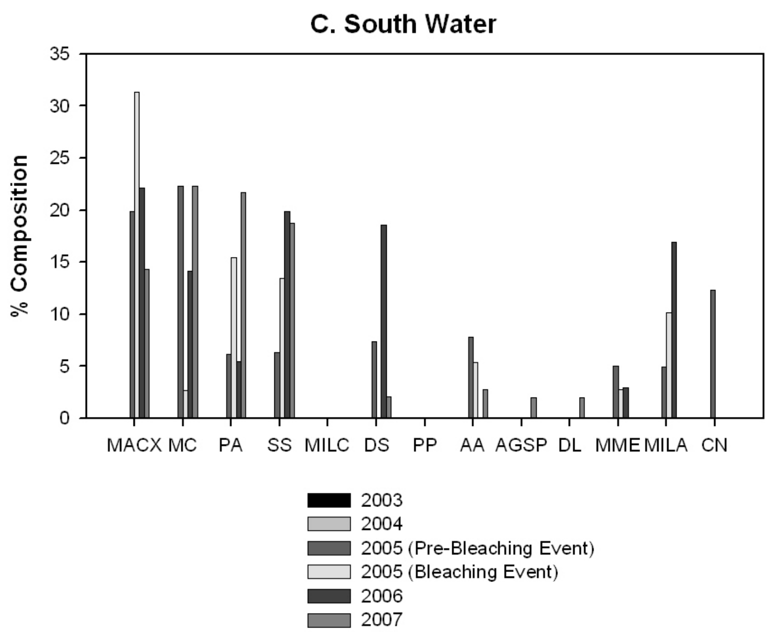
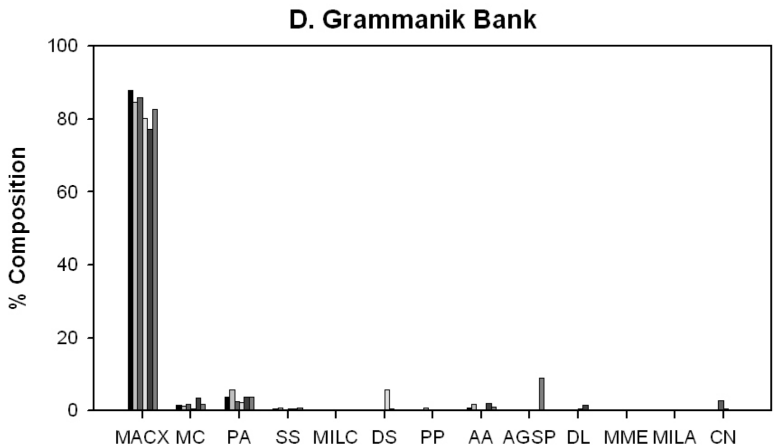
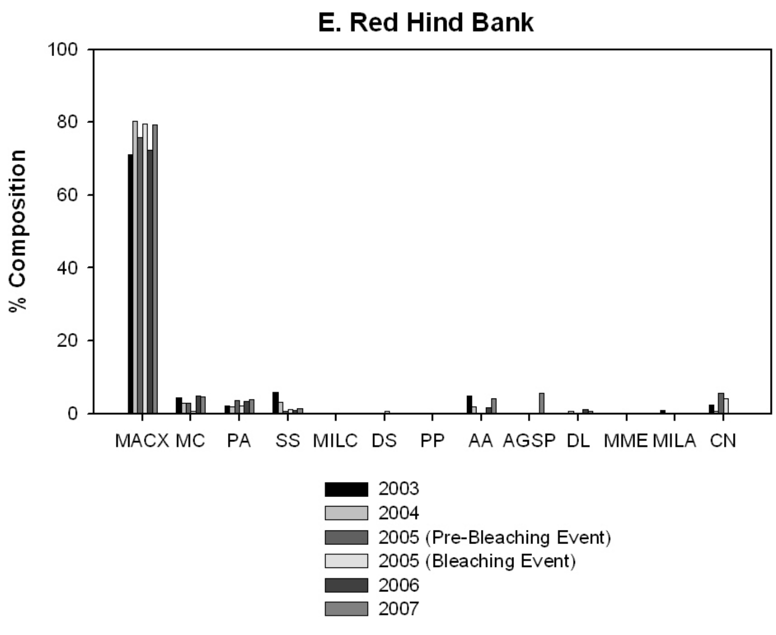
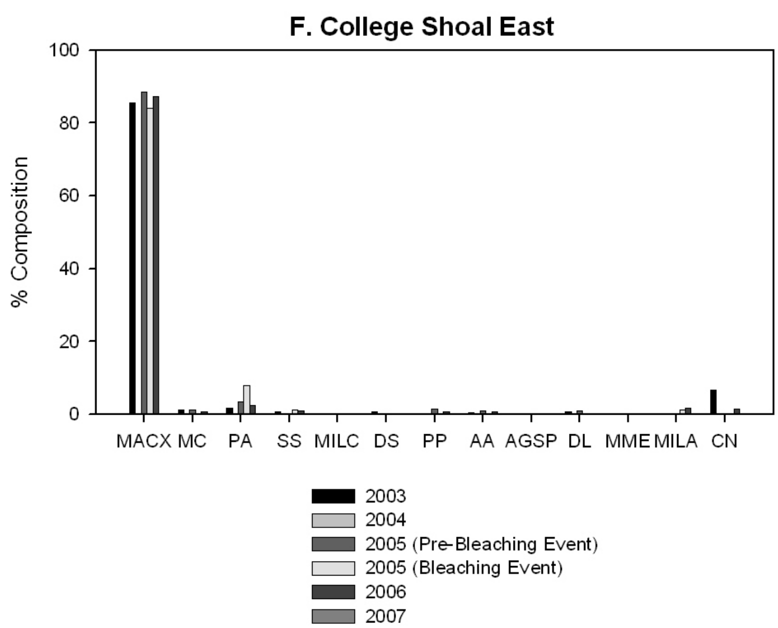


Figure 17. Percent of species composition of living coral cover of the most common coral species at St. Thomas sites: A. Seahorse Cottage Shoal B. South Capella, C. South Water and Shelf Edge sites D. Grammanik Bank, E. Red Hind Bank and F. College Shoal East. MACX *Montastraea annularis* complex; MC *Montastraea cavernosa*; PA *Porites astreoides*; SS *Siderastrea siderea*; MILC *Millepora complanata*; DS *Diploria strigosa*; PP *Porites porites*; AA *Agaricia agaricites;* DL *Diploria labyrinthiformis*; MME *Meandrina meandrites*; MILA *Millepora alcicornis*; CN *Colpophylia natans*.


C. South Water
35
30
25
20
15
10
5
0
% Composition
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
2003
2004
2005 (Pre-Bleaching Event)
2005 (Bleaching Event)
2006
2007


D. Grammanik Bank
% Composition
100
80
60
40
20
0
MACX MC PA SS MILC DS PP AA AGSP DL MME MILA CN


E. Red Hind Bank
% Composition
100
80
60
40
20
0
MACX MC PA SS MILC DS PP AA AGSP DL MME MILA CN
2003
2004
2005 (Pre-Bleaching Event)
2005 (Bleaching Event)
2006
2007


F. College Shoal East
100
80
60
40
20
0
% Composition
MACX
MC
PA
SS
MILC
DS
PP
AA
AGSP
DL
MME
MILA
CN
2003
2004
2005 (Pre-Bleaching Event)
2005 (Bleaching Event)
2006
2007

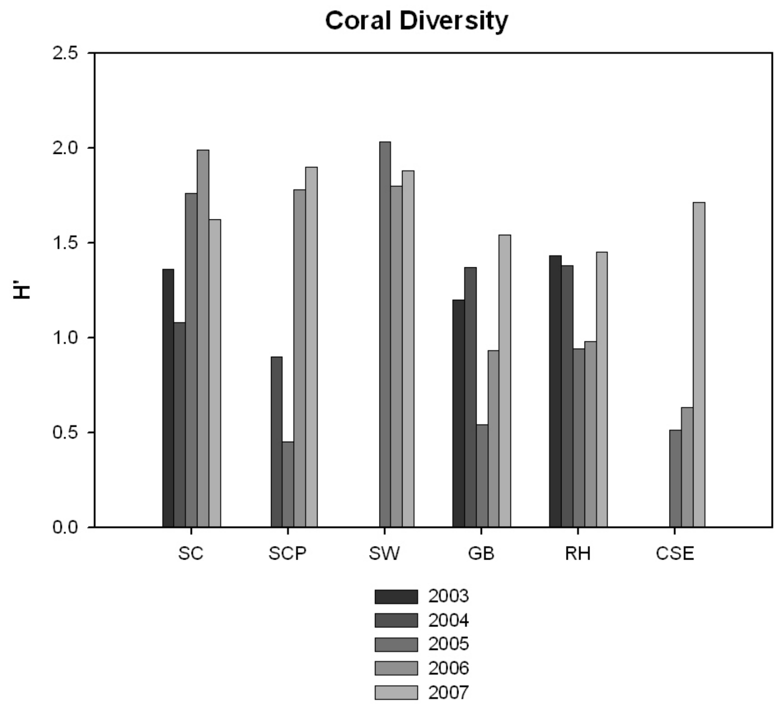


Figure 18. Shannon - Weaver Diversity Index (H') for corals at six monitored sites in St. Thomas, USVI. SC Seahorse Cottage Shoal; SCP South Capella; SW South Water; GB Grammanik Bank; RH Red Hind Bank; CSE College Shoal East.

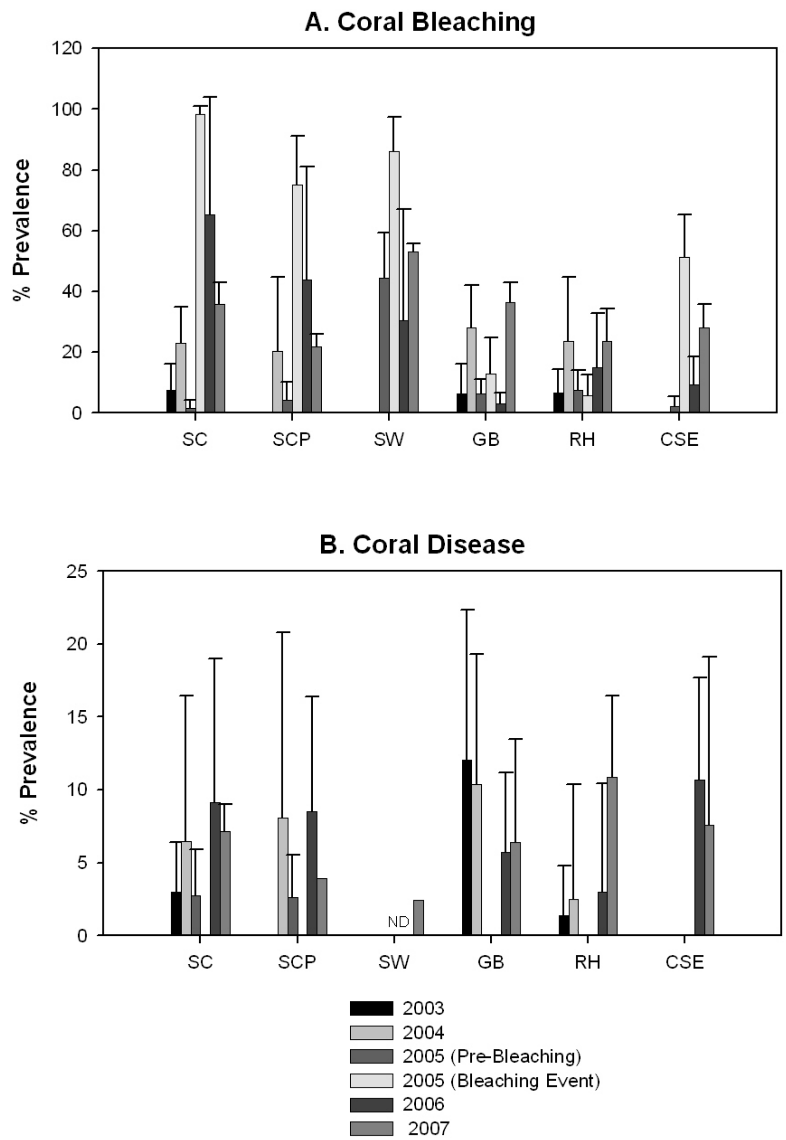


Figure 19. Mean percentage ± SE of A. colonies with bleaching and B. colonies with disease of all coral colonies sampled at each monitoring site for year 2001-2007. SC Seahorse Cottage Shoal; SCP South Capella; SW South Water; GB Grammanik Bank; RH Red Hind Bank; CSE College Shoal East.

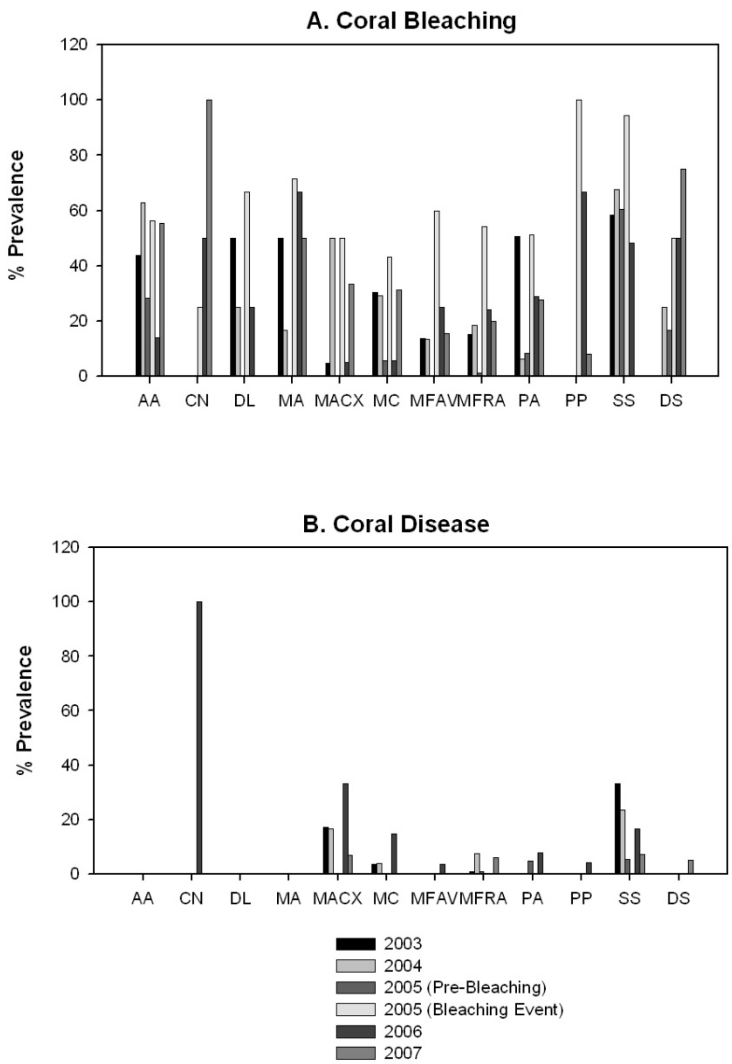


Figure 19. Percentage of A. bleached colonies and B. diseased colonies of all coral species with disease and bleaching sampled at all St. Thomas monitoring sites. AA *Agaricea agaricites*; DL *Diploria labyrinthiformis*; DS *Diploria strigosa*; MA *Montastraea annularis*; MACX unidentified species belonging to *the M. annularis* complex; MC M. cavernosa; MFAV *M. faveolata*; MFRA *M. franksii*; PA *Porites astreoides*; PP *Porites porites*; SS *Siderastrea siderea*.

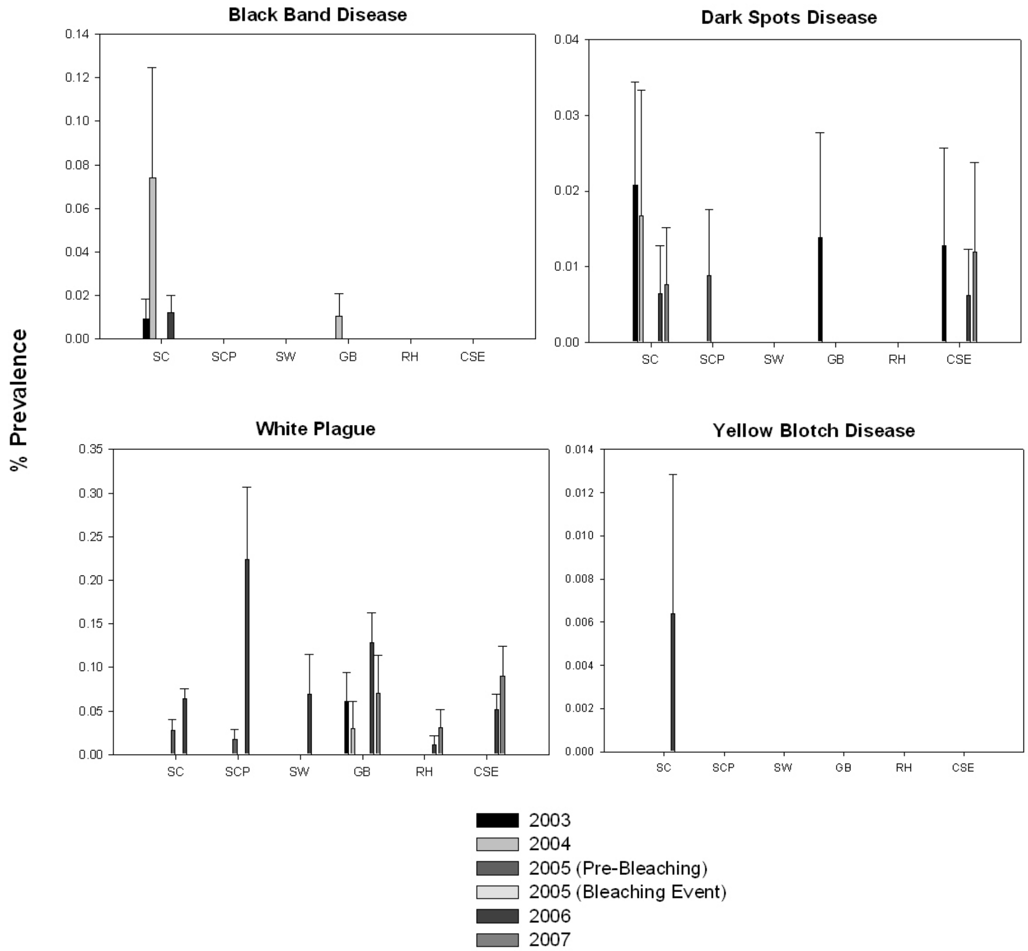


Figure 20. Prevalence of disease ± SE at six sites on St. Thomas from 2003-2007.
SC Seahorse Cottage Shoal, SCP South Capella, SW South Water, GB Grammanik Bank, RH Red Hind, CSE College Shoal East.

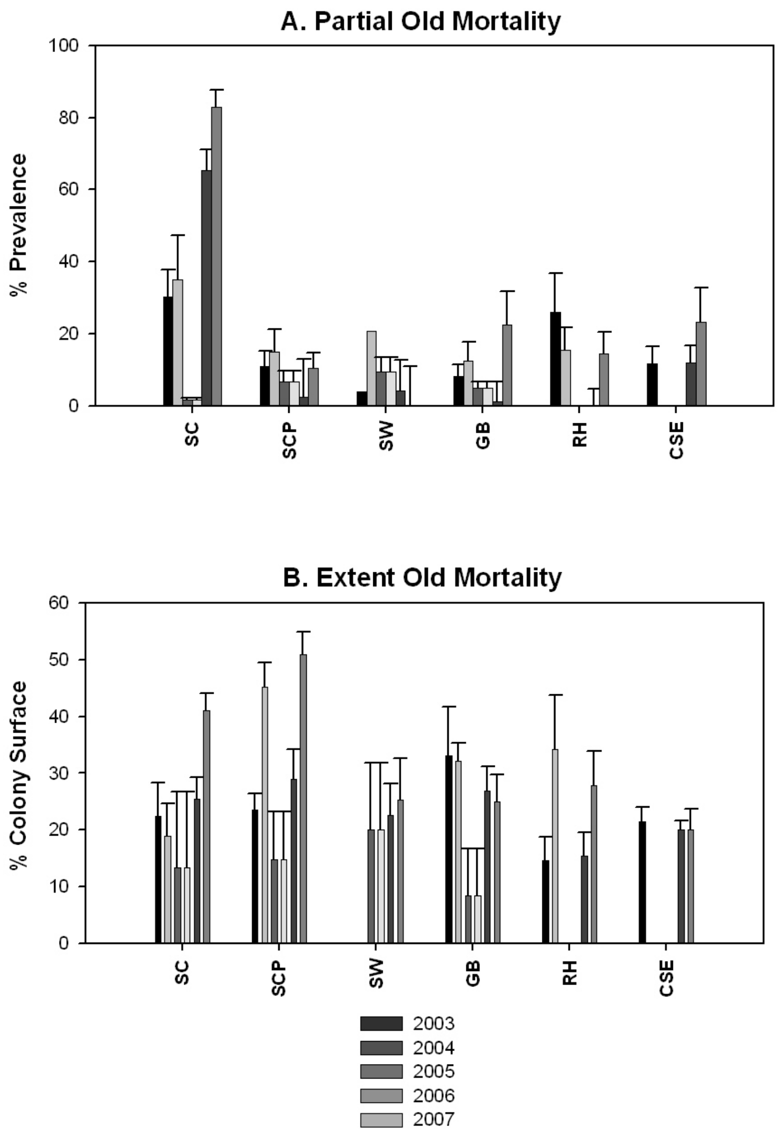


Figure 21. A. Prevalence and B. extent of colony affected by old mortality ± SE at six sites on St.Thomas from 2003-2007. SC Seahorse Cottage Shoal, SCP South Capella, SW South Water, GB Grammanik Bank, RH Red Hind, CSE College Shoal East.

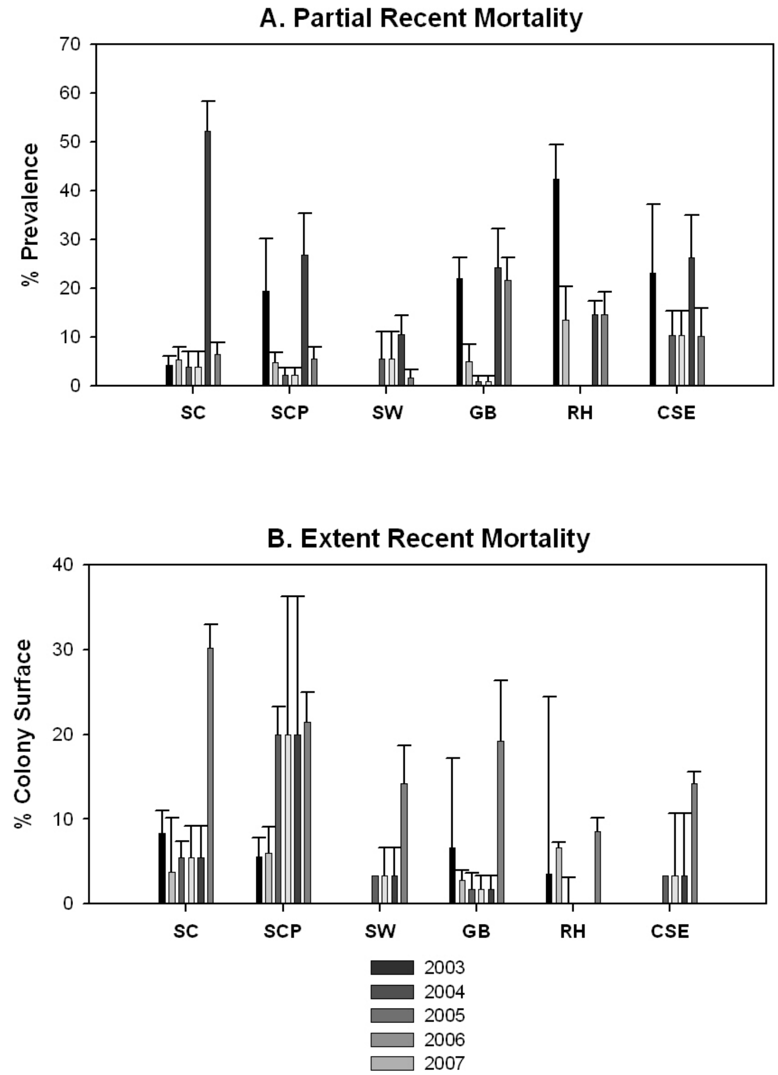


Figure 22. A. Prevalence and B. extent of colony affected by old mortality ± SE at six sites on St.Thomas from 2003-2007. SC Seahorse Cottage Shoal, SCP South Capella, SW South Water, GB Grammanik Bank, RH Red Hind, CSE College Shoal East.

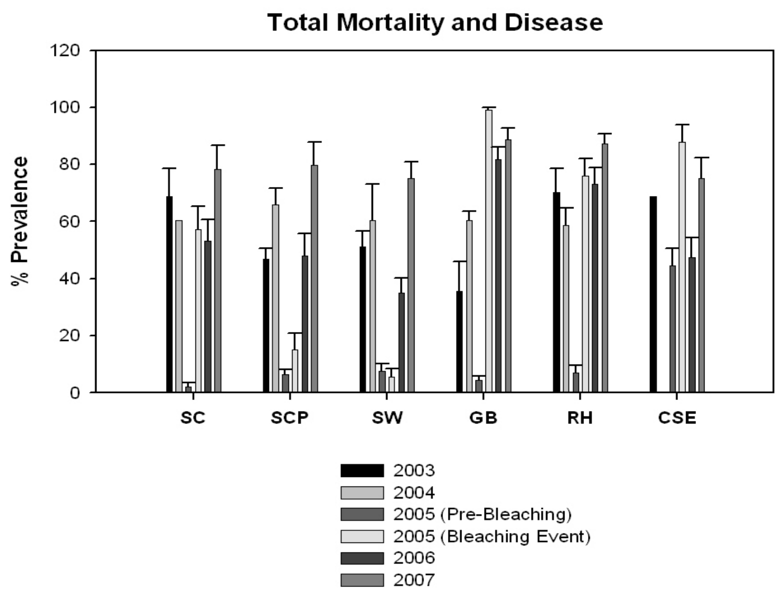
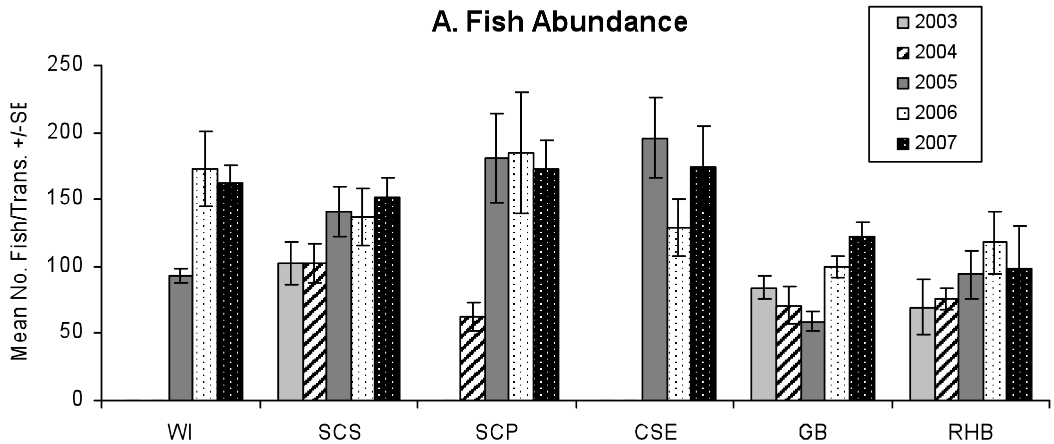


Figure 23. Prevalence of total mortality and disease ± SE for six sites on St. Thomas from 2003-2007. SC Seahorse Cottage Shoal, SCP South Capella, SW South Water, GB Grammanik Bank, RH Red Hind, CSE College Shoal East.



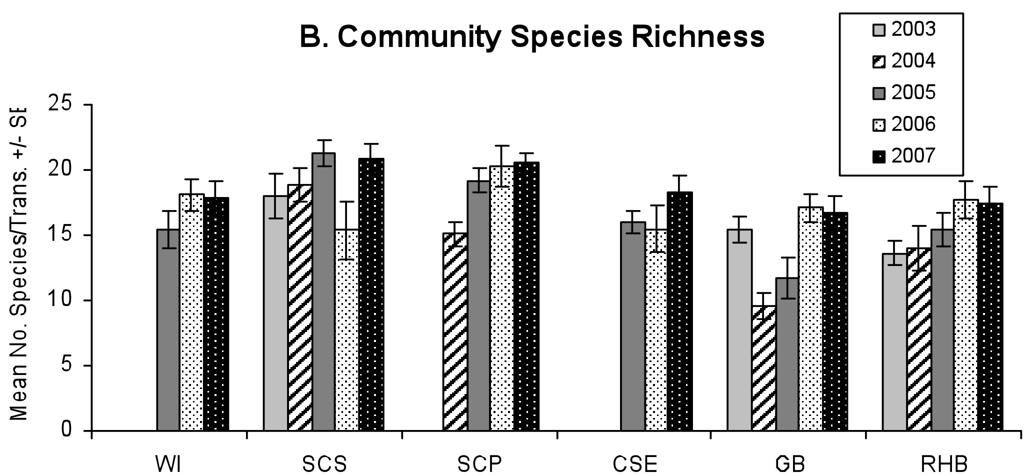


Figure 24. A, B
Reef fish assemblage structure across six St. Thomas sites from 2003-2007. A. Average abundance, B. Average species richness. Sites are as follows: WI=Water Island, SCS=Seahorse Cottage Shoal, SCP=South Capella, CSE=College Shoal East, GB=Grammanik Bank, RHB=Red Hind Bank.

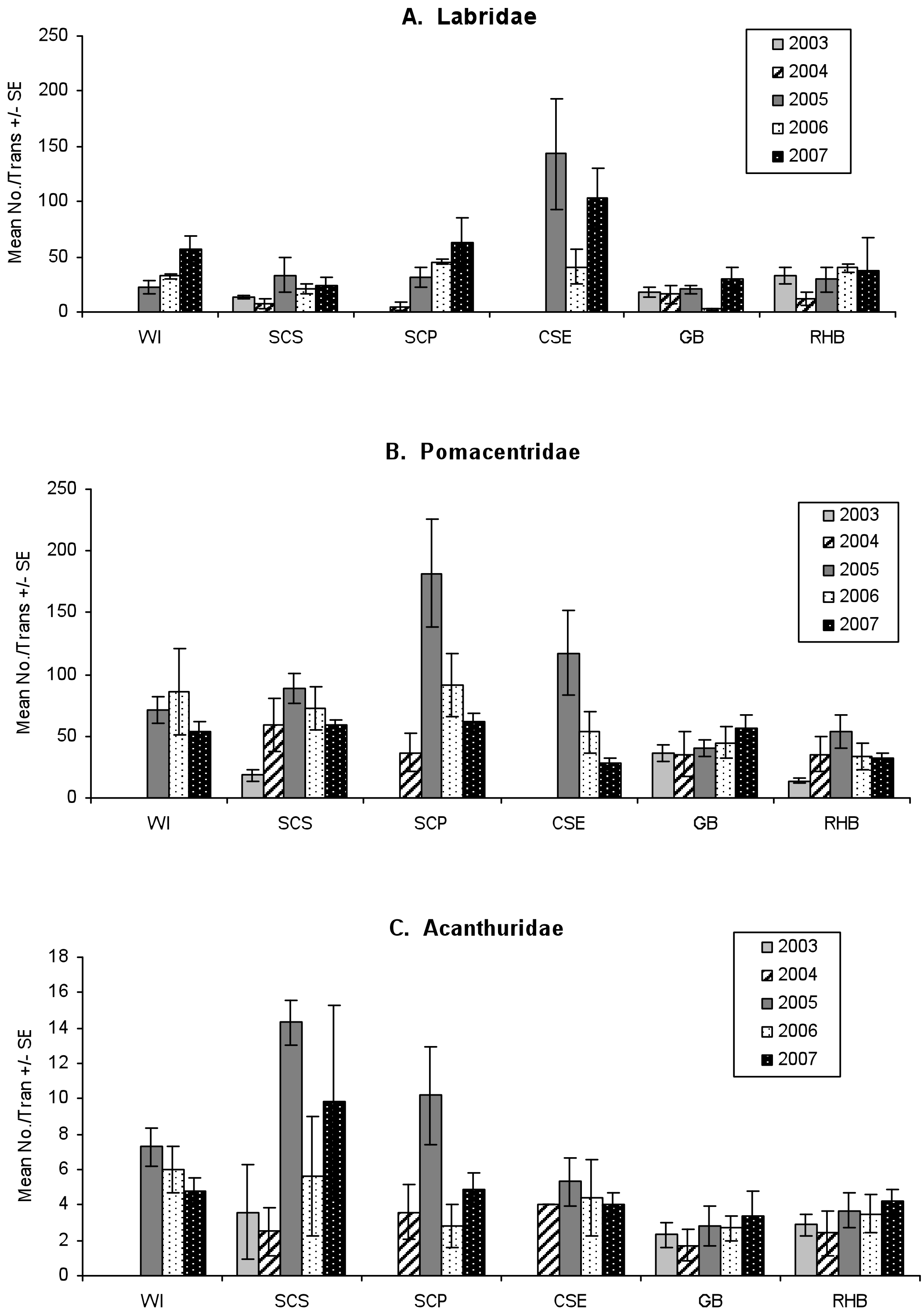
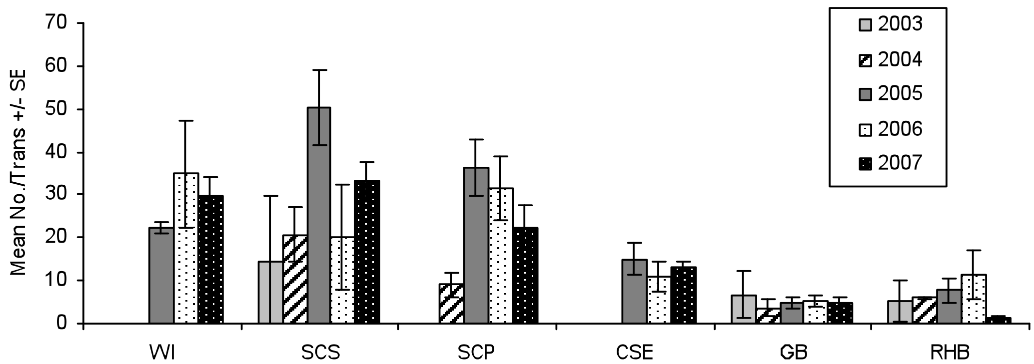
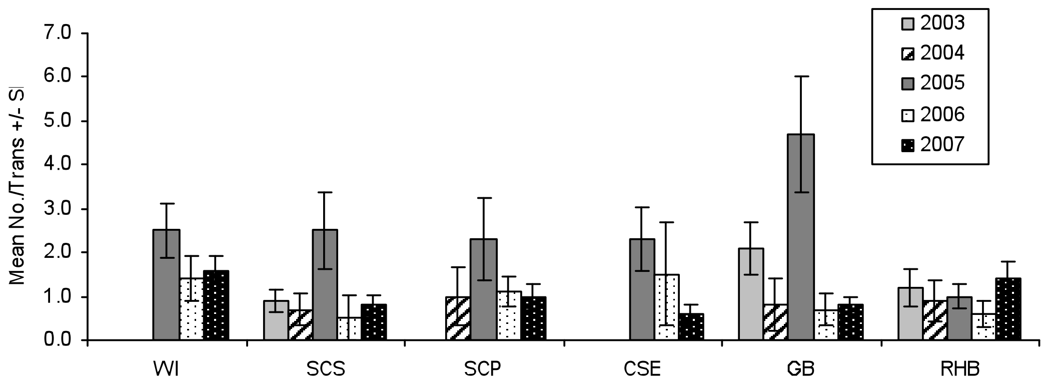


Figure 25. A-JFish abundance by family across six St. Thomas reef sites from 2003 through 2007. Sites are as follows: WI=Water Island, SCS=Seahorse Cottage Shoal, SCP=South Capella, CSE=College Shoal East, GB=Grammanik Bank, RHB=Red Hind Bank.

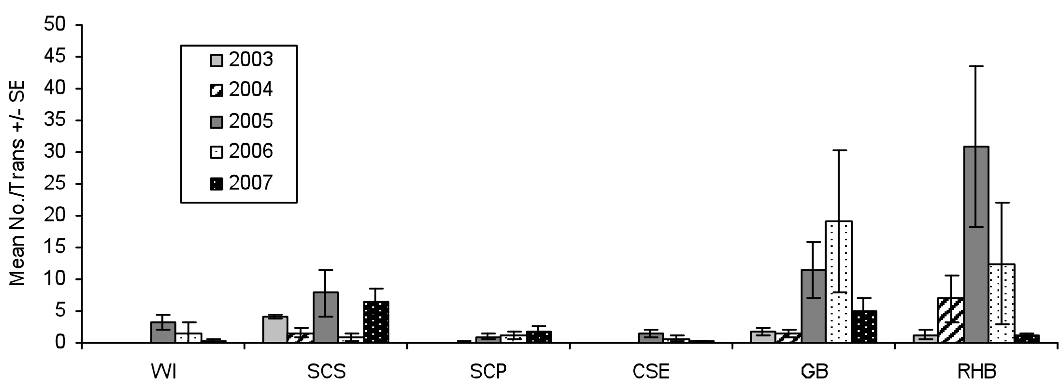
D. Scaridae



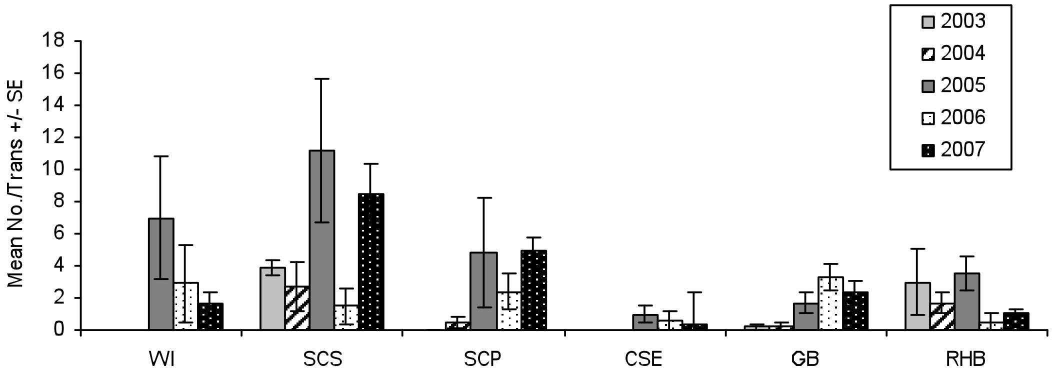
E. Serranidae



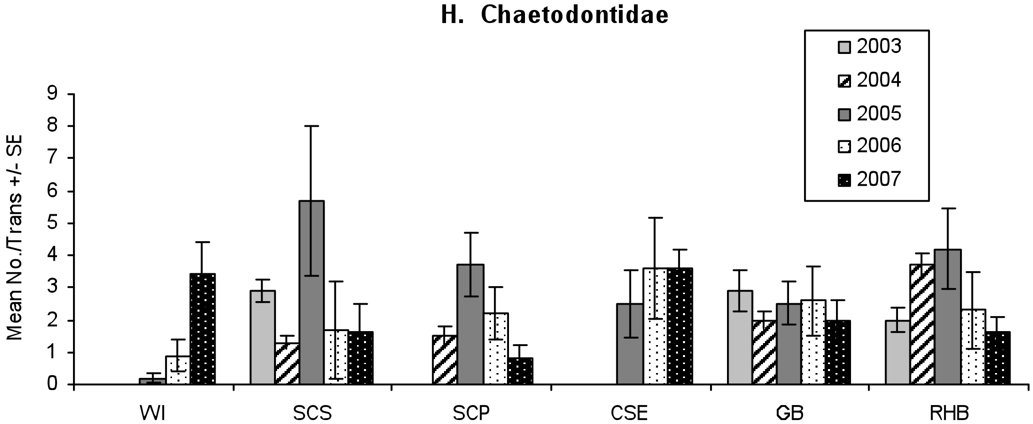
F. Lutjanidae



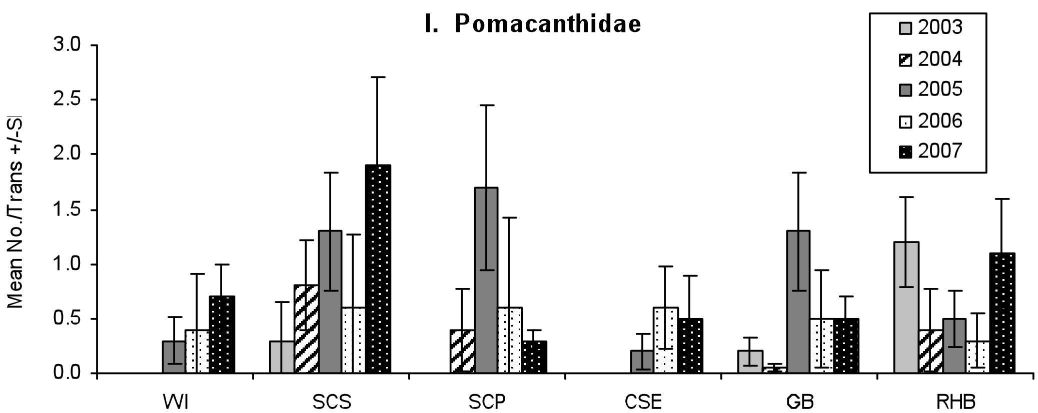
G. Haemulidae



H. Chaetodontidae



I. Pomacanthidae



J. Balistidae