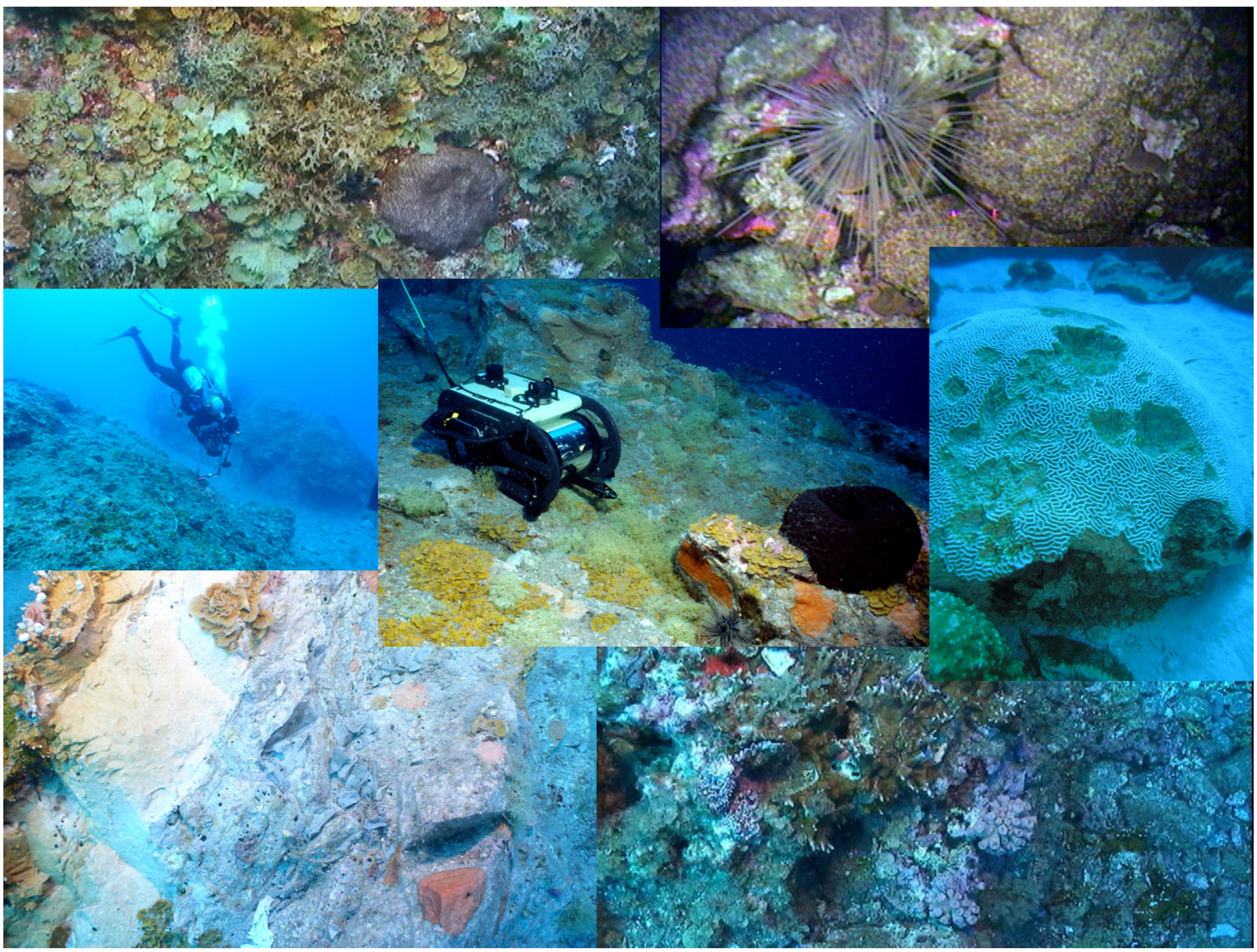
OCS Study
MMS 2009-032

Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity



U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity

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ABOUT THE COVER

Montage of photographs from Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks created by Martha Robbart, PBS&J.

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EXECUTIVE SUMMARY

The most active hurricane season on record in the Atlantic and Gulf of Mexico occurred in 2005, fueled by higher than normal sea-surface temperatures (National Climatic Data Center 2005). Eleven tropical cyclones entered the Gulf of Mexico in 2005, including Hurricane Rita (a Category 5 storm on the Saffir-Simpson Scale). Hurricane Rita was a Category 3 storm when it passed near the shelf edge banks on September 23, 2005 and produced wind speeds of 126.7-138.3 mph (110-120 knots). Hurricane force winds extended 86-mi (139-km) and tropical storm force winds extended as far as 207-mi (333-km) from the center of the storm (National Hurricane Center 2007).

Several sensitive habitats within the northwestern Gulf of Mexico were close to the path of Hurricane Rita, including Sonnier Bank (24-km or 15-mi east), McGrail Bank (12-km or 7-mi west), Geyer Bank (58-km or 36-mi west), Bright Bank (75-km or 47-mi west) and the East Flower Garden Bank (EFGB) (93-km or 58-mi west). Hindcast hydrodynamic models estimated wave heights at ~66-ft (20-m) or higher on these banks. This may have exposed some bank caps, even at 20- to 30-m depth. The implications for benthic community structure could have been catastrophic, and MMS considered it essential to characterize the banks in their post-hurricane state. In order to understand the potential wave and current conditions present in the vicinity of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks during the passage of Hurricane Rita, PBS&J conducted a wave hindcast study. On the cap at Sonnier Bank (22-m or ~72-ft depth) and Bright Bank (33-m or ~108-ft depth), significant wave heights during the passage of Hurricane Rita were estimated at ~43-ft (13-m) and ~66-ft (20-m), respectively. Greater wave heights may have occurred at banks with caps located in deeper water, regardless of the bank's distance from the storm track. Thus, McGrail and Geyer Banks, which have caps located at deeper depths, may theoretically have experienced larger wave heights than Bright and Sonnier Banks. These larger wave height conditions were hindcast based on the potential effects of wave focusing, shoaling, and breaking. The estimated wave height at both McGrail and Geyer Banks was ~85-ft (26-m). The maximum hindcast bottom velocity was 4-m/s or ~8-kn for all four banks.

This study characterized and compared the benthic habitats of four banks (Sonnier, McGrail, Geyer, and Bright) and recorded possible hurricane damage at these banks and the EFGB. At Sonnier, McGrail, Geyer, and Bright Banks, videographic records were collected by SCUBA and ROV in April and May 2007, at four depth ranges to assess benthic cover to the lowest possible taxonomic level: 22-27 m, 30-36.5 m, 45-50 m, and 55-60 m (72-89 ft, 98-120 ft, 148-164 ft, and 180-197 ft). Video transects were qualitatively assessed for evidence of hurricane damage. To document recovery from Hurricane Rita at the existing long-term monitoring site on the EFGB, repetitive quadrats and perimeter line surveys were conducted in November 2005 and compared to data collected subsequently in June 2006.

Sonnier Bank, the only bank located east of the storm track, exhibited the least live cover at all depth ranges (~2-38%) when compared to McGrail, Geyer, and Bright Banks (~17-86%). Qualitative analysis of video footage collected by divers at Sonnier Bank in 1996, 2002, and 2005 showed differences in benthic cover compared to video collected in 2007. In previous years, more live cover of a mix of algae and sponges (predominantly *Neofibularia* sp. and *Ircinia* spp.) was obvious. Another notable difference was the apparent disappearance of *Xestospongia muta* colonies, which were present in 1996 (~50 colonies), declined to one individual in 2002, and then were not recorded in 2005 or 2007. The single colony recorded in 2002 exhibited disease-like characteristics, with discoloration and an eroded pinacoderm.

McGrail Bank was approximately 7-mi (12-km) from the track of Hurricane Rita and has the deepest reef cap of any bank in this study (45-m or 148-ft depth). Live cover at McGrail Bank ranged from 17-38% and was dominated by macroalgae (red, green and brown), nodules of red coralline algae, and coral (predominately *Stephanocoenia intersepta*). Previous videos were not available for qualitative analysis. No apparent hurricane damage, in the form of overturned or injured corals, was observed.

Live cover at Geyer Bank was mostly colonized by brown macroalgae (specifically *Sargassum* spp.), corals, and sponges. Brown macroalgae, the dominant component, ranged from 22-42%. Corals (0-10%) and sponges (1-4%) were less prominent. According to transect video, Geyer Bank is the only bank in this study with an established population of the invasive, non-hermatypic coral *Tubastraea coccinea*. It is important to note that scientists have observed one or two colonies of *Tubastraea coccinea* at Sonnier Bank (Hickerson, personal communication, 2008); however, *T. coccinea* colonies were not observed in our Sonnier Bank transect video. Diver video collected at Geyer Bank in 2003 showed similar benthic cover to the video that was recorded in 2007. Again, no obvious signs of hurricane damage were observed.

Bright Bank exhibited the highest live cover (86%) and was dominated by macroalgae (57%), turf algae (12%), and corals (8%). Coral species observed included *Diploria strigosa, Millepora alcicornis, Montastraea cavernosa*, and *Stephanocoenia intersepta.* Diver video taken in September 2003 from Bright Bank revealed mostly bare substrate, low macroalgal cover, and few large colonies of *Millepora alcicornis* and *Diploria strigosa*. Sponge species were also observed, including *Agelas clathrodes*, *Ircinia* spp., and *Xestospongia muta*. At Bright Bank no hurricane damage was observed.

The Shannon Wiener Diversity Index (H') was calculated for each bank at each depth range using the lowest taxonomic groupings possible (species or genus). The highest diversity of these four banks was at Sonnier Bank from 22-27 m ($H' = 2.86$), largely due to the variety of sponges present there. Geyer and McGrail Banks exhibited their highest diversity values in the 45- to 50-m depth range, ($H' = 2.13$ and $H' = 2.08$, respectively). The high species richness of brown macroalgae accounted for these high diversity values. At Bright Bank $H' = 1.81$ in the 30- to 36.5-m depth range.

Multivariate statistical analyses were performed using benthic cover data at Sonnier, McGrail, Geyer, and Bright Banks. Analysis of Similarity (ANOSIM) tests showed significant differences between banks (Global $R = 0.54$, $P = 0.001$). Within site comparisons showed less dissimilarity between depths. Multidimensional scaling (MDS) highlighted the dissimilarities among banks, with depths within sites grouping more closely.

Repetitive quadrat stations were photographed at the EFGB in November 2005 and June 2006 to document recovery from Hurricane Rita. Coral cover remained consistently high from November 2005 to June 2006, at 61.34% ± 2.75 SE and 62.87% ± 2.32 SE, respectively. Macroalgae increased from November 2005 to June 2006 by ~5.4%, while CTB decreased by ~6.9%. Approximately 1.5% of coral colonies photographed within repetitive quadrats at the EFGB were missing in November 2005, most likely due to the effects of Hurricane Rita. However, this did not notably affect estimates of coral cover. The most obvious difference in November 2005 repetitive quadrats was the high level of bleaching: 9.74% ± 1.07 SE of assessed coral points were bleached. Paling and fish biting measurements were low at 1.5% or less. The June 2006 data showed a decrease in the level of bleaching (0.62%) compared to November 2005 and a slight increase in the amount of fish biting (2.31%). Coral disease was not observed in the June 2006 repetitive quadrat photographs, although the identification of disease in these photographs is not reliable because of the 2-m distance from the substrate (Zimmer, personal communication, 2005).

The perimeter lines around the EFGB study site were videotaped in November 2005 and June 2006 to document change at known locations along the perimeter and within the study site. Lower levels of bleaching and paling were seen in June 2006 compared to November 2005. These qualitative observations corroborate the quantitative results from the repetitive quadrat data.

The unique biological characteristics of the benthic communities of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks highlight their intrinsic value within the northwestern Gulf of Mexico ecosystem. The differences in the benthic biotas strongly suggest that these habitats are truly sensitive, because nearest neighbors may not be the source of recruitment. With predicted wave velocities of 8 knots or more acting on these banks during the passage of Hurricane Rita, the effects on the benthic communities could have been catastrophic. Sonnier Bank suffered a loss of benthic cover and hardbottom associated with the hurricane, but the community was recovering, with algae and sponges dominating live areas by April/May of 2007. McGrail, Geyer, and Bright Banks did not exhibit any obvious hurricane damage in the surveys; given that these banks are dominated by algae and sponges, any damage to the living benthos may be hard to detect after the twenty months between the passage of the storm and the survey. McGrail Bank, with its large *Stephanocoenia intersepta* colonies, exhibited no apparent damage to corals, which may have been protected by their considerable depth (45-m or 148-ft).

1.0 INTRODUCTION

1.1. HURRICANES IN THE NORTHWESTERN GULF OF MEXICO

During the 20th century, numerous tropical storms and hurricanes passed over sensitive marine habitats in the Gulf of Mexico, including the Flower Garden Banks and other mid- and outer-shelf banks (Scholten and Deslarzes 1998). Strong hurricanes moved through the region of the Flower Garden Banks in 1900, 1909, 1915, 1957, 1961 (Category 4), 1964, 1974, 1979, and 1980 (Category 5). In the summer of 1980, Hurricane Allen, with a surge of more than 16-ft (5-m) and wind speeds of 60-mph (96-km/hr), caused physical damage to the coral reefs of the Flower Garden Banks. An example of this severe damage is the documented displacement of an ~4409-lb (2000-kg) coral head which was moved hundreds of feet across the reef cap on the East Flower Garden Bank (EFGB) (C.L. Combs, personal communication, 1989).

The 2005 Atlantic hurricane season was the most active on record, fueled by record high sea-surface temperatures in the Atlantic and Gulf of Mexico (National Climatic Data Center 2005). Eleven tropical cyclones entered the Gulf of Mexico in 2005. One of these cyclones, Hurricane Rita, passed within 58-mi (93-km) of the EFGB on September 23 as a Category 3 hurricane. Hurricane Rita passed 7-mi (12-km) to the east of McGrail Bank (reef cap at 45-m or ~148-ft) and approximately 15-mi (24-km) to the west of Sonnier Bank (reef cap at 22-m or ~72-ft) (Figure 1.1.1). On September 23 Hurricane Rita had wind speeds of 127-138 mph (110-120 kn). Hurricane force winds extended approximately 86-mi (139-km) from its center (Figure 1.1.2) and tropical storm force winds extended as far as 207-mi (333-km) from its center (National Hurricane Center 2007). Other storms in 2004 and 2005 passed more than ~311-mi (500-km) away from the vicinity of the Flower Garden Banks (Table 1.1.1).

Preliminary assessments of the coral reefs at the EFGB following Hurricane Rita included evidence of substantial mechanical impacts, fractured and displaced corals, and sediment-scoured corals bordering sand flats (Figure 1.1.3A, B), as well as corals scarred and indented by waterborne objects (Figure 1.1.3C) (Hickerson and Schmahl, personal communication, 2005). As an example of physical damage that occurred, a large coral head, measuring ~13-ft (4-m) across and ~7-ft (2-m) high, was dislodged from the reef cap. Approximately one meter of coarse sand was removed from large sand flats. Large barrel sponges (*Xestospongia muta*) were partially or fully removed from the reef or were filled with sand (Hickerson and Schmahl, personal communication, 2005). In a survey in November 2005, many coral colonies were missing from permanent quadrats at the EFGB long-term monitoring site (Precht et al. 2008a).

Hurricane impacts were preceded and followed by other natural disturbances at the Flower Garden Banks including extreme warming of the water column from August through November 2005, which was associated with severe coral bleaching (Hickerson and Schmahl, personal communication, 2005), and runoff transported from the Texas-Louisiana coast to the shelf edge in the days and weeks following Hurricanes Katrina and Rita (NOAA CoastWatch 2005). In addition to its direct physical impacts, the passage of Hurricane Rita lowered sea temperatures (by increasing vertical mixing) and likely attenuated the coral bleaching event at the Flower Garden Banks. Thus, despite their physical destruction, hurricanes may also exert a positive influence on coral reefs (Manzello et al. 2007).

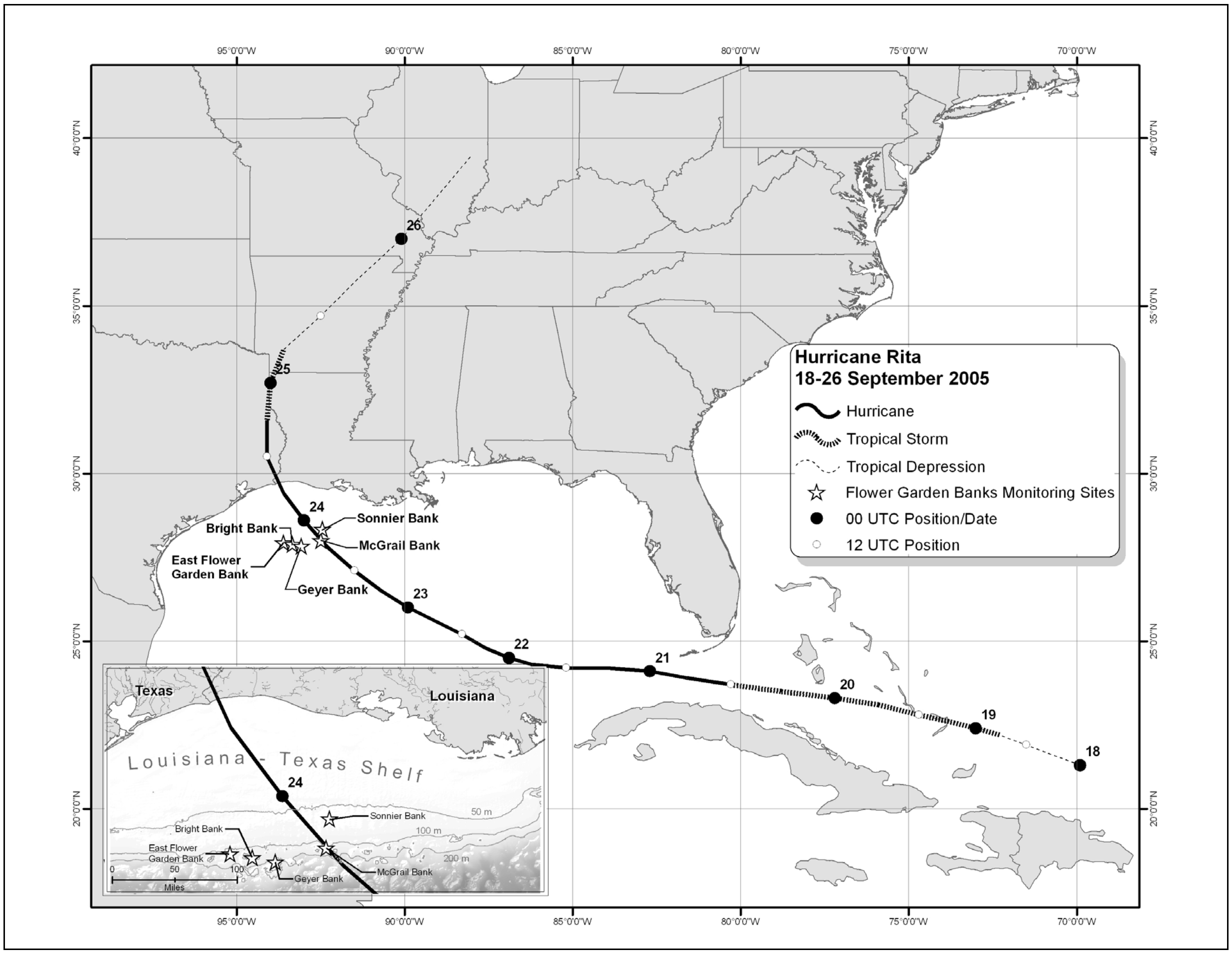


Figure 1.1.1. Track of Hurricane Rita, September 18-26, 2005, in relation to the banks evaluated in this study (National Hurricane Center 2007).

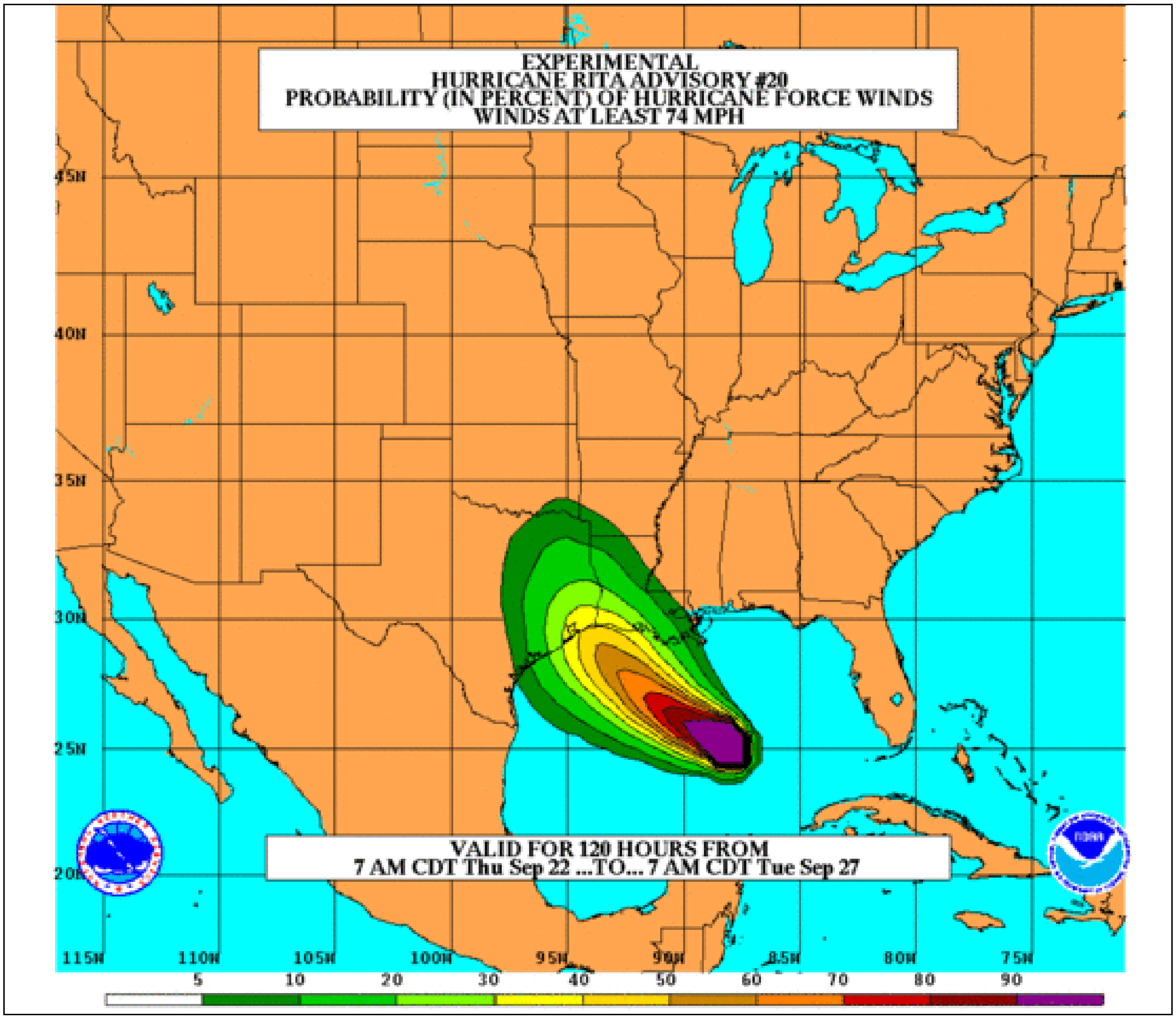


Figure 1.1.2. Map displaying the probability of hurricane force winds on September 22, 2005.

Table 1.1.1.

List of tropical cyclones that entered the Gulf of Mexico (GOM) in 2004 and 2005. The name and category of a given cyclone is listed according to its condition when it was closest to the outer-shelf banks. Information on the cyclones was taken from The Weather Underground, Inc. (2005a and 2005b).

Name/Category	**Date**	**Wind Speed (mph) or Hurricane Category**	**Trajectory**
Tropical Storm Bonnie	8/10/04	50	Central GOM, ~373-mi (600-km) east of the Flower Garden Banks
Hurricane Charley	8/13/04	Cat 4	Passed over the Florida Straits, southwest Florida
Tropical Storm Frances	9/4/04	65	Northeast GOM, >621-mi (>1000-km) east of the Flower Garden Banks
Hurricane Ivan	9/15/04	Cat 4	Passed ~342-mi (550-km) east of the Flower Garden Banks
Tropical Storm Matthew	10/09/04	40	Passed ~199-mi (320-km) east of the Flower Garden Banks
Tropical Storm Arlene	6/11/05	70	Central GOM, ~373-mi (600-km) east of the Flower Garden Banks
Tropical Storm Bret	6/25/05	40	Southwest GOM, >497-mi (>800-km) south of the Flower Garden Banks
Tropical Storm Cindy	7/5/05	70	Central GOM, ~311-mi (500-km) east of the Flower Garden Banks
Hurricane Dennis	7/10/05	Cat 4	Central GOM, ~497-mi (800-km) east of the Flower Garden Banks
Hurricane Emily	7/19/05	Cat 1	Southwest GOM, ~373-mi (600-km) south of the Flower Garden Banks
Tropical Storm Gert	7/25/05	45	Southwest GOM, ~466-mi (750-km) south of the Flower Garden Banks
Tropical Storm Jose	8/23/05	50	Southwest GOM, ~497-mi (800-km) south of the Flower Garden Banks
Hurricane Katrina	8/28/05	Cat 5	Central GOM, ~311-mi (500-km) east of the Flower Garden Banks
Hurricane Rita	9/23/05	Cat 3	Central GOM, ~56-mi (90-km) west of the Flower Garden Banks
Tropical Storm Stan	10/3/05	40	Southwest GOM, ~528-mi (850-km) south of the Flower Garden Banks
Hurricane Wilma	10/24/05	Cat 3	Southeast GOM, ~559-mi (900-km) southeast of the Flower Garden Banks

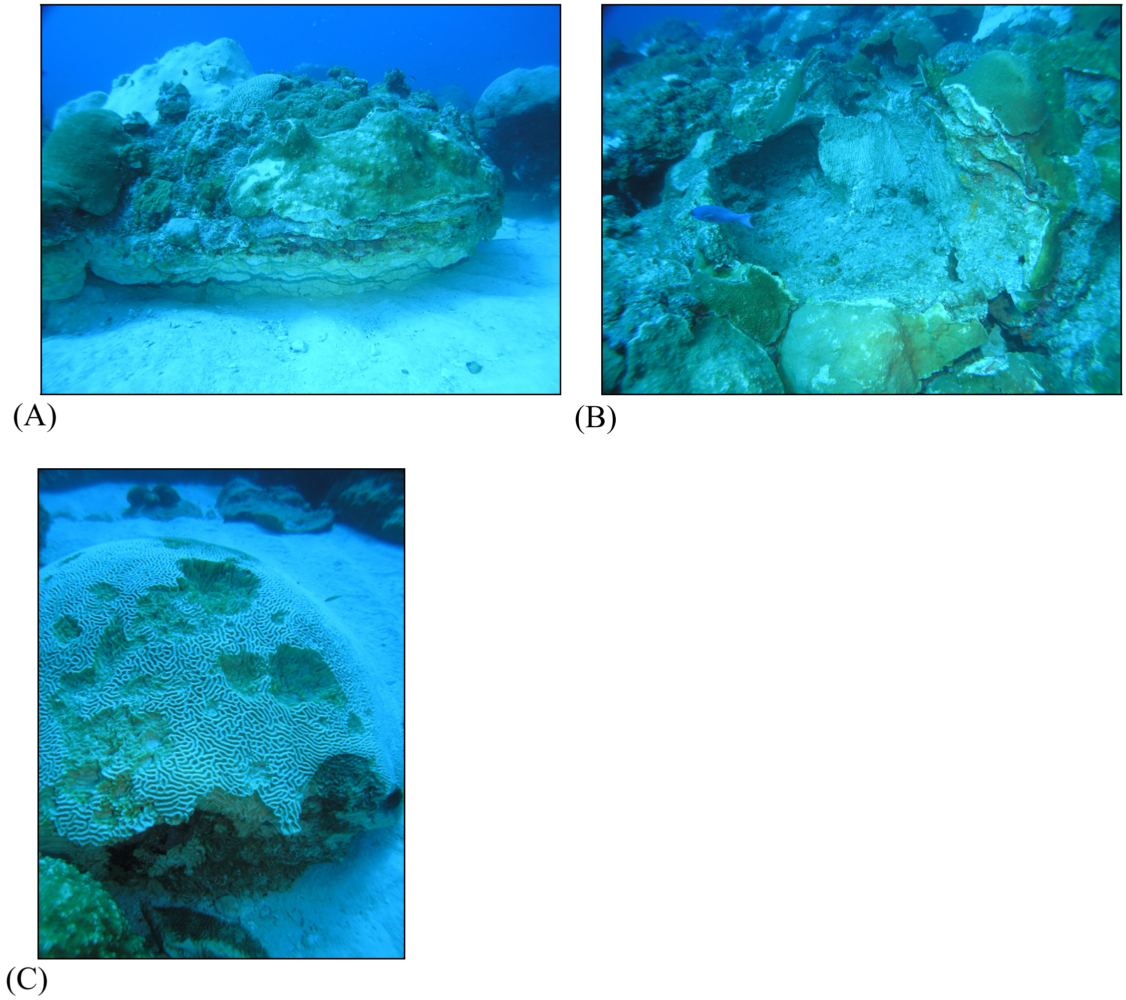


Figure 1.1.3. (A) Sediment-scouring, (B) footprint of dislodged coral colony, and (C) coral colony gouged by waterborne object(s). Photos courtesy of Emma L. Hickerson, Flower Garden Banks National Marine Sanctuary.

This study serves as 1) a baseline characterization of the benthic communities at Sonnier, McGrail, Geyer, and Bright Banks and 2) an assessment of possible hurricane damage at multiple depth ranges at these banks and at the EFGB long-term monitoring site. Sonnier, McGrail, Geyer, and Bright Banks were all within ~47-mi (75-km) of the passage of Hurricane Rita (Table 1.1.2) and have not been thoroughly characterized in terms of their benthic composition since the early 1980s. In order to understand how wind, wave, and current conditions may have acted on these topographic features during the passage of Hurricane Rita, hydrodynamic hindcast models were run using data from a study that modeled the effects of Hurricanes Katrina and Rita for the Gulf of Mexico (Oceanweather Incorporated 2006). Data from a November 2005 survey at the EFGB long-term monitoring site are compared to data collected in June 2006 at the same site. These comparisons were made to document possible recovery 9 months after the storm.

Table 1.1.2.

Shortest distance between the path of Hurricane Rita and each of the five banks studied.

Bank	**Distance (km)**
McGrail	12
Sonnier	24
Geyer	58
Bright	75
East	93

1.2. STUDY BANKS IN THE NORTHWESTERN GULF OF MEXICO

1.2.1. General Bank Information

Banks in the Gulf of Mexico vary in terms of their geological and biological characteristics, but have been grouped into three main categories: mid-shelf banks, outer-shelf banks with carbonate reef caps, and reefs growing on relict carbonate shelf (Rezak et al. 1985). The banks in this study fall within the first two categories. Mid-shelf banks and outer-shelf carbonate reef caps are formed by salt diapir structures uplifting the seafloor into the photic zone. Mid-shelf banks, such as Sonnier Bank, are characterized by uncolonized open substrate, in which the bedding of Tertiary limestones, claystones, and siltstones is apparent (Rezak et al. 1985). Major components of biological communities capping mid-shelf banks include the hydrocoral *Millepora alcicornis*, the sponge *Neofibularia nolitangere*, and macroalgae. At deeper depths algal/sponge communities characterize the mid-shelf banks (Table 1.2.1). McGrail, Geyer, Bright, and East Flower Garden Banks are outer-shelf banks with carbonate reef caps. Algal/sponge communities dominate the substrate at outer-shelf banks, with the exception of the Flower Garden Banks which are characterized by low diversity coral assemblages (Table 1.2.1) (Rezak et al. 1985). The benthic communities at these banks have not been studied in detail, with the exception of the Flower Garden Banks.

Table 1.2.1.

Biological zones by depth (in meters)
(adapted from Rezak et al. 1985 and Hickerson et al. 2008).
"–" represents that the zone is not present

	Coral Reef Zone			**Coral Community Zone**	**Coralline Algae Zone**
Bank	***Montastraea* habitat**	***Madracis***	***Stephanocoenia***	***Millepora*/Sponge**	**Algal/Sponge**
Sonnier	–	–	–	18-52	52-74
McGrail	–	–	45-47	–	45-82
Geyer	–	–	–	37-52	60-98
Bright	–	–	37	–	52-74
EFGB	15-36	28-44	36-52	–	45-90

1.2.2. Sonnier Bank

Sonnier Bank is located at 28°20'N and 92°27'W and is the only bank in this study to lie east of Hurricane Rita's path (Figure 1.1.1). At Sonnier Bank, several peaks are arranged in an arcuate pattern and rise from a depth of ~197-ft (60-m) up to within ~66-ft (20-m) of the sea-surface (Figure 1.2.2). Each peak is a fault block created by the collapse of a salt diapir (Rezak et al. 1985). There is approximately 11,000-m^2 of bank surface area between 22-30 m before the bank drops off to deeper depths. Some preliminary mapping and fish community studies have been conducted at Sonnier Bank (Boland 1999) (Figure 1.2.3). The peak visited during this study is steeply sloping, with its shallowest depth at ~72-ft (22-m).

The benthic community of Sonnier Bank is similar to other mid-shelf banks, especially Stetson Bank (Rezak et al. 1985). Sonnier Bank is characterized by hydrocorals and sponges, with *Millepora alcicornis*, *Neofibularia nolitangere*, and *Ircinia* spp. as the dominant living benthic components (Rezak et al. 1985). Nine species of scleractinian corals are found at Sonnier Bank, including *Agaricia* spp., *Madracis* spp., *Siderastrea* sp., *Stephanocoenia intersepta*, and *Montastraea cavernosa*; however, these corals are not abundant (Rezak and Bright 1979; Irion and Anuskiewicz 1999).

1.2.3. McGrail Bank

McGrail Bank, located at 27°57'N and 92°35'W, is a deep shelf-edge carbonate bank positioned atop a salt diapir. McGrail Bank has the deepest peak of any bank in this study (45-m or 148-ft) (Figure 1.2.4). Deep-water coral reef resources are characteristic of this bank, and coral cover is high (up to 30%) compared to other banks in the region (Weaver et al. 2005; Schmahl and Hickerson 2006). Dominant corals include *Stephanocoenia intersepta, Diploria strigosa*, *Montastraea cavernosa,* and *Agaricia* spp. (Schmahl and Hickerson 2006). Rezak et al. (1985) documented abundant nodules of red coralline algae as well as high cover of fleshy macroalgae in the algal-sponge zone at depths of ~148-154 ft (45-47 m).

1.2.4. Geyer Bank

Geyer Bank, located at 27°51'N and 93°04'W, is a shelf-edge carbonate bank with extensive reef communities (Rezak and Bright 1981). Geyer Bank is the southernmost bank surveyed during this study. The shallowest peaks (~128-ft or 39-m), all of which are steeply sloping, are located in the northern area of the bank (Figure 1.2.5). Corals include *Stephanocoenia intersepta, Agaricia* spp., *Madracis* spp., and *Millepora alcicornis* (Hickerson 2004). Geyer Bank is characterized by an abundance of *Sargassum* spp. and appeared to be the only bank with an established population of the invasive, non-hermatypic coral *Tubastraea coccinea*. It is important to note that scientists have observed one or two colonies of *Tubastraea coccinea* at Sonnier Bank (Hickerson, personal communication, 2008); however, *T. coccinea* colonies were not observed in our Sonnier Bank transect video. Substantial populations of the echinoid *Diadema antillarum* and large oceanic fish species have also been reported (Hickerson, personal communication, 2007).

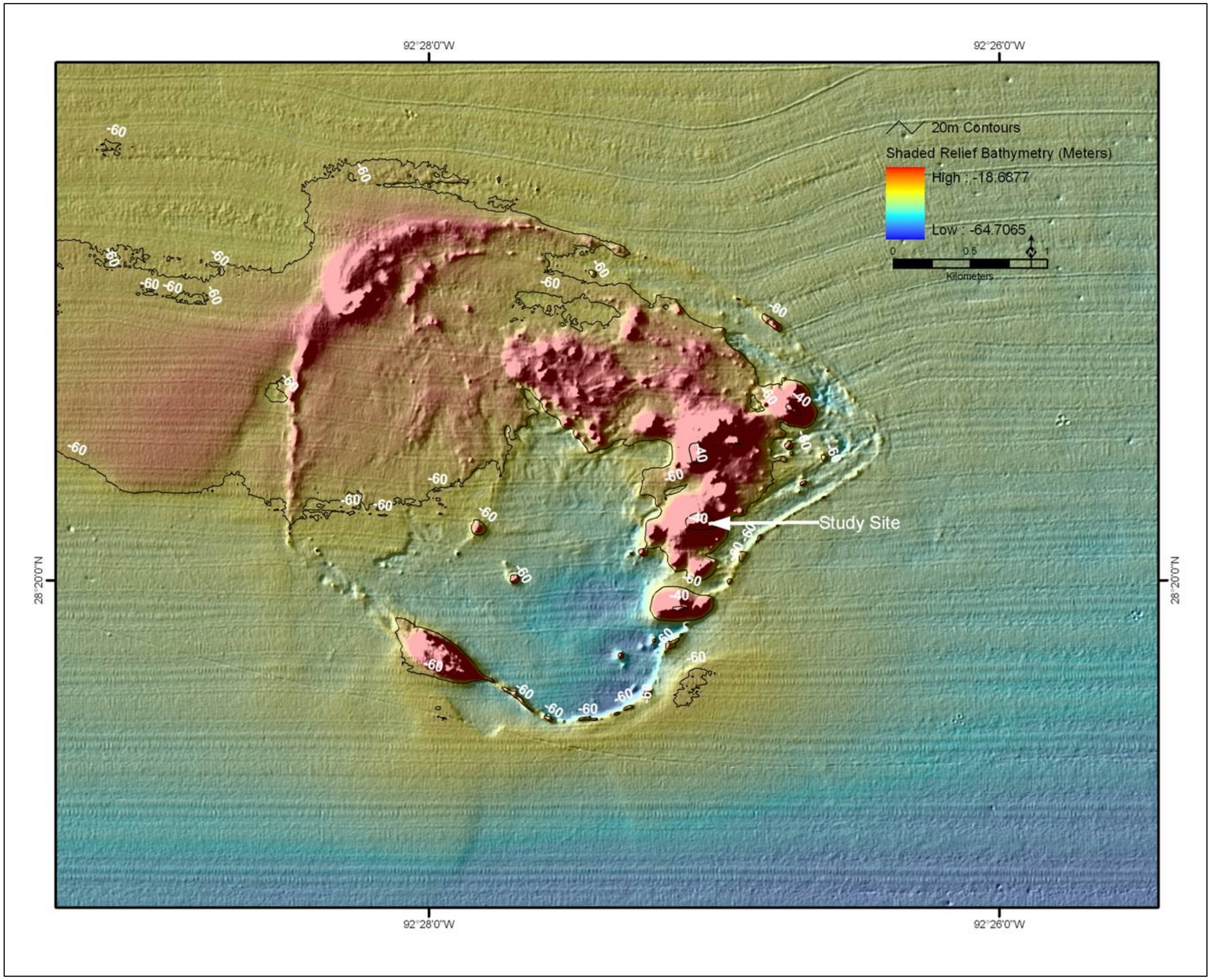


Figure 1.2.2. Bathymetric map of Sonnier Bank, showing location of the study site (USDOI, GS 2003).

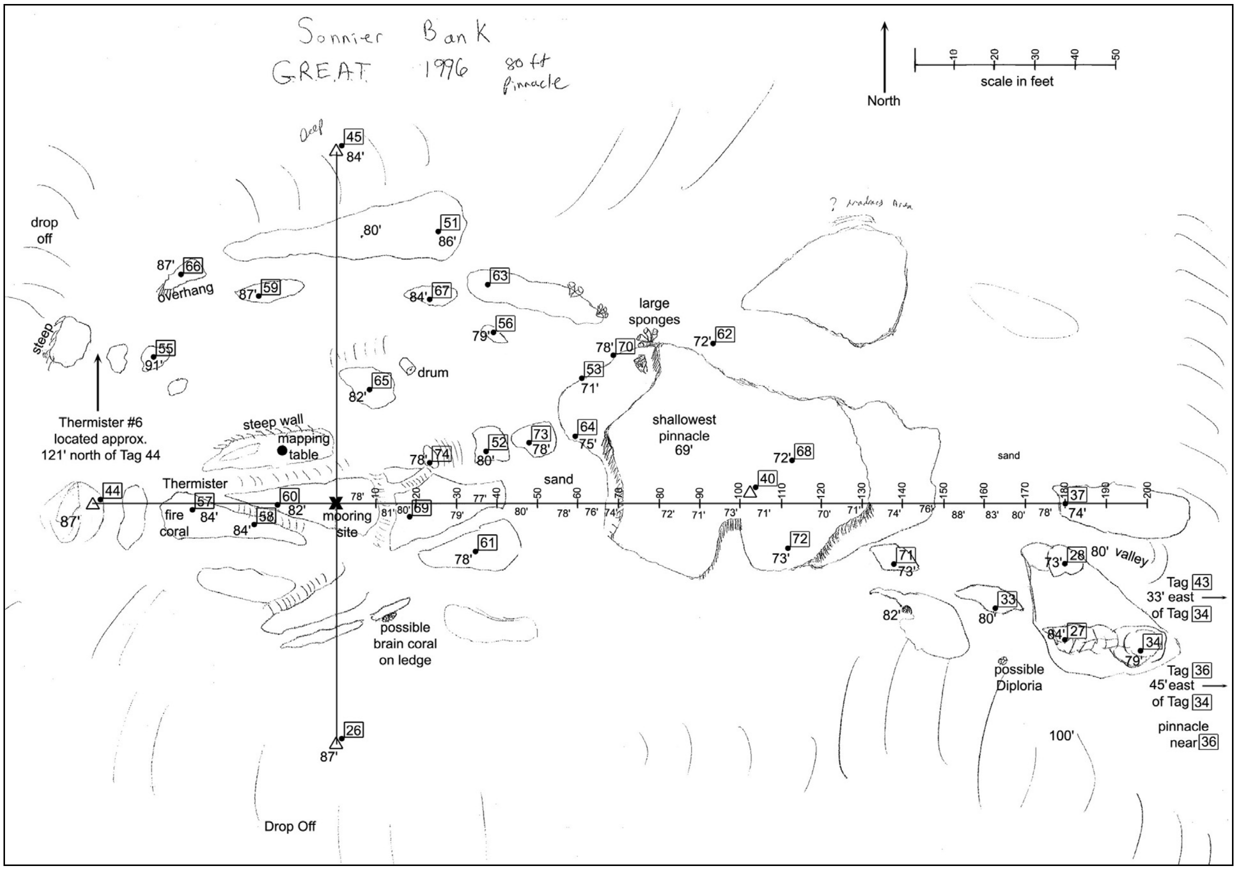


Figure 1.2.3. Map of the peak at Sonnier Bank (22-m depth) sampled during this study (courtesy of Greg Boland through Gulf Reef Environmental Action Team and MMS).

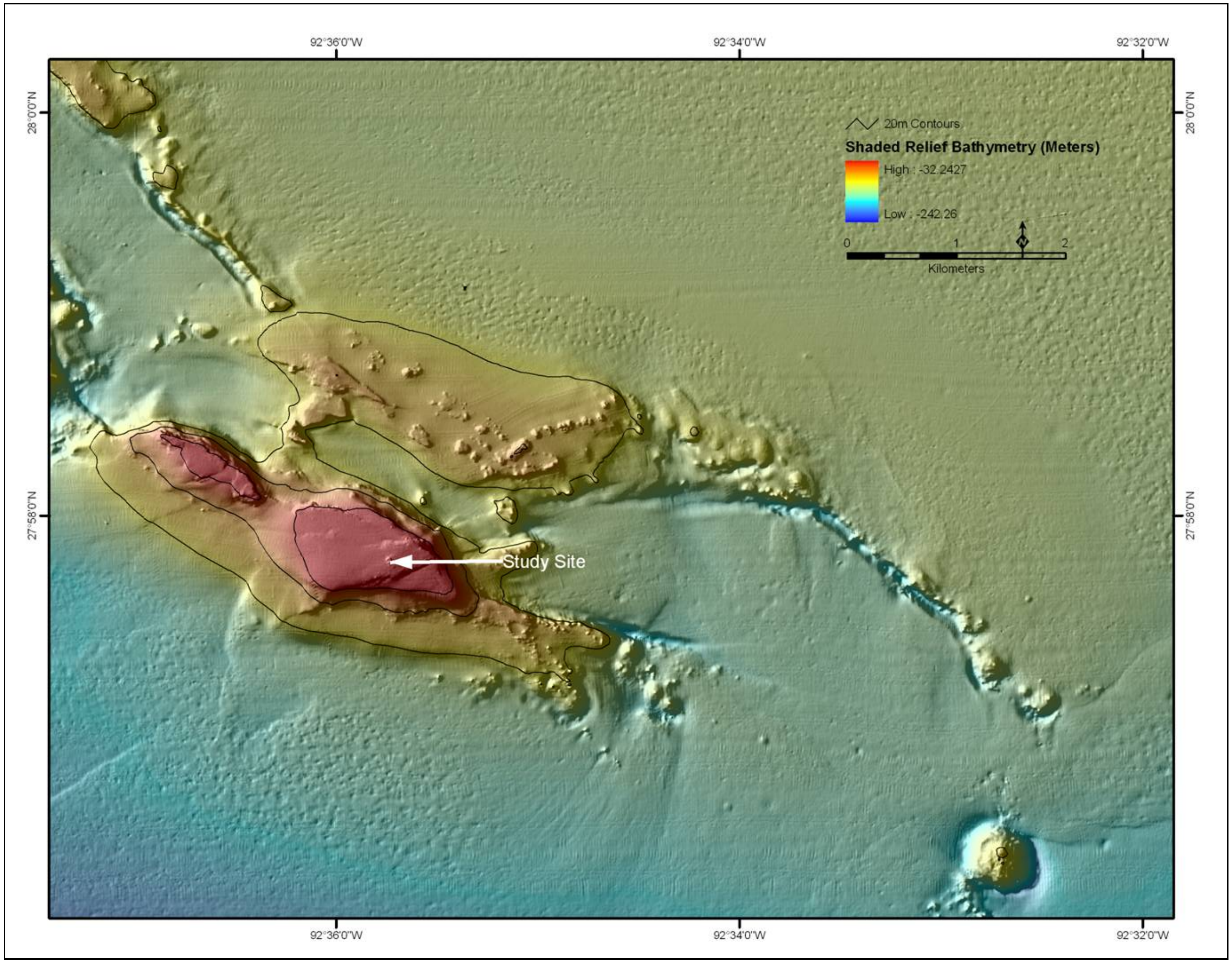


Figure 1.2.4. Bathymetric map of McGrail Bank, showing location of the study site (USDOI, GS 2003). Note: The high of 32-m depicted in the figure legend is due to an outlier present in the bathymetry data. The true high or top of bank is located at 45-m.

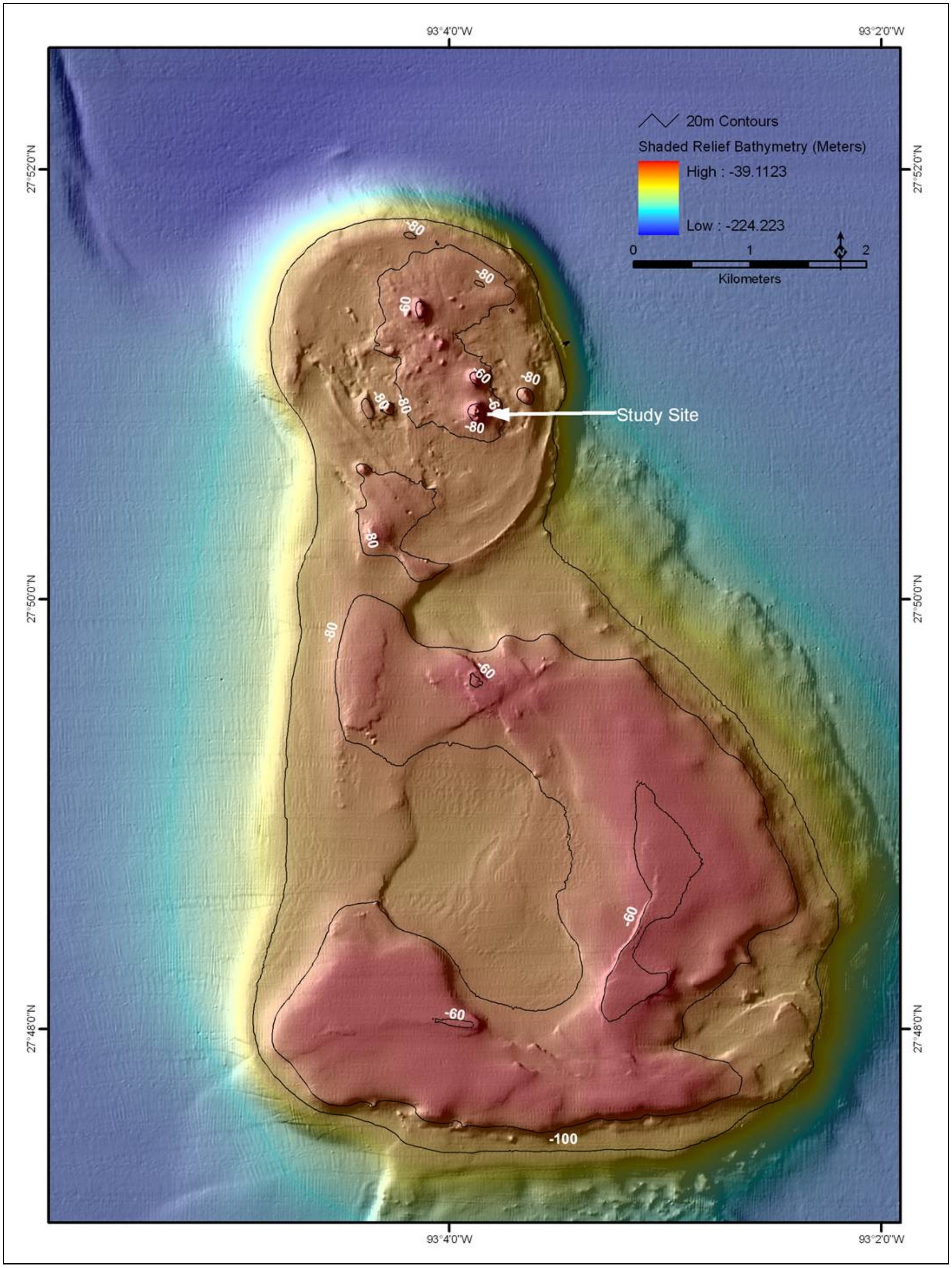


Figure 1.2.5. Bathymetric map of Geyer Bank, showing location of the study site (USDOI, GS 2003).

1.2.5. Bright Bank

Bright Bank is located at 27°53'N and 93°18'W (Figure 1.2.6) and is 108-ft (33-m) at its shallowest depth. Bright Bank is dominated by sponges, macroalgae, and several species of scleractinian corals. Bare siltstone mounds interrupt the flat, coral cap of Bright Bank. Corals include *Agaricia* spp., *Madracis* spp., *Stephanocoenia intersepta*, and *Montastraea cavernosa* (Hickerson 2004). Recent bathymetric work has revealed a mud volcano and hydrocarbon seeps at depth (Schmahl et al. 2003). For at least the past 30 years, treasure salvage activities have taken place at Bright Bank, resulting in the destruction of many coral colonies (Hickerson, personal communication, 2007).

1.2.6. East Flower Garden Bank

The shallowest portion of the EFGB is located at 59-ft (18-m) and consists of a well-developed coral reef cap located at 27°54'N and 93°36'W (Figure 1.2.7). The reef cap at the EFGB is well documented and characterized by a high coral cover, low-diversity scleractinian assemblage. Diversity is lower than Caribbean reefs but higher than other banks in the area. The EFGB supports a robust reef-fish population, with regular visitation by larger pelagic species.

An annual monitoring cruise was conducted in June 2005 at the East and West Flower Garden Banks. A post-hurricane assessment was performed five months later in November 2005 at the EFGB to assess damages that may have been caused by Hurricane Rita. Data collected in June 2005 and November 2005 at the EFGB revealed that coral cover within the established long-term monitoring study site remained relatively constant (62.78% ± 2.60 and 61.34% ± 2.75, respectively) and species relative abundance showed stability with *Montastraea annularis* species complex, *Diploria strigosa*, and *Porites* spp. as the dominant species (Precht et al. 2008a). In June 2005 macroalgae was high at 24%, while CTB was lower at 10%. After the hurricane, in November 2005, the inverse relationship between macroalgae and CTB was evident, with 24% CTB and 13% macroalgae (Precht et al. 2008a).

The EFGB contains four biological zones: Coral Reef Zone, Coral Community Zone, Coralline Algae Zone, and Deep Coral Zone (Hickerson et al. 2008). The coral cap contains the Coral Reef Zone which contains several major habitats that are named based on their dominant coral species in the coral assemblage. The primary habitat in the Coral Reef Zone is the *Montastraea* habitat; however, the Zone also contains the *Madracis* habitat in depths from 92-144 ft (28-44 m) and the *Stephanocoenia* habitat at depths below 118-ft (36-m). The Coral Community Zone, which is found at depths of 59-164 ft (18-50 m), is comprised of areas that have low densities of hermatypic corals or are characterized by coral reef biota, such as the hydrozoan *Millepora* spp., sponges, and macroalgae. The Coralline Algae Zone occurs at depths of 148-295 ft (45-90 m) and is characterized by species of crustose coralline algae that actively produce carbonate substrate, including algal nodules. The Deep Coral Zone occurs at depths of 295-ft (90-m) and greater, where active photosynthesis is not possible, and is characterized by a diverse assemblage of organisms, including antipatharian and gorgonian corals, azooxanthellate branching corals, small, solitary hard corals, crinoids, bryozoans, and sponges.

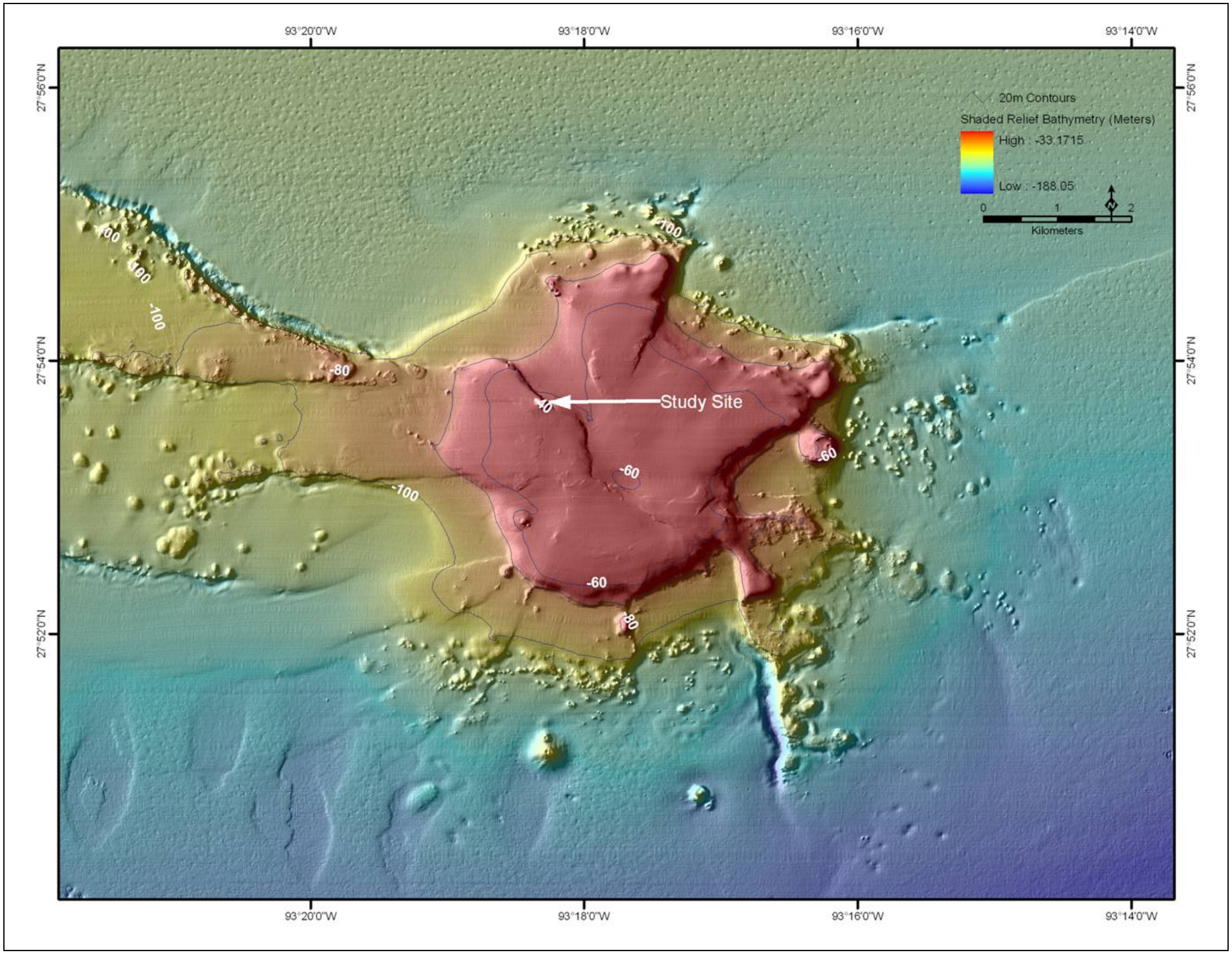


Figure 1.2.6. Bathymetric map of Bright Bank, showing location of the study site (USDOI, GS 2003).

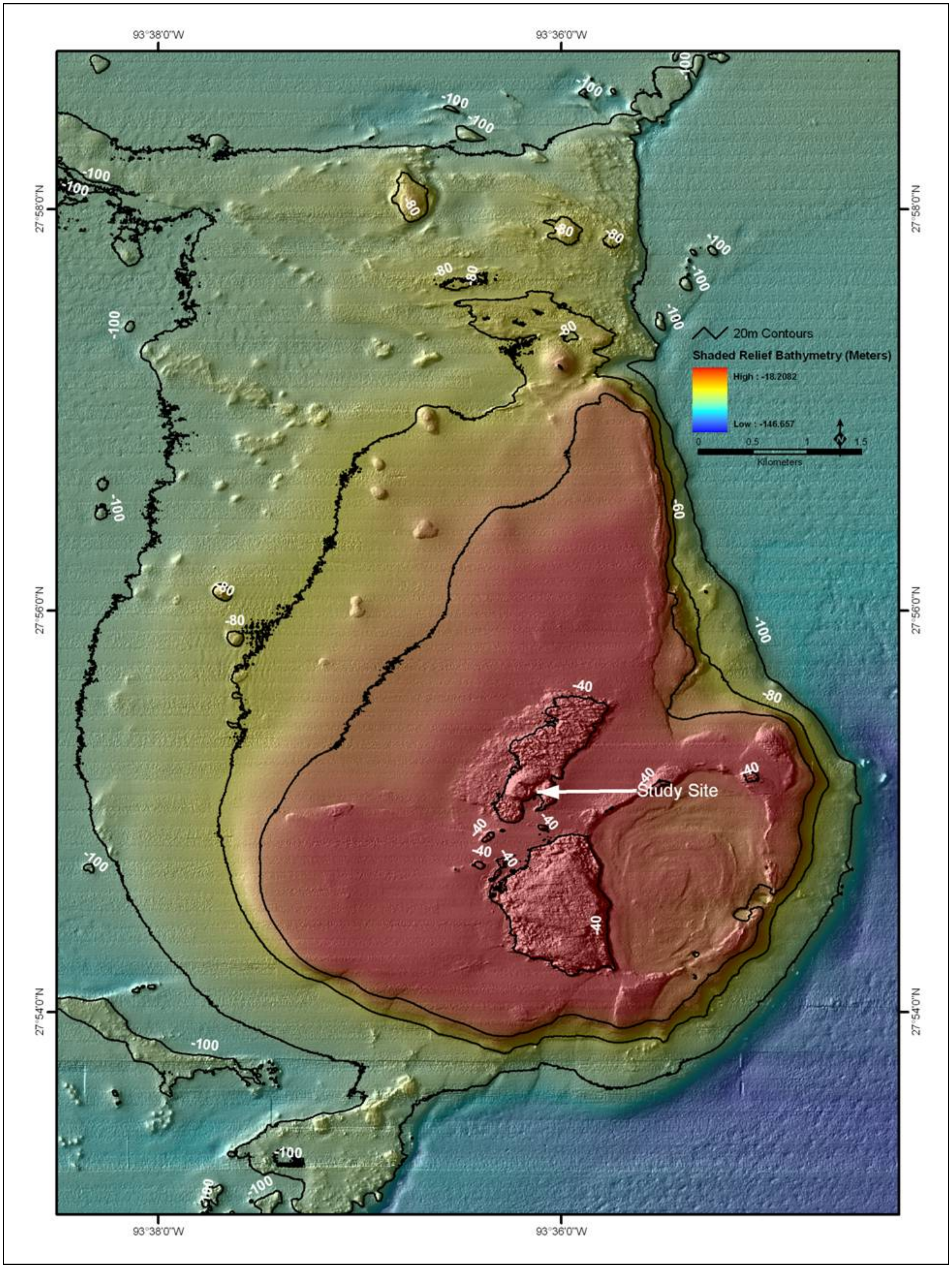


Figure 1.2.7. Bathymetric map of the EFGB, showing location of the study site (USDOI, GS 2003).

2.0 METHODS

2.1. VIDEO TRANSECT METHOD

2.1.1. Methodological Rationale

This study was designed to serve as (1) a quantitative, baseline evaluation of the benthic communities at Sonnier, McGrail, Geyer, and Bright Banks and (2) an assessment of possible hurricane effects at multiple depths at these banks. The benthic habitats of these banks are not well known and this was the first quantitative characterization of these banks at multiple depths. These banks are of particular interest because Hurricane Rita passed 7-mi (12-km) east of McGrail Bank and 15-mi (24-km) west of Sonnier Bank in September 2005. Hindcast models indicated that waves may have reached heights of up to 85-ft (26-m) at these banks, which may have exposed some bank caps, even those that are in 66-98 ft (20-30 m) under normal sea conditions. The implications for benthic community structure could have been catastrophic and the Minerals Management Service (MMS) considered it critical to assess the banks in their post-hurricane state.

The sampling protocol for this study was developed using literature references that included descriptions of biological communities at banks in the northwestern Gulf of Mexico (Rezak et al. 1985; Boland 1999; Rezak and Bright 1979; Schmahl and Hickerson 2006). Rezak et al. (1985) included the most complete description of benthic communities or habitat types along a depth gradient at several banks within the Gulf of Mexico. These data were collected by diver and manned submersible in the late 1970s through the early 1980s and recently modified by Hickerson et al. (2008) (Table 1.2.1).

In April and May 2007, videographic transects were collected by divers and a remotely operated vehicle (ROV) to characterize the benthic habitats of Sonnier, McGrail, Geyer, and Bright Banks. The sampling depth range in this study was from 72-197 ft (22-60 m). Four distinct depth ranges (zones) were sampled within the habitat types described by Rezak et al. (1985) (Table 2.1.1 and Table 2.1.2). The discontinuity between the four depth ranges was purposefully established to prevent overlap at the margins of each sampling zone.

2.1.2. Field Methods

Divers videotaped transects within no-decompression diving limits, down to ~120-ft (36.5-m). A diver swam slowly along each transect, videotaping at a height of 1.3-ft (40-cm) from the substratum, using a digital video camera in an Ikelite® underwater housing fitted with a wide-angle lens and underwater video lights. A depth gauge and scaling bar projected forward from the video housing, ensuring that the camera remained a constant distance from the bottom. By holding the video camera perpendicular to the substratum and swimming slowly along the transect, it was possible to produce clear stop-action images for analysis (Aronson et al. 1994; Murdoch and Aronson 1999; Precht et al. 2006).

Table 2.1.1.

Biological zonation of benthic communities by depth at Sonnier, McGrail, Geyer, and Bright Banks with corresponding depths from this study (adapted from Rezak et al. 1985).

Depth Ranges (m) this study	Depth Zones (m) Rezak et al. 1985	Bank			
		Sonnier	**McGrail**	**Geyer**	**Bright**
22-27	18-52	*Millepora* sponge			
30-36.5	37-52	*Millepora* sponge		*Millepora* sponge	*Stephanocoenia*
45-50	45-47	*Millepora* sponge	*Stephanocoenia*	*Millepora* sponge	Algal sponge
55-60	45-82	52+ Nepheloid	Algal sponge		Algal sponge to 74
ND	60-98	ND	82-? Antipatharian	Algal sponge	74-? Antipatharian

Table 2.1.2.

Summary of data collected by diver and ROV during this study. Abbreviations: D = sampled by diver; R = sampled by ROV; NS = not sampled; "-" = zone not present. The number following the dash represents number of transects. Note that Bright Bank was sampled by divers only. The 45- to 50-m and 55- to 60-m depth ranges were sampled by ROV only.

Depth Zone (m)	Bank			
	Sonnier	**McGrail**	**Geyer**	**Bright**
22-27	D-2	-	-	-
30-36.5	D-8	-	D-8	D-3
45-50	R-7	R-12	R-4	NS
55-60	R-6	R-8	R-7	NS

A TrackLink® 1500 High Accuracy Ultra Short Baseline acoustic positioning system (USBL) with two beacons was used to track divers videotaping transects at Sonnier, Geyer, and Bright Banks. The TrackLink system has an accuracy of 0.25 degrees. Data were converted into a GIS format in order to visualize where diver and ROV transects were in geographic space.

22- to 27- m Transects

At Sonnier Bank in the 22- to 27-m (72- to 89-ft) depth range, eight 10-m (33-ft) transects were positioned on the cap of the bank. Starting at a U-bolt attached to the seafloor (a mooring for vessels up to approximately 108-ft or 33-m in length), a fiberglass surveyor's tape was laid ~656-ft (200-m) along the entire extent of the east-west axis of the cap of the bank. Transects were positioned at random distances along the east-west axis of the reef cap, and extended along random headings from the reference line. Because the transects were positioned with reference to the line and were, therefore, pseudoreplicates, the data from the individual transects were pooled, creating what was in essence one long transect for statistical analysis. One other transect was laid in the 22- to 27-m (72- to 89-ft) depth range, and started ~69-ft (21-m) northeast of the U-bolt and videotaped in a 90° direction. The TrackLink System technology was used to record diver locations underwater. A map was developed using the geo-referenced locations of divers that represents the eight transects that were later pooled and the single long transect that ran in a southeast-northwest direction (Figure 2.1.2).

30- to 36.5-m Transects
Due to the limited bottom time associated with the depths at Sonnier, Geyer, and Bright Banks, transect tapes were not deployed by divers. Depth contours along the reef slopes were used as a substitute for transect lines to guide the videographer. A diver swam along the depth contour holding the video camera 1.3-ft (40-cm) above the bottom, as in the transect method described above. Continuous video footage was collected at each bank within this depth range. A map was developed using the geo-referenced locations of the divers collecting video transects and their actual locations (e.g., Figure 2.1.2). Discrete transects were extracted from the footage, as described below.

2.1.3. Laboratory Analysis

Digital videography provides a permanent data record and is a reliable and logistically simple method of obtaining benthic cover data. Each video frame covered a 1.3-ft (40-cm) wide block of substratum. Each 10-m (33-ft) transect thus yielded ~4-m^2 of benthic imagery, with each video frame measuring 40-cm x 27-cm, or 1080-cm^2. This frame size was selected to enable investigators to identify corals and many other sessile invertebrates to species level at colony sizes down to 1.2-in (3-cm) longest dimension. Such precision is not attainable using video frames that record larger areas of the substratum (Aronson et al. 1994; Murdoch and Aronson 1999).

22- to 27-m Transects
The 10-m (33-ft) transects recorded at Sonnier Bank in the 22- to 27-m (72- to 89-ft) depth range were cut into non-overlapping still images using ULead® VideoStudio® 9. Digital filters were applied using the ULead® software in order to enhance image quality. The original videotape of the transect was used to gain more detail or different perspectives on particular still images.

After image capture and enhancement, randomly placed dots were added to each frame using Coral Point Count® (CPCe), for a total of 500 dots per transect. Organisms positioned beneath each random dot were identified to the lowest possible taxonomic level in one of the following categories: corals, antipatharians, sponges, turf algae (>3 mm thallus height), brown macroalgae, red (non-coralline) macroalgae, green macroalgae, other live organisms, coralline (red) algae, TB [fine turfs (<3-mm thallus height) and bare space], rubble, sand, and unknown. After each image was analyzed, the data were entered into project-specific Microsoft Excel spreadsheets.

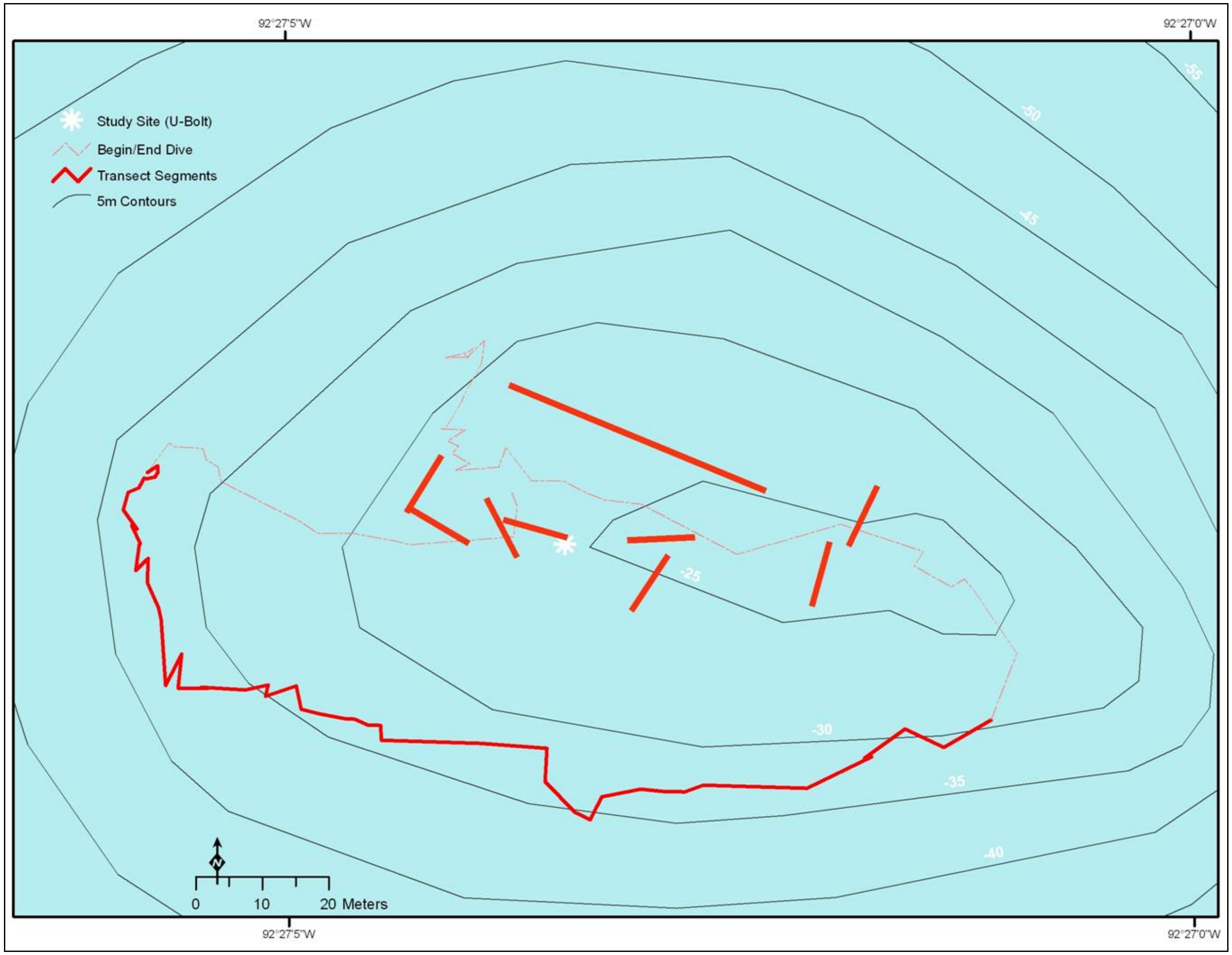


Figure 2.1.2. Approximation of diver tracks, showing geographic positions of video transects at Sonnier Bank from 22-27 m (center of figure) and from 30-36.5 m (continuous line, lower left and bottom).

Quality assurance/quality control (QA/QC) for the video analysis consisted of independent analysis by trained observers of the same piece of captured video. There was agreement between pairs of observers at least 95% of the time.

30- to 36.5-m Transects
Videography in the 30- to 36.5-m (98- to 120-ft) depth range at Sonnier, Geyer, and Bright Banks produced continuous video footage for as long as a diver could remain on the bottom. The following method was used to create individual transects from this continuous footage.

Not all video footage was usable for quantitative purposes, due to changes in distance from the bottom or selective videotaping of interesting mobile fauna by divers. First, the video footage was broken into still images using ULead® VideoStudio® 9. Digital filters were applied using the ULead® software to enhance image quality. Images that were not suitable for quantitative use were removed and used for qualitative analysis where possible. From the remaining still images, Transect 1 (T1) began at a random time near the beginning of the tape and continued for 37 frames (~4-m^2). After the 37th frame, a random number of frames (between 5 and 15) was skipped to select the beginning of the next transect (T2), and so on (Figure 2.1.3).

Transects in 30- to 36.5-m (98- to 120-ft) depth range were analyzed in the same manner as the 22- to 27-m (72- to 89-ft) transects, using the same 13 benthic categories. See Section 2.1.3 for data categories and QA/QC procedures.

2.2. Roving Diver Method

2.2.1. Methodological Rationale

The roving diver method was used to capture landscape-scale views of all banks visited. This video footage can be analyzed qualitatively for possible hurricane impacts, as it provides a broader perspective than the video transects.

2.2.2. Field Methods

Divers recorded video footage both during their descents and after the transects were videotaped. Roving diver video was recorded from 3-7 ft (1-2 m) above the substrate, looking down at a 45° angle.

2.2.3. Laboratory Analysis

The roving diver videos were qualitatively analyzed for possible hurricane impacts. Video footage from previous surveys (Sonnier Bank in 1996, 2002, and 2005; Geyer Bank in 2003; and Bright Bank in 2003) was assessed to estimate pre-hurricane conditions and benthic community structure.

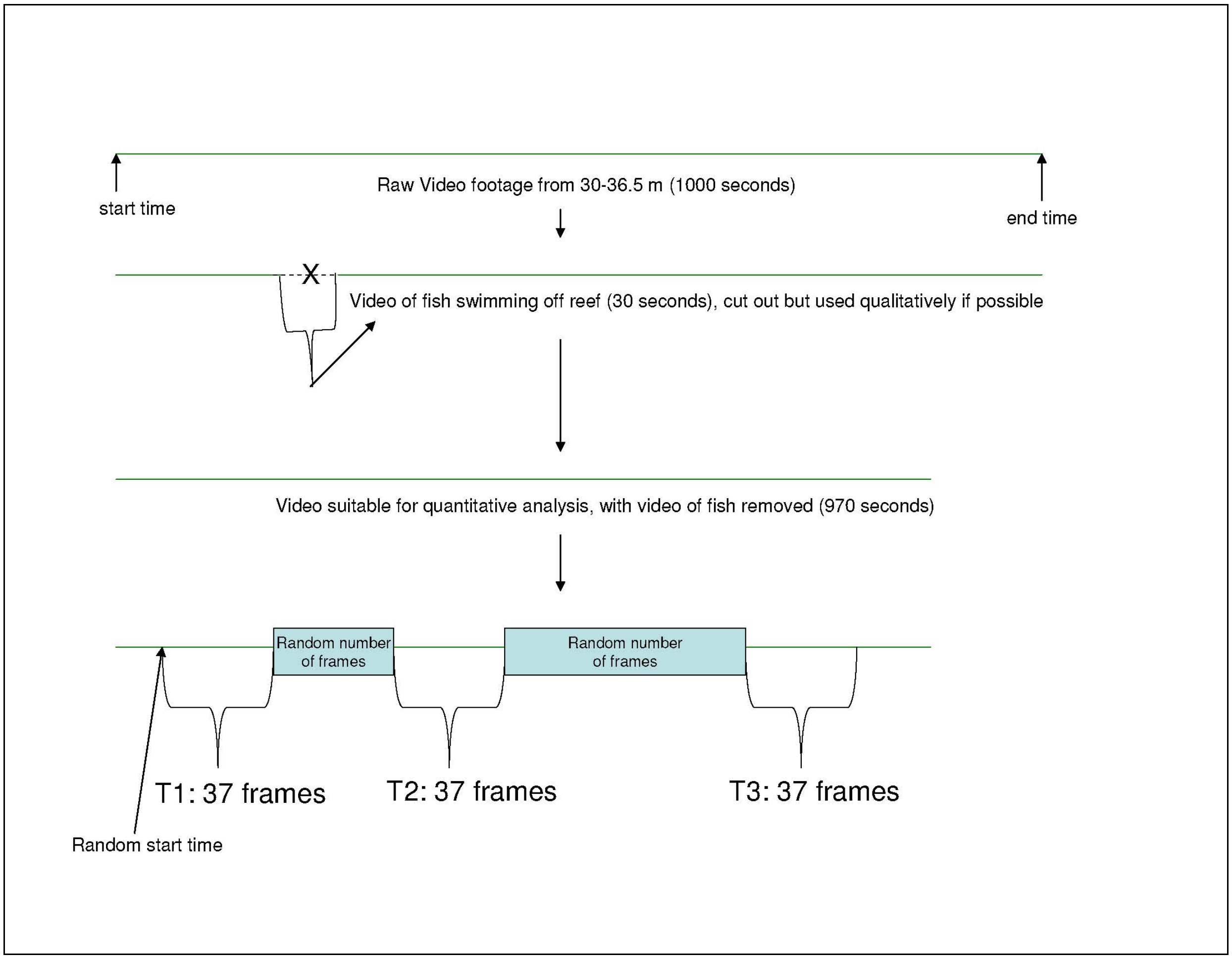


Figure 2.1.3. Diagram illustrating the method used to create transects from continuous video footage taken along contour lines at 30- to 36.5-m depth at Sonnier, Geyer, and Bright Banks.

2.3. ROV Transect Method

2.3.1. Methodological Rationale

The ROV video footage was collected at two depth ranges, 45-50 m (148-164 ft) and 55-60 m (180-197 ft), to characterize benthic communities and assess possible hurricane impacts. Additionally, it was an important goal of the study to distinguish between storm damage and damage due to oil and gas activities, which might be apparent at a greater depth.

2.3.2. Field Methods

While the vessel was moored or anchored at each bank (Sonnier, McGrail, and Geyer), ROV video was collected using a Seabotix LBV 300S-6[2] ROV (Figure 2.3.2). The ROV was tethered to the vessel with a ~984-ft (300-m) umbilical cord and was controlled using a joystick located within the cabin of the ship. Real-time video was displayed while the ROV traversed the benthos with time, direction, depth, and heading displayed on the video screen. The video was recorded onto an external hard drive and back-up copies were recorded on DVDs.

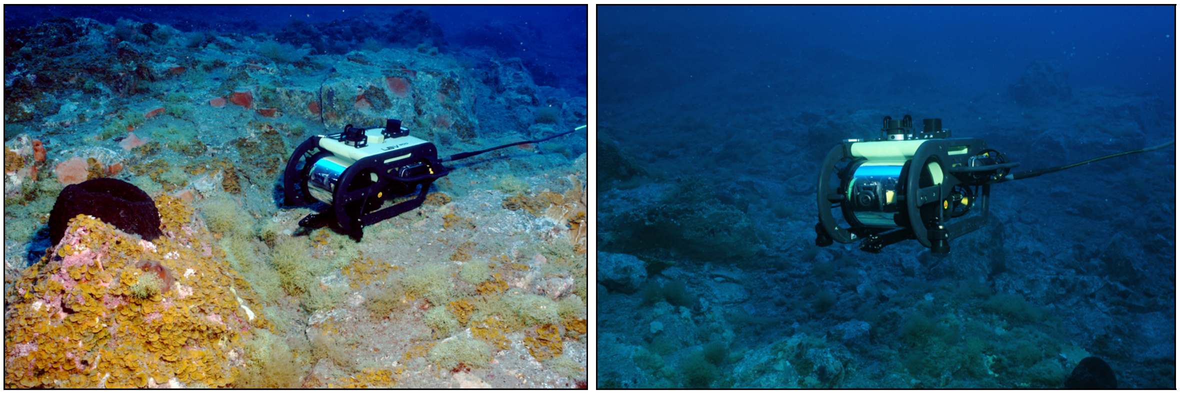


Figure 2.3.2. Seabotix LBV 300S-6^2 ROV at Sonnier Bank on May 22, 2007.

A TrackLink® 1500 High Accuracy Ultra Short Baseline acoustic positioning system (USBL) with two beacons was used to track the ROV at Sonnier, McGrail, and Geyer Banks at the 45- to 50-m (148- to 164-ft) and 55- to 60-m (180- to 197-ft) depth ranges. The TrackLink system has an accuracy of 0.25 degrees. The position of the Seabotix LBV 300S-6^2 ROV was recorded in real time and these data were collected and stored. Using ArcView GIS, these data were converted into a visualization of the ROV track (Figure 2.3.3-2.3.5).

The ROV operations took place on May 21, 2007 at Geyer Bank between 1501 and 1721 hours local time and on May 22, 2007 at Sonnier Bank between 0820 and 1155 hours. ROV operations at McGrail Bank were conducted at night on May 22, 2007 between 0006 and 0218 hours due to impending bad weather.

2.3.3. ROV Laboratory Analysis

The ROV video data were analyzed in the same manner as the video footage collected by divers at 30- to 36.5-m (98- to 120-ft) depth (Section 2.1.3.). Video was converted into non-overlapping still images. Still images that could not be used for quantitative analysis were removed, but were used for qualitative analysis if possible. Transects started at a random time (in seconds) and proceeded for 37 frames (~10-m length, or 4-m^2 area). A random number of frames were skipped before beginning the next 37 frame transect. See Section 2.1.3. for data categories and QA/QC procedures.

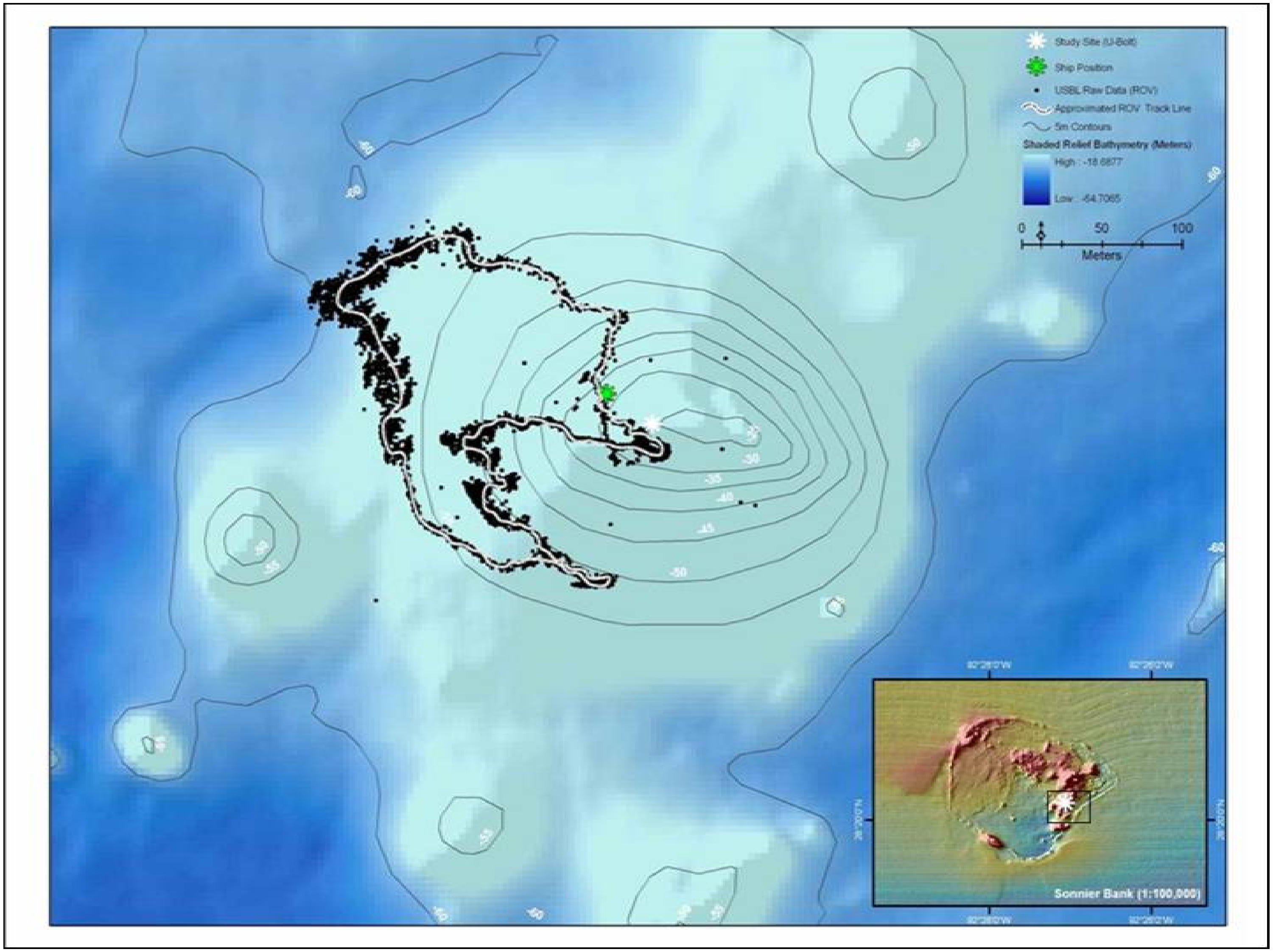


Figure 2.3.3. Map of ROV track at Sonnier Bank to and from the ship to a maximum depth of ~60-m.

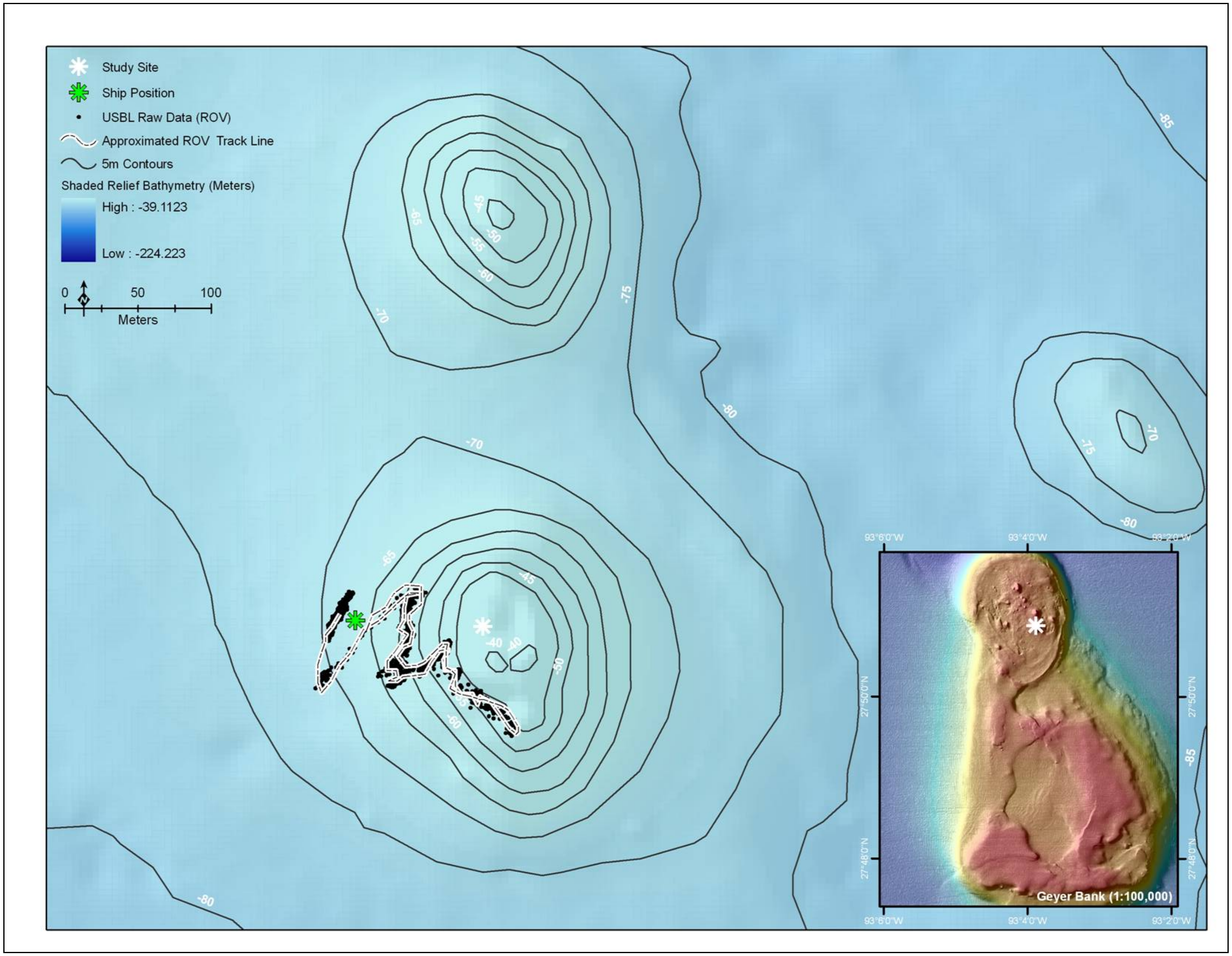


Figure 2.3.4. Map of ROV track at Geyer Bank to and from the ship to a maximum depth of ~60-m.

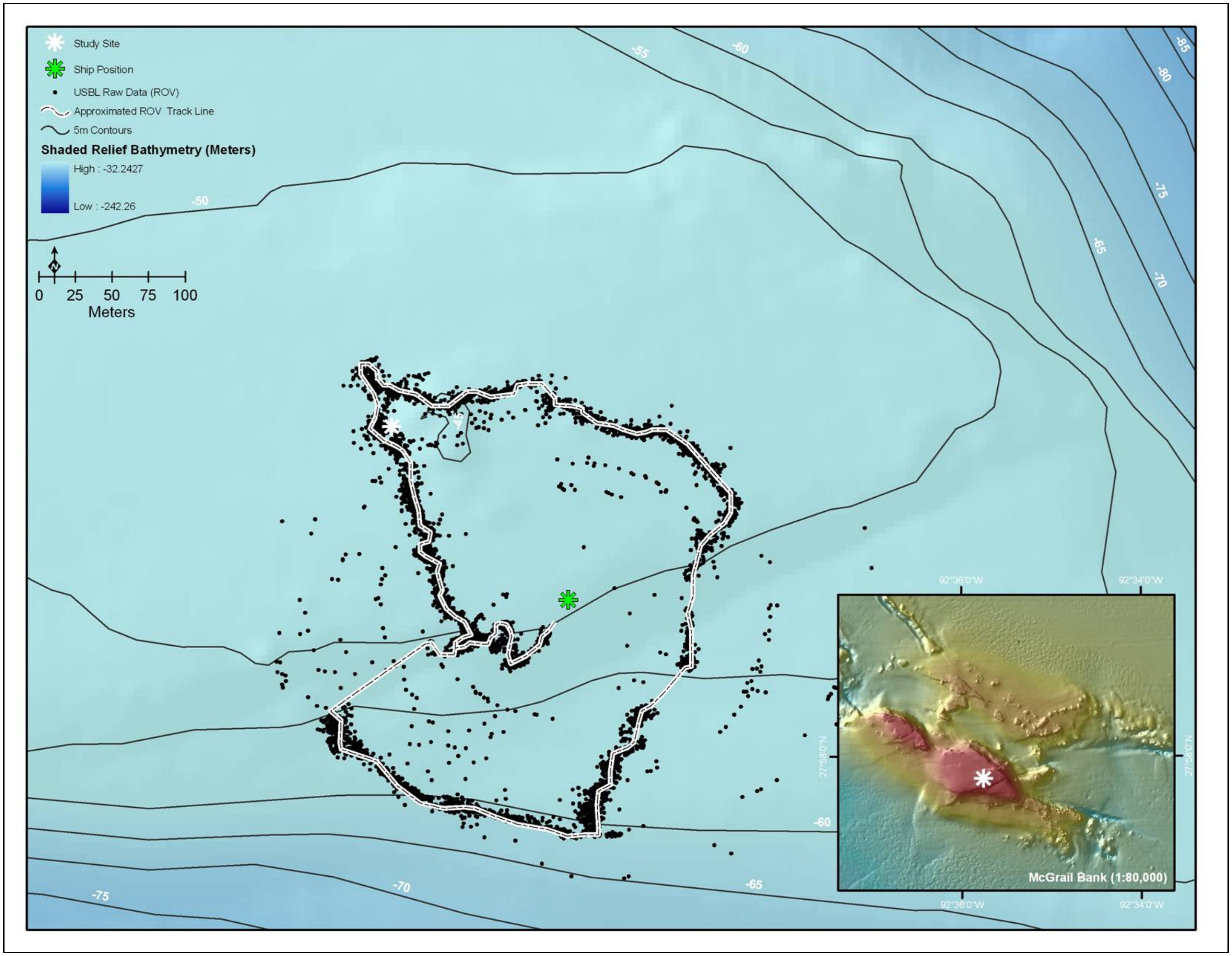


Figure 2.3.5. Map of ROV track at McGrail Bank to and from the ship to a maximum depth of ~60-m.

2.4. TRANSECT STATISTICAL ANALYSIS METHODOLOGY

Descriptive statistics, univariate statistics, and graphs were created using Excel®. Live cover data was square-root transformed and analyzed using a one-way ANOVA (Analysis of Variance), followed by a Tukeys HSD test. Transect data, which consisted of all groups analyzed to the lowest taxonomic level, were entered into an Access® database to facilitate analysis using SAS®. Data fell within the following larger categories: corals (scleractinians and hydrocorals), antipatharians, sponges, turf algae (>3-mm thallus height), brown macroalgae, red (non-coralline) macroalgae, green macroalgae, other live organisms, coralline algae, TB [fine turfs (<3-mm thallus height) and bare space], rubble, sand, and unknown. In SAS® the data were partitioned into subsets and transposed so that they would be in the correct format for analysis with PRIMER® software. The data subsets were:

1. Bright, Geyer, and Sonnier Banks at 30- to 36.5-m (98- to 120-ft) depth (SET A).
2. Geyer, McGrail, and Sonnier Banks at 45- to 50-m (148- to 164-ft) and 55- to 60-m (180- to 197-ft) depth (SET B).
3. Geyer and Sonnier at 30- to 36.5-m (98- to 120-ft), 45- to 50-m (148- to 164-ft), and 55- to 60-m (180- to 197-ft) depth (SET C).

Each data subset was exported from SAS® to Excel® and then imported into a unique PRIMER® workstation.

The three data subsets were analyzed using PRIMER® Version 6.1.6. In each case the data were square-root transformed to reduce the disproportionate effects of dominant categories. The transformed data were then converted to a Bray-Curtis similarity matrix.

Cluster analyses were performed on the Bray-Curtis matrices, using the group-averages clustering algorithm, and dendrograms were plotted. Multiple analyses were performed to evaluate linkages with respect to both site and depth range.

Multidimensional scaling (MDS) analyses were performed on the Bray-Curtis matrices, allowing for 50 restarts and a 0.01 minimum stress level with Kruskal fit scheme 1 in PRIMER®. As with the cluster analyses, multiple analyses were performed to evaluate the effects of both site and depth range.

One-way Analysis of Similarity (ANOSIM) analyses were performed on the Bray-Curtis matrices, allowing for a maximum of 999 permutations. For the subset data "SET A," a one-way ANOSIM design was utilized, as the only factor in these data was site. For "SET B" and "SET C," one-way analyses were performed separately for both factors: site and depth. Additionally, two-way crossed ANOSIM analyses were performed, with multiple transects from a given site and depth range serving as replicates.

2.5. Repetitive Quadrats

2.5.1. Methodological Rationale

To monitor changes in coral reef community structure as a result of Hurricane Rita, repetitive 8-m^2 quadrats were photographed at the EFGB in June 2005, November 2005, and June 2006 and analyzed in two ways. The first analytical approach measured the percent cover of benthic components in November 2005 and June 2006 using random dot analysis. The second approach used planimetry to analyze select coral colonies within repetitive quadrats between June 2005 and November 2005 and between November 2005 and June 2006. Colonies of the dominant corals at the Flower Garden Banks were selected for analysis if their margins were visible in the photographs. Since the alignment of photographs is not exactly the same each year, corals closer to the centers of the photographs were chosen.

2.5.2. Field Methods

Forty repetitive quadrat stations were photographed within the 100-m x 100-m study site at the EFGB in November 2005. Thirty-nine stations were re-photographed in June 2006. In November 2005, 9 deep station repetitive quadrats were photographed at the EFGB, and 7 stations were re-photographed in June 2006. Stations were photographed using a Nikonos V camera with a 15-mm lens. The camera was loaded with Kodak Ektachrome 200 ASA, 36-exposure slide film and standard settings were applied (distance = 2-m, f8). The camera was mounted in the center of a T-bar camera frame. Two Ikelite 75 watt-sec strobes, placed 4-ft (1.2-m) apart, were mounted on the ends of the T-bar and set on TTL and slave (Gittings et al. 1992). The camera was positioned in a north-facing direction and leveled to ensure repetitive photographs from year to year. The consistent orientation of the camera was achieved with a compass and a bubble level.

2.5.3. Image Analysis of Repetitive Quadrats

Percent cover of corals by species; the cover of coral bleaching, paling, concentrated and isolated fish biting, and disease; and the cover of algae were determined by overlaying 300 random dots on each repetitive quadrat station photograph using CPCe® point-count software with Excel® extensions. Percent coverage was calculated from the November 2005 images and compared to the June 2006 images. Forty-nine images were analyzed in November 2005: 40 from within the 100-m x 100-m study site and 9 from the deep station repetitive quadrats. Forty-six images were analyzed in June 2006: 39 from within the 100-m x 100-m study site and 7 from the deep stations.

Planimetry was used to measure changes in tissue extent for select coral colonies photographed within the quadrats in successive years. Four to six coral colonies were chosen within each repetitive quadrat. Areal measurements were taken using Sigma Scan Pro 5® planimetry software in each year for matched coral colonies. Each image was calibrated to an image size of 25.2-cm by 37.9-cm. To show effects of the hurricane, 40 image pairs were analyzed from within the 100-m x 100-m study site and 9 image pairs were compared from the deep repetitive quadrat stations between June 2005 and November 2005. Thirty-seven image pairs were compared from within the study site and 7 image pairs were analyzed from the deep stations between November 2005 and June 2006.

2.5.4. Data Presentation and Statistical Analysis of Repetitive Quadrats

Mean percent coverages of benthic categories (corals, sponges, macroalgae, other live, CTB [crustose coralline algae, fine turfs, and bare rock], sand and rubble, and unknown) and coral conditions (bleaching, paling, fish biting, and disease) were calculated using random-dot analysis with CPCe® software. In order to obtain an estimate of percent cover for a given benthic category, the total number of dots within that category was divided by the total number of dots analyzed for all repetitive quadrat stations (minus the number of dots that fell on tape, wand, or shadow). In order to obtain a percent-cover value for a particular coral condition, the total number of dots landing on a particular condition (i.e. bleaching, fish biting, and disease) was divided by the total number of dots falling on living coral in all the repetitive quadrat stations.

Planimetry was calculated by taking areal measurements of dominant corals each year. The areal values were compared between June 2005 and November 2005, and between November 2005 and June 2006. Descriptive statistics were used to characterize the change in area of dominant coral colonies following Hurricane Rita within 8-m^2 repetitive quadrats.

2.6. Perimeter Videography

2.6.1. Methodological Rationale

The perimeter lines were videotaped in November 2005 and June 2006 to document changes at known locations along the perimeter and within the study site. General aspects of coral condition were documented and compared year to year.

2.6.2. Field Methods

Divers videotaped two 100-m segments of the perimeter lines at the EFGB—the north and east lines—in November 2005 and June 2006. The videos commenced at the northwest corner and continued along the north line to the northeast corner, then along the east line to the southeast corner. The videographer maintained ~7-ft (2-m) distance above the substratum using a weighted line attached to the video housing. The camera was aimed down at a 45° angle to capture the substratum. At each corner of the study site, the videographer recorded a 360° panoramic view of the reef.

2.6.3. Laboratory Methods

The video footage was reviewed to record the general condition of corals along the perimeter of the EFGB study site. Individual coral heads displaying disease, bleaching, paling, or tissue loss due to fish biting were identified and recorded. The categories were as follows: bleaching, paling, healthy colony, concentrated fish biting, isolated fish biting, growth infilling (tissue regrowth), new incidence of fish biting, surface replaced by turf algae, and unchanged from the previous year. Concentrated fish biting removes the coral polyps completely from an affected area and may be due to the activity of the parrotfish *Sparisoma viride* (Bruckner and Bruckner 1998; Bruckner et al. 2000). Isolated fish biting is less dense and occurs on a smaller scale, typically representing the activity of damselfish within their territories. Affected coral colonies were compared between November 2005 and June 2006 and changes in their condition were recorded. In addition to the comparison of coral colonies, coral species composition and fish counts were assessed. These analyses were qualitative and, therefore, no statistical analyses were performed.

2.7. Hydrodynamic Model Analysis Methods

In order to understand the wave and current conditions in the vicinity of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks during the passage of Hurricane Rita, PBS&J conducted a wave study using hindcast data provided by Oceanweather, Inc. The Oceanweather, Inc. study was completed for MMS to provide hindcast wind and wave datasets in the Gulf of Mexico for Hurricanes Katrina and Rita (Table 2.6.1). This study consisted of two distinct analyses: (1) a numerical modeling effort to determine the magnitude of wave transformation from the hindcast wave location to the bank locations and (2) an analytical model to estimate the potential currents resulting from the transformed wave conditions.

Numerical modeling was performed with the REF/DIF program (Kirby and Dalrymple 1994), which is a weakly non-linear water wave refraction and diffraction model. The model inputs are the hindcast wave height, period, and direction for the vicinity of the banks, as well as the water depth at each bank location. REF/DIF computes the predicted wave height and direction at each bank location, taking into account wave refraction, diffraction, and shoaling due to the sharp changes in water depth. The model was employed to assess the extent of the effects of bank bathymetry on storm waves propagating over the banks at the bank locations. The model showed that the banks have a sizable impact on wave conditions in their vicinity. The results from the modeling effort were used to alter the hindcast data. The wave heights from the hindcast study were increased to a point just before breaking would have occurred, which is approximately 60% of the water depth at each bank location.

These new wave conditions were used as input for an analytical calculation of potential induced water velocities at the bank locations. This analysis utilizes Stream Function Wave Theory (Dean 1965), a fully non-linear formulation that is applicable for waves in deep water to near breaking conditions. The program (Chaplin 1999) uses transformed wave height, wave period, and water depth at the bank locations to estimate two-dimensional velocity throughout the water column induced by the storm waves. Because the hurricane waves that impacted the banks were quite large relative to the water depths, linear wave theory cannot be used to accurately calculate water motions. Therefore, a fully-non linear application is most appropriate for the calculation of water velocities in this case (Dean and Dalrymple 1991). The output of this analysis is predicted water velocity with depth, from the seafloor to the water surface, induced by the passage of storm waves.

Table 2.6.1.

Wave conditions during Hurricane Rita as hindcast by Oceanweather Inc. (2006). Depth of seamount is a value obtained from bathymetry data using GIS.

Site	McGrail Bank	Geyer Bank	Sonnier Bank	Bright Bank	EFGB
Latitude (deg N)	27.96	27.85	28.34	27.89	27.91
Longitude (deg W)	92.6	93.06	92.46	93.31	93.6
Hindcast model grid	Basin (Rita)	Basin (Rita)	Basin (Rita)	Basin (Rita)	Basin (Rita)
Hindcast node ID	51886	51308	8629	51587	51581
Depth (m)	201	223	60	139	131
Sig Wave Height (m)	13.6	11.7	12.6	10.9	9.85
Assoc Period (swell, s)	14.3	15.5	14.5	15.4	15.1
Peak Period (swell, s)	15.5	15.5	15.9	16.2	15.4
Max surface current (m/s)	0.2	0.16	1.89	0.19	0.21
Depth of seamount (m)	45.0	39.1	22.2	32.9	21.0

3.0 RESULTS

3.1. TRANSECT DATA DESCRIPTIVE STATISTICS

The transect data were collected to characterize and compare the benthic habitats of Sonnier, McGrail, Geyer, and Bright Banks subsequent to the passing of Hurricane Rita. Living benthic cover at each bank generally declined with depth (Figure 3.1.1; Appendices 1 and 2). Bright Bank exhibited the highest live cover of any bank (86%), while Sonnier had the lowest live cover (2%). Live cover data were pooled for each bank and data were square-root transformed in order to perform a one-way ANOVA (Analysis of Variance) (Table 3.1.1). Live cover was significantly different across banks ($F = 16.49$, $df = 64$, $P<0.0001$). Tukey's HSD test showed significant differences between all pairs containing Sonnier Bank, as well as between Bright Bank and McGrail Bank (Table 3.1.1).

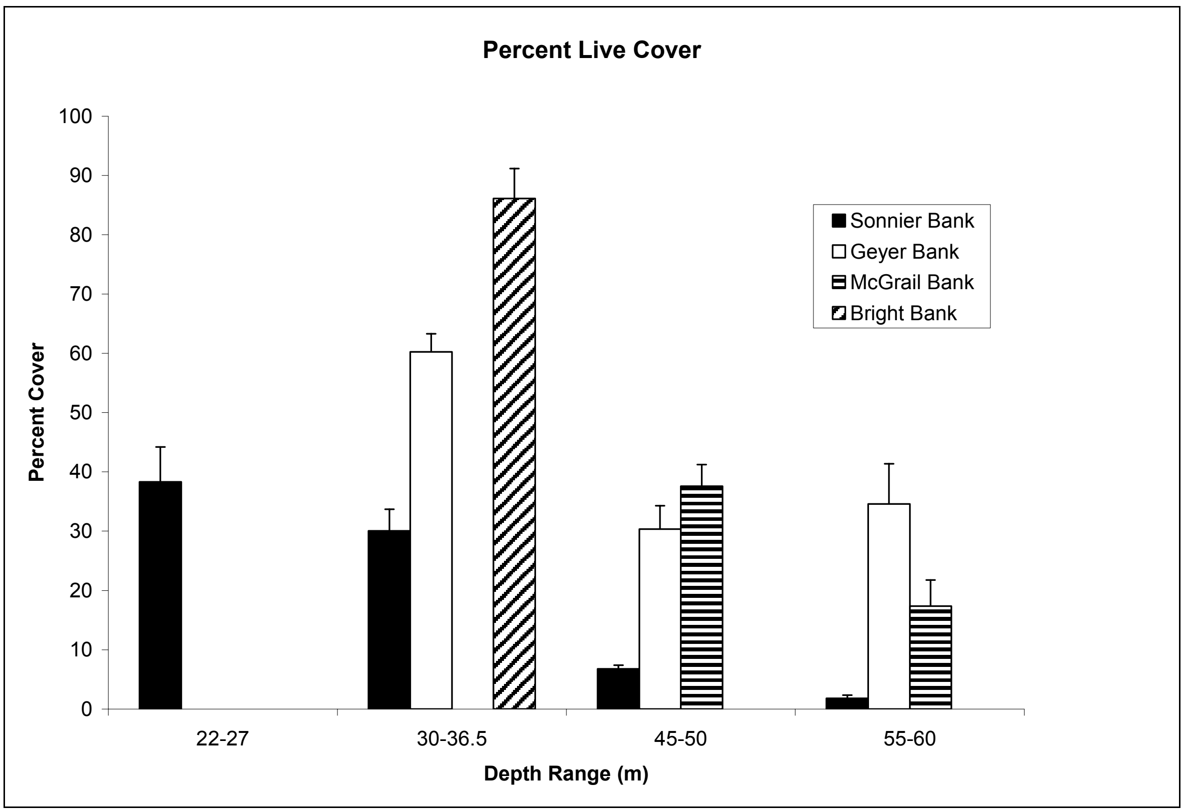


Figure 3.1.1. Percent live cover at Sonnier, Geyer, McGrail, and Bright Banks in all depth ranges. Error bars represent one standard error.

Of the four banks assessed, Sonnier Bank was the only bank containing all four depth ranges. Surveys at Sonnier, Geyer, and McGrail Banks began at the reef cap and proceeded to a maximum depth of ~197-ft (60-m). Due to time constraints, only one depth range (30-36.5 m or 98-120 ft) was surveyed at Bright Bank. The benthic characteristics of the EFGB have been thoroughly documented (long-term monitoring of the Flower Garden Banks has occurred since 1989) and consequently, the EFGB was not included in the April and May 2007 transect data collection. Thus, data for the EFGB is not included in the following analyses.

Table 3.1.1.

Results of one-way ANOVA and Tukey HSD test performed on square root transformed live cover estimates from diver and ROV transects.
Asterisk (*) denotes significant difference at a 95% confidence interval.

Square root transformed data					
Bank	**n**	**Mean**	**Standard Error**	**Pooled Standard Error**	**Standard Deviation**
Sonnier Bank	23	3.5414	0.4141	0.3567	1.9861
Geyer Bank	19	6.4916	0.3625	0.3924	1.5800
McGrail Bank	20	5.2135	0.3491	0.3825	1.5612
Bright Bank	3	9.2727	0.2742	0.9875	0.4749

Source of variation	Sum of Squares	df	Mean Square	F statistic	*P* value
Square root transformed data	144.7145	3	48.2382	16.49	<0.0001
Residual	178.4716	61	2.9258		
Total	323.1861	64			

Tukey Contrast	Difference	95% Confidence Interval
Sonnier Bank v Geyer Bank	-2.9502	-4.3508183225 to -1.5495810395*
Sonnier Bank v McGrail Bank	-1.6721	-3.0534138161 to -0.2907929789*
Sonnier Bank v Bright Bank	-5.7313	-8.504656051 to -2.9580400542*
Geyer Bank v McGrail Bank	1.2781	-0.1692634323 to 2.7254559993
Geyer Bank v Bright Bank	-2.7811	-5.5879381622 to 0.0256414189
McGrail Bank v Bright Bank	-4.0592	-6.8564494781 to -1.2620398321*

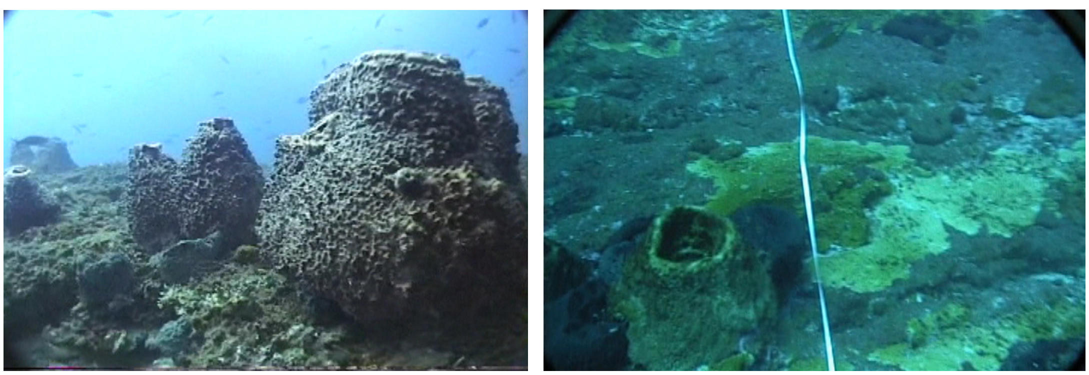
Obvious hurricane damage, such as toppled coral heads or broken sponges, was not detected at these banks. Due to the dominance of algae and sponge communities, and the paucity of hard corals, some signs of hurricane damage typical of coral reefs (e.g., toppled coral heads) were not evident. Some algal taxa would be expected to grow back within six months of a hurricane, while sponges would have a longer recovery period. Sponges may have healed in the twenty months between the passage of the hurricane and this study. No overturned corals were documented at sites with corals (Bright and McGrail Banks), although overturned corals and other coral related damage were evident in videotapes and photographs from the EFGB. Percent live cover is given by species and depth for each bank in Appendix 1.

3.2. SONNIER BANK

Sonnier Bank was dominated by brown macroalgae, sponges, and *Millepora alcicornis* in shallow areas, while TB (fine turfs < 3-mm and bare space) and rubble (bare or covered in fine turf algae) were dominant at depth. A complete list of taxa identified in the video footage is provided with percent cover by depth range in Appendix 1.

Video footage of Sonnier Bank from 1996 (NOAA), 2002 (MMS), and 2005 (NOAA) were viewed for qualitative analysis and compared to one another and the transect videos from this study. The video footage from 1996 and 2005 were recreational videos recorded on the reef cap of Sonnier Bank (courtesy of E.L. Hickerson). The video footage from 2002 was collected by the Gulf Reef Environmental Action Team (GREAT). The goal of the project was to establish a monitoring program to detect natural variation at Sonnier Bank in advance of any nearby oil and gas development activities (Boland, personal communication, 2008). The second, and final, monitoring trip occurred in May 2002, which included the videotaping of transects on the 79-ft (24-m) peak.

The depths videotaped in previous years (1996, 2002, and 2005) are comparable to the shallowest depth range in this study, which is 22-27 m (72-89 ft). Although impossible to quantify, it appeared that there was more live cover of algae, sponges, and *Millepora alcicornis* in earlier years. The barrel sponge *Xestospongia muta* was recorded in 1996 and 2002, but this species was absent from the 2005 videotapes (Figure 3.2.1). *Xestospongia muta* was not recorded at Sonnier Bank in 2007. Roving diver video from April-May 2007 showed areas of low-lying algal and sponge cover, with no evidence of overturned corals or other organisms removed from their growth positions. Numerous areas of rubble were observed and they were evident in the transect video.



(A) (B)

Figure 3.2.1. (A) *Xestospongia muta* from 1996 video (NOAA) and (B) *X. muta* from 2002 video (Boland 2002).

22- to 27-m Depth

Atop Sonnier Bank from 22-27 m (72-89 ft), live cover was ~38% and consisted mostly of brown macroalgae, *Millepora alcicornis* (the only coral recorded in these transects), sponges, and turf algae, the latter of which was unidentifiable to taxonomic group (Figure 3.1.1; Figure 3.2.2; Table 3.2.1). Appendix 2 contains transect data for all the banks.

30- to 36.5-m Depth

In the 30- to 36.5-m (98- to 120-ft) depth range, live cover decreased to ~30%. The dominant live component of the substratum was brown macroalgae, comprising 22%. The cover of *Millepora alcicornis* declined to 1.6%. Rubble was prominent in this depth range, covering ~40% of the substratum (Figure 3.2.2; Figure 3.2.3; Table 3.2.2).

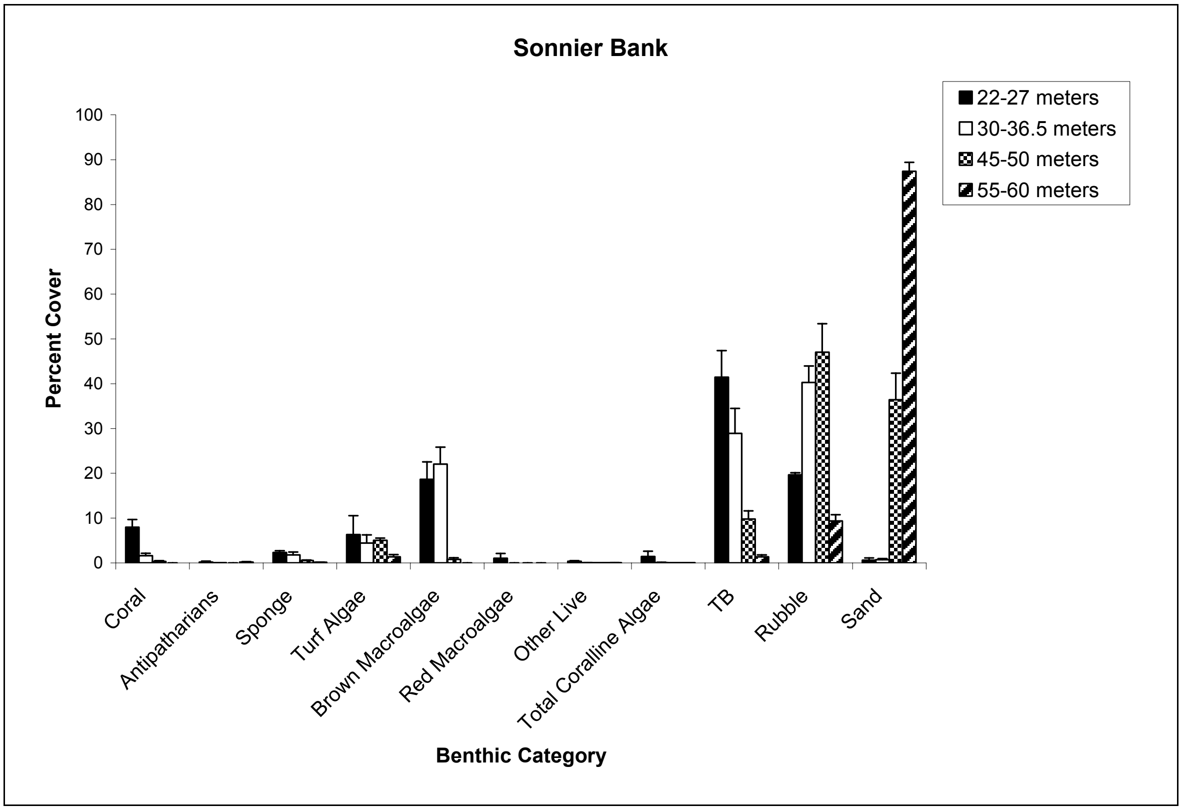


Figure 3.2.2. Percent cover of benthic categories at all depth ranges at Sonnier Bank. Error bars represent one standard error.

Table 3.2.1.

Percent cover of benthic categories at Sonnier Bank from 22- to 27-m depth. No samples of green macroalgae or unknown categories were identified.

SONNIER BANK 22-27 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Millepora alcicornis	7.98	1.73
Total Coral	**7.98**	**1.73**
ANTIPATHARIANS		
Stichopathes sp.	0.20	0.20
Total Antipatharians	**0.20**	**0.20**
SPONGES		
Agelas clathrodes	0.61	0.09
Ircinia spp.	0.33	0.03
Neofibularia nolitangere	0.46	0.44
Niphates erecta	0.05	0.05
Spheciospongia sp.	0.25	0.25
Unidentified Sponges	0.65	0.45
Total Sponge	**2.35**	**0.35**

Table 3.2.1. Percent cover of benthic categories at Sonnier Bank from 22- to 27-m depth (continued).

SONNIER BANK 22-27 METERS		
	Mean Percent Cover	**Standard Error**
TURF ALGAE		
Total Turf Algae	**6.34**	**4.24**
BROWN MACROALGAE		
Dictyota spp.	8.43	1.93
Lobophora variegata	7.75	3.85
Padina sp.	0.34	0.24
Unidentified Brown macroalgae	2.11	2.09
Total Brown Macroalgae	**18.63**	**3.93**
RED MACROALGAE		
Total Red Macroalgae	**1.06**	**1.06**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Diadema antillarum	0.05	0.05
Gastropoda	0.25	0.15
Holothuroidea	0.05	0.05
Total Other Live	**0.35**	**0.15**
CORALLINE ALGAE		
Total Coralline Algae	**1.41**	**1.19**
FINE TURF, BARE		
Rubble	19.64	0.46
TB	41.45	5.95
Total TB and Rubble	**61.09**	**6.41**
SAND		
Sand	0.60	0.50
Total Sand	**0.60**	**0.50**
UNKNOWNS		
Total Unknown	**0.00**	**0.00**
Total Live Cover	**38.31**	
TOTAL	**100.0**	

45- to 50-m Depth

Live cover at 45- to 50-m (148- to 164-ft) depth was low, at 6.8 %. Live cover consisted primarily of turf algae, at 5% cover. Within this depth range, rubble was prevalent at 47% cover (Figure 3.2.2; Table 3.2.3).

55- to 60-m Depth

Live cover at 55- to 60-m (180- to 197-ft) depth was extremely low, at 1.8%. Sand was the largest space occupant at this depth, covering 87% of the substratum and rubble decreased to ~9% cover (Figure 3.2.2; Table 3.2.4). Within this depth range, a number of fireworms were noted, although not at a sufficiently high density to be quantified at the sampling density employed (500 dots per 4-m^2). No obvious signs of hurricane damage were documented.

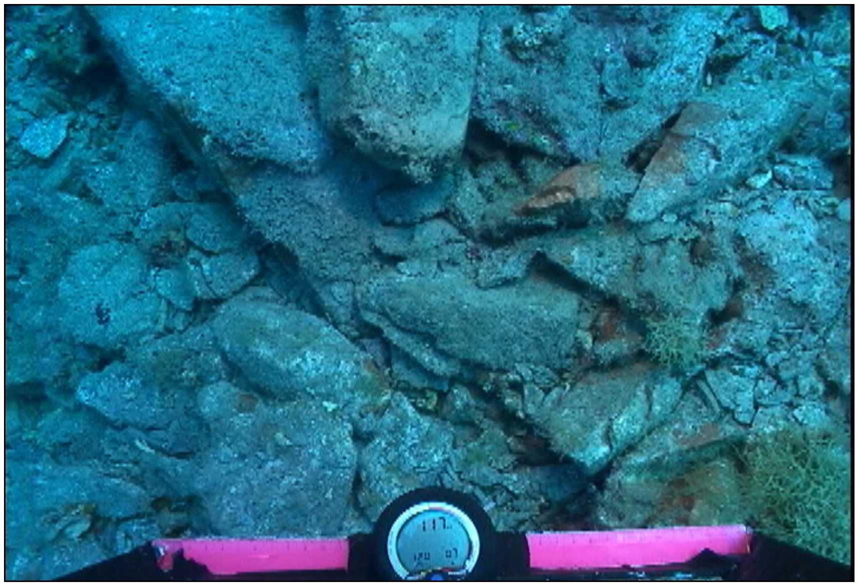


Figure 3.2.3. Large rubble typical of 30- to 36.5-m depth range at Sonnier Bank.

Table 3.2.2.

Percent cover of benthic categories at Sonnier Bank from 30- to 36.5-m depth.
No samples of red macroalgae, green macroalgae, or unknown categories were identified.

SONNIER BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Millepora alcicornis	1.60	0.55
Total Coral	**1.60**	**0.55**
ANTIPATHARIANS		
Stichopathes sp.	0.03	0.03
Total Antipatharians	**0.03**	**0.03**
SPONGES		
Agelas clathrodes	0.03	0.03
Ircinia spp.	0.28	0.13
Neofibularia nolitangere	0.50	0.33
Niphates erecta	0.28	0.14
Spheciospongia sp.	0.25	0.17
Unidentified Sponges	0.45	0.07
Total Sponge	**1.78**	**0.65**
TURF ALGAE		
Total Turf Algae	**4.48**	**1.78**
BROWN MACROALGAE		
Dictyota spp.	13.48	0.99
Lobophora variegata	1.65	0.56

Table 3.2.2. Percent cover of benthic categories at Sonnier Bank from 30- to 36.5-m depth (continued).

SONNIER BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
Padina spp.	0.03	0.03
Unidentified Brown Macroalgae	6.90	3.08
Total Brown Macroalgae	**22.1**	**3.80**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Fish	0.03	0.03
Gastropoda	0.03	0.03
Total Other Live	**0.05**	**0.03**
CORALLINE ALGAE		
Total Coralline Algae	**0.08**	**0.05**
FINE TURF, BARE		
Rubble	40.30	3.68
TB	28.90	5.55
Total TB and Rubble	**69.20**	**3.61**
SAND		
Sand	0.75	0.23
Total Sand	**0.75**	**0.23**
UNKNOWNS		
Total Unknown	**0.00**	**0.00**
Total Live Cover	**30.06**	
TOTAL	**100.0**	

3.3. McGrail Bank

Live cover at McGrail Bank was dominated by macroalgae and coral (specifically *Stephanocoenia intersepta*) in the 45- to 50-m (148- to 164-ft) depth range and algal nodules and macroalgae at deeper depths (55-60 m or 180-197 ft). Rubble and sand were the major benthic components in both depth ranges. A complete list of taxa identified in the video footage is provided with percent cover by depth range in Appendix 1.

45- to 50-m Depth

Atop McGrail Bank at 148-ft (45-m), live cover was ~38%, consisting primarily of brown and green macroalgae, as well as scleractinian corals (Figure 3.1.1; Figure 3.3.1; Table 3.3.1). Rubble was a dominant feature at 39% cover. Differentiated from rubble were algal nodules, which our transect video only identified at McGrail Bank and comprised ~2% of the substratum cover. The mean coral cover was ~5% and consisted mostly of *Stephanocoenia intersepta*, at 4.8% cover (Figure 3.3.2), with *Millepora alcicornis*, *Agaricia* sp., and *Montastraea cavernosa* comprising the remaining 0.7% (Appendix 2).

Table 3.2.3.

Percent cover of benthic categories at Sonnier Bank from 45- to 50-m depth. No samples of antipatharians, red macroalgae, or green macroalgae were identified.

SONNIER BANK 45-50 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Octocorallia	0.34	0.17
Total Coral	**0.34**	**0.17**
ANTIPATHARIANS		
Total Antipatharians	**0.00**	**0.00**
SPONGES		
Ircinia spp.	0.11	0.09
Unidentified Sponges	0.43	0.13
Total Sponge	**0.54**	**0.12**
TURF ALGAE		
Total Turf Algae	**5.03**	**0.53**
BROWN MACROALGAE		
Dictyota spp.	0.31	0.25
Unidentified Brown Macroalgae	0.49	0.29
Total Brown Macroalgae	**0.80**	**0.34**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Gastropoda	0.03	0.03
Total Other Live	**0.03**	**0.03**
CORALLINE ALGAE		
Total Coralline Algae	**0.03**	**0.03**
FINE TURF, BARE		
Rubble	47.00	6.41
TB	9.77	1.83
Total TB and Rubble	**56.77**	**5.57**
SAND		
Sand	36.4	5.94
Total Sand	**36.40**	**5.94**
UNKNOWNS		
Total Unknown	**0.06**	**0.04**
Total Live Cover	**6.77**	
TOTAL	**100.0**	

Table 3.2.4.

Percent cover of benthic categories at Sonnier Bank from 55- to 60-m depth. No samples of coral, brown macroalgae, red macroalgae, green macroalgae, or unknown categories were identified.

SONNIER BANK 55-60 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Total Coral	**0.00**	**0.00**
ANTIPATHARIANS		
Antipatharia spp.	0.17	0.11
Total Antipatharian	**0.17**	**0.11**
SPONGES		
Unidentified Sponges	0.13	0.07
Total Sponge	**0.13**	**0.07**
TURF ALGAE		
Total Turf Algae	**1.40**	**0.49**
BROWN MACROALGAE		
Total Brown Macroalgae	**0.00**	**0.00**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Cerianthidea	0.03	0.03
Gastropoda	0.03	0.03
Total Other Live	**0.07**	**0.04**
CORALLINE ALGAE		
Total Coralline Algae	**0.03**	**0.03**
FINE TURF, BARE		
Rubble	9.37	1.39
TB	1.40	0.38
Total TB and Rubble	**10.77**	**1.67**
SAND		
Fish Hole	0.13	0.10
Sand	87.30	1.94
Total Sand	**87.43**	**1.98**
UNKNOWNS		
Total Unknown	**0.00**	**0.00**
Total Live Cover	**1.80**	
TOTAL	**100.0**	

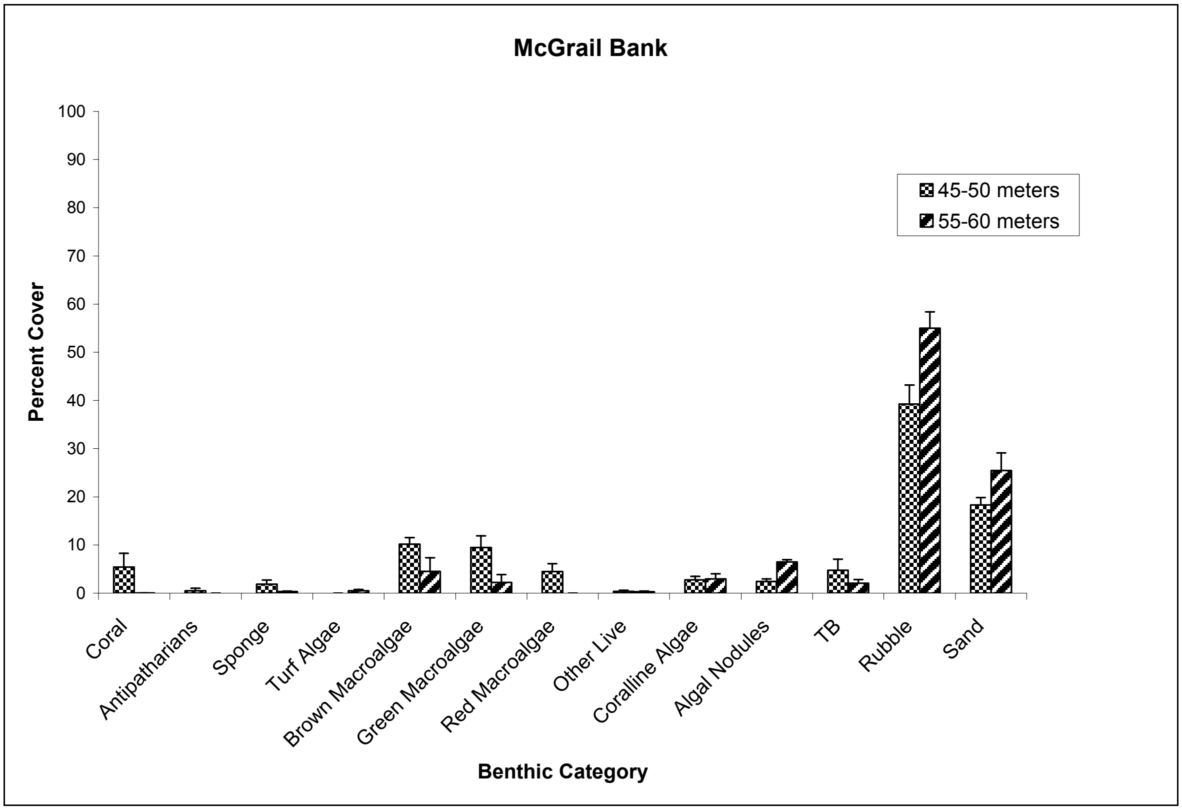


Figure 3.3.1. Percent cover of benthic categories in both depth ranges at McGrail Bank. Error bars represent one standard error.

It should be noted that the percent cover of *Stephanocoenia intersepta* appeared to be much higher in some areas compared to others within this depth range, ranging from 0-32% within the transect data (Appendix 2). A multidimensional scaling (MDS) analysis was performed on the 45- to 50-m (148- to 164-ft) transect data, based on multivariate cover of the four hard-coral taxa (*Agaricia* sp., *Millepora alcicornis*, *Montastraea cavernosa*, and *Stephanocoenia intersepta*.) The MDS plot (Figure 3.3.3) reveals that there is indeed high variability among transects in the composition of the coral assemblage at McGrail Bank in this depth range. The low stress level (0.01) of the MDS plot provides confidence in this result. No obvious signs of hurricane damage were documented.

55- to 60-m Depth

Live cover within this depth range was ~17% (Figure 3.1.1) and was comprised mostly of algal nodules (Figure 3.3.4) and the brown macroalga *Lobophora variegata* (Figure 3.3.1; Table 3.3.2). Rubble and sand were the dominant features of McGrail Bank in the ROV transects from 55- to 60-m (180- to 197-ft) depth (Figure 3.3.1; Table 3.3.2). No obvious signs of hurricane damage were documented.

Table 3.3.1.

Percent cover of benthic categories at McGrail Bank from 45- to 50-m depth.
No samples of turf algae were identified.

MCGRAIL BANK 45-50 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Agaricia spp.	0.08	0.04
Millepora alcicornis	0.59	0.25
Montastraea cavernosa	0.02	0.02
Stephanocoenia intersepta	4.75	2.65
Total Coral	**5.43**	**2.84**
ANTIPATHARIANS		
Antipatharia spp.	0.52	0.50
Total Antipatharians	**0.52**	**0.50**
SPONGES		
Agelas clathrodes	0.19	0.08
Ircinia spp.	0.26	0.18
Pseudoceratina crassa	0.04	0.03
Unidentified Sponges	1.02	0.53
Xestospongia muta	0.37	0.21
Total Sponge	**1.88**	**0.85**
TURF ALGAE		
Total Turf Algae	**0.00**	**0.00**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	0.60	0.13
Dictyota spp.	5.88	1.36
Lobophora variegata	2.56	0.77
Sargassum spp.	1.10	0.27
Total Brown Macroalgae	**10.15**	**1.40**
RED MACROALGAE		
Red Macroalgae	4.48	1.61
Total Red Macroalgae	**4.48**	**1.61**
GREEN MACROALGAE		
Green Macroalgae	9.50	2.43
Total Green Macroalgae	**9.50**	**2.43**
OTHER LIVE		
Diadema antillarum	0.29	0.16
Fish	0.08	0.03
Asteroidea/Ophiuroidea	0.02	0.02
Gastropoda	0.02	0.02
Total Other Live	**0.40**	**0.18**
CORALLINE ALGAE		
Algal Nodules	2.44	0.50
Crustose Coralline Algae	2.79	0.70
Total Coralline Algae	**5.22**	**0.58**

Table 3.3.1. Percent cover of benthic categories at McGrail Bank from 45- to 50-m depth (continued).

MCGRAIL BANK 45-50 METERS		
	Mean Percent Cover	**Standard Error**
FINE TURF, BARE		
Rubble	39.26	3.96
TB	4.76	2.27
Total TB and Rubble	**44.01**	**2.50**
SAND		
Total Sand	**18.31**	**1.54**
UNKNOWNS		
Total Unknown	**0.09**	**0.04**
Total Live Cover	**37.58**	
TOTAL	**100.0**	

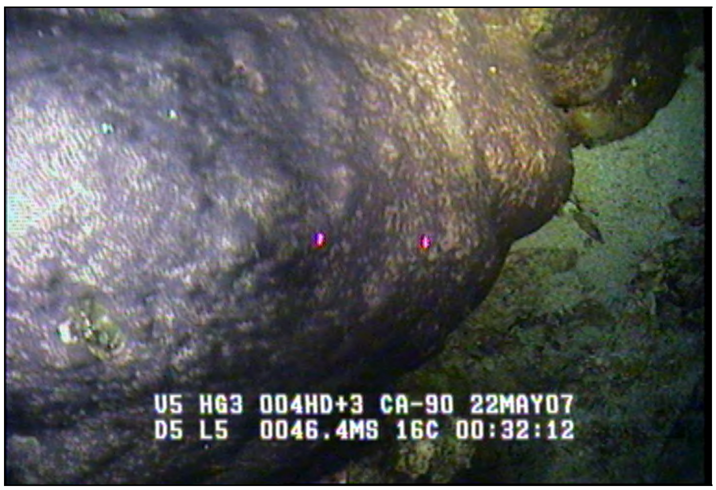


Figure 3.3.2. Frame capture from ROV video at McGrail Bank, showing a large colony of the coral *Stephanocoenia intersepta*. Laser lights in the center of the frame are 5-cm apart.

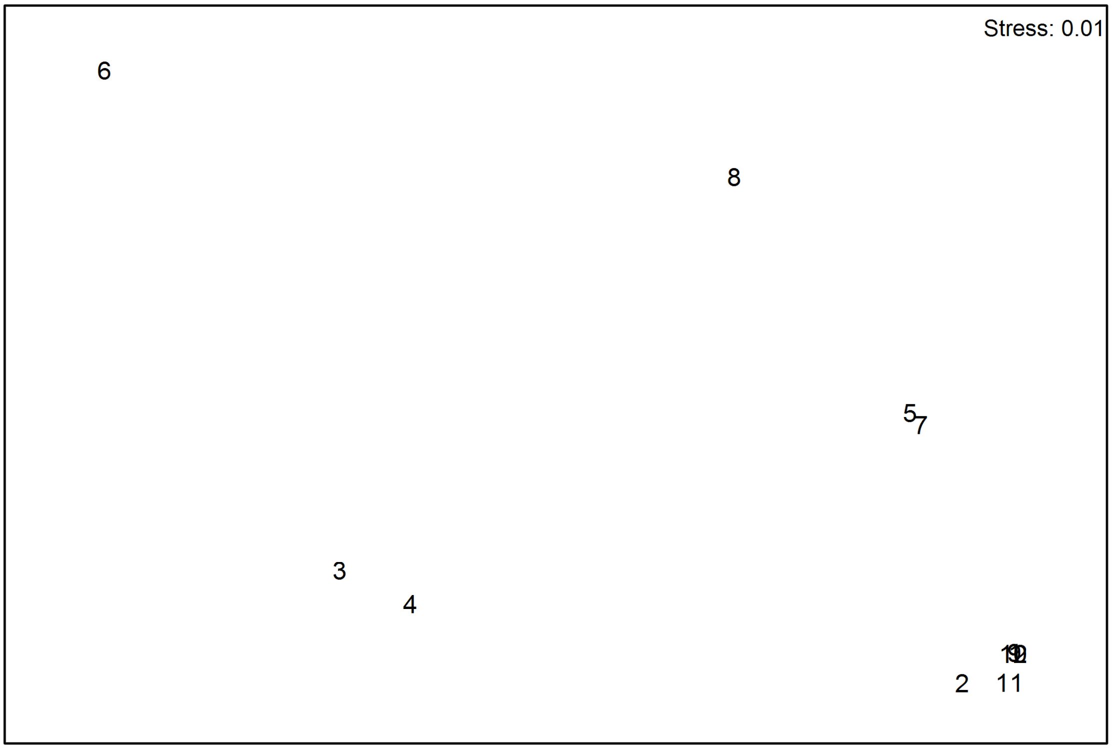


Figure 3.3.3. Two-dimensional MDS plot, based on square-root-transformed Bray-Curtis similarities, comparing multivariate cover of the four hard-coral taxa at McGrail Bank within the 45- to 50-m depth range.

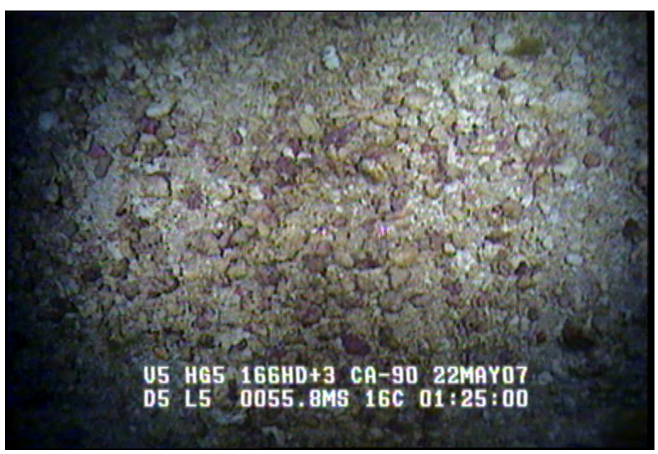


Figure 3.3.4. Frame capture from ROV video at McGrail Bank, showing algal nodules at 55- to 60-m depth. Laser lights in the center of the frame are 5-cm apart.

Table 3.3.2.

Percent cover of benthic categories at McGrail Bank from 55- to 60-m depth. No samples of antipatharians or red macroalgae were identified.

MCGRAIL BANK 55-60 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Octocorallia	0.03	0.03
Total Coral	**0.03**	**0.03**
ANTIPATHARIANS		
Total Antipatharians	**0.00**	**0.00**
SPONGES		
Unidentified Sponges	0.33	0.11
Total Sponge	**0.33**	**0.11**
TURF ALGAE		
Total Turf Algae	**0.52**	**0.27**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	0.24	0.08
Dictyota spp.	0.76	0.47
Lobophora variegata	3.55	2.37
Total Brown Macroalgae	**4.54**	**2.79**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Green Macroalgae	2.17	1.65
Halimeda sp.	0.03	0.03
Total Green Macroalgae	**2.20**	**1.65**
OTHER LIVE		
Cerianthidea	0.19	0.10
Fish	0.03	0.03
Asteroidea/Ophiuroidea	0.06	0.04
Total Other Live	**0.28**	**0.14**
CORALLINE ALGAE		
Algal Nodules	6.51	0.46
Crustose coralline algae	2.95	1.06
Total Coralline Algae	**9.46**	**1.10**
FINE TURF, BARE		
Rubble	54.99	3.38
TB	2.06	0.76
Total TB and Rubble	**57.06**	**3.00**
SAND		
Total Sand	**25.46**	**3.65**
UNKNOWNS		
Total Unknown	**0.12**	**0.05**
Total Live Cover	**17.37**	
TOTAL	**100.0**	

3.4. Geyer Bank

Geyer Bank was dominated by brown macroalgae, rubble, and TB. A complete list of taxa identified in the video footage is provided with percent cover by depth range in Appendix 1.

Fish populations were the focus of diver-collected video surveys at Geyer Bank in July 2003 (Moore 2003a), and therefore a limited qualitative comparison of the benthic communities was possible between 2003 and 2007. The benthic community at Geyer Bank was dominated by macroalgae and hydrocorals, specifically *Sargassum* spp. and *Millepora alcicornis*, respectively. Sponges were also observed, including *Neofibularia nolitangere*, *Aplysina* spp., *Ircinia* spp., and *Xestospongia muta.* Geyer Bank was the only location in this study with an observed population of *Tubastraea coccinea*. Observed *T. coccinea* colonies occupied all angles of the substrate, both vertical and horizontal surfaces.

30- to 36.5-m Depth

Live cover within the 30- to 36.5-m (98- to 120-ft) depth range was 60% at Geyer Bank (Figure 3.1.1). Live cover at this depth consisted mostly of brown macroalgae, at 42% cover, with *Sargassum* being the dominant genus, at 27% (Figure 3.4.1; Figure 3.4.2; Table 3.4.1). Coral was present at Geyer Bank, accounting for ~10% of cover, with *Millepora alcicornis* as the dominant species (Figure 3.4.1; Table 3.4.1; Appendix 2). No obvious signs of hurricane damage were documented.

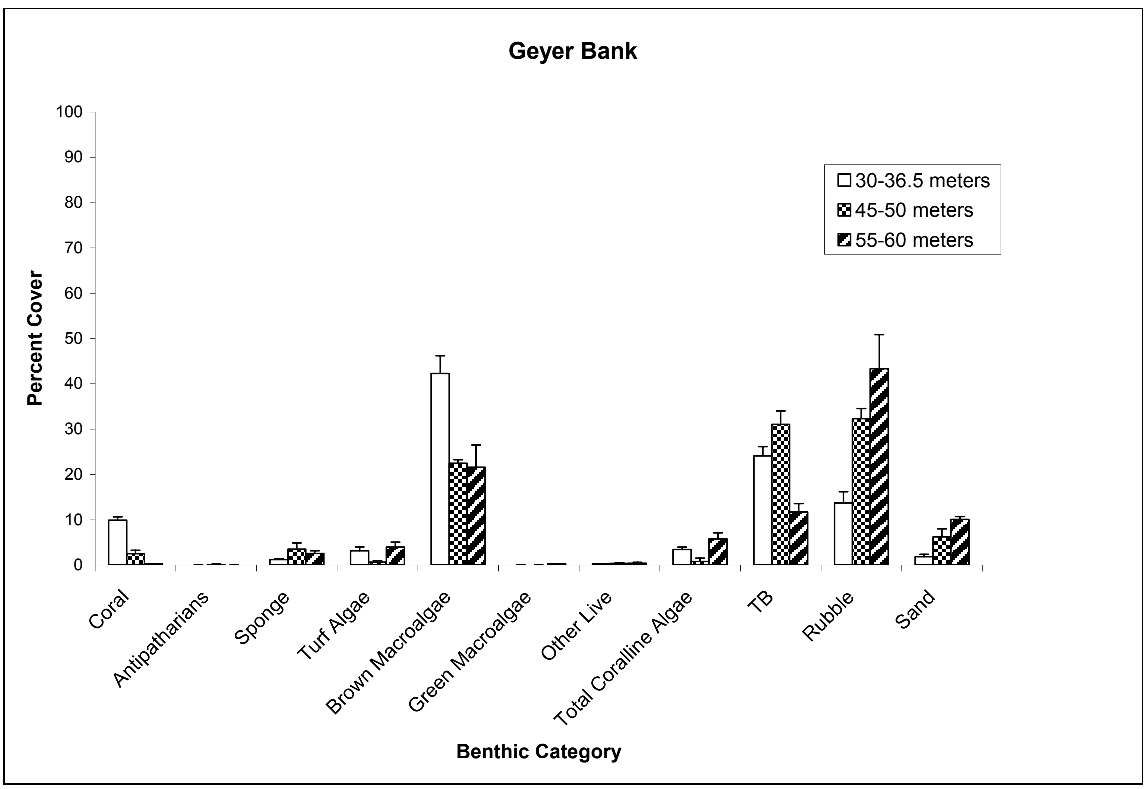


Figure 3.4.1. Percent cover of benthic categories in all depth ranges at Geyer Bank. Error bars represent one standard error.

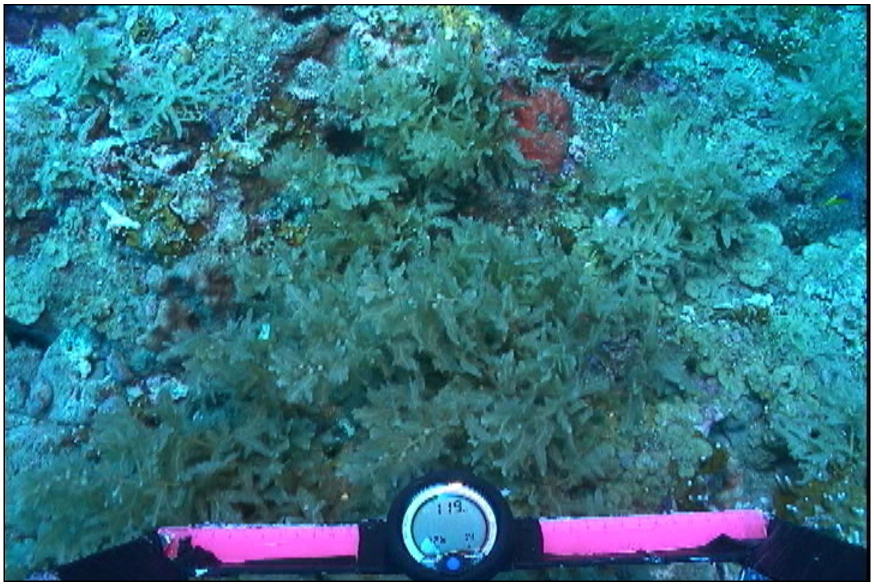


Figure 3.4.2. Frame capture of *Sargassum* spp., typical benthic cover in the 30- to 36.5-m depth range at Geyer Bank.

Table 3.4.1.

Percent cover of benthic categories at Geyer Bank from 30- to 36.5-m depth. No samples of antipatharians, red macroalgae, or green macroalgae were identified.

GEYER BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Millepora alcicornis	9.15	0.68
Porites sp.	0.03	0.03
Unidentified Scleractinia	0.18	0.08
Stephanocoenia intersepta	0.33	0.14
Tubastraea coccinea	0.23	0.17
Total Coral	**9.90**	**0.74**
ANTIPATHARIANS		
Total Antipatharian	**0.00**	**0.00**
SPONGES		
Aplysina spp.	0.23	0.10
Clathria spp.	0.03	0.03
Cliona sp.	0.05	0.05
Neofibularia nolitangere	0.10	0.10
Unidentified Sponges	0.75	0.13
Xestospongia muta	0.08	0.08
Total Sponge	**1.23**	**0.18**

Table 3.4.1. Percent cover of benthic categories at Geyer Bank from 30- to 36.5-m depth (continued).

GEYER BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
TURF ALGAE		
Total Turf Algae	**3.18**	**0.81**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	0.08	0.04
Dictyota spp.	2.68	0.43
Lobophora variegata	12.65	0.90
Padina spp.	0.03	0.03
Sargassum spp.	26.88	3.38
Total Brown Macroalgae	**42.30**	**3.90**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Fish	0.23	0.10
Total Other Live	**0.23**	**0.10**
CORALLINE ALGAE		
Total Coralline Algae	**3.43**	**0.53**
FINE TURF, BARE		
Rubble	13.70	2.46
TB	24.10	2.07
Total TB and Rubble	**37.80**	**2.91**
SAND		
Total Sand	**1.83**	**0.54**
UNKNOWNS		
Total Unknown	**0.13**	**0.04**
Total Live Cover	**60.25**	
TOTAL	**100.0**	

45- to 50-m Depth

Live cover was ~30% at Geyer Bank in the 45- to 50-m (148- to 164-ft) depth range (Figure 3.1.1). Brown macroalgae was still the dominant taxonomic group, but decreased to ~22% (Figure 3.4.1; Table 3.4.2). Rubble and bare space increased to 63% in this depth range. No obvious signs of hurricane damage were documented.

55- to 60-m Depth

Live cover was ~35% in the 55- to 60-m (180- to 197-ft) depth range (Figure 3.1.1). Turf algae and coralline algae were higher than in 45-50 m (148-164 ft), accounting for the difference in live cover (Figure 3.4.1; Table 3.4.3). No obvious signs of hurricane damage were documented.

Table 3.4.2.

Percent cover of benthic categories at Geyer Bank from 45- to 50-m depth. No samples of red or green macroalgae were identified.

GEYER BANK 45-50 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Millepora alcicornis	2.20	0.92
Unidentified Scleractinia	0.10	0.06
Stephanocoenia intersepta	0.20	0.14
Total Coral	**2.50**	**0.77**
ANTIPATHARIANS		
Stichopathes sp.	0.10	0.10
Total Antipatharian	**0.10**	**0.10**
SPONGES		
Agelas clathrodes	1.30	0.62
Unidentified Sponges	1.55	0.76
Xestospongia muta	0.65	0.39
Total Sponge	**3.50**	**1.37**
TURF ALGAE		
Total Turf Algae	**0.65**	**0.33**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	8.35	1.21
Dictyota spp.	8.30	1.01
Lobophora variegata	0.85	0.47
Padina spp.	0.05	0.05
Sargassum spp.	4.90	0.83
Total Brown Macroalgae	**22.45**	**0.81**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Total Green Macroalgae	**0.00**	**0.00**
OTHER LIVE		
Fish	0.35	0.17
Total Other Live	**0.35**	**0.17**
CORALLINE ALGAE		
Total Coralline Algae	**0.80**	**0.73**
FINE TURF, BARE		
Rubble	32.30	2.27
TB	31.05	2.98
Total TB and Rubble	**63.35**	**2.63**
SAND		
Total Sand	**6.25**	**1.77**
UNKNOWNS		
Total Unknown	**0.05**	**0.05**
Total Live Cover	**30.35**	
TOTAL	**100.00**	

Table 3.4.3.

Percent cover of benthic categories at Geyer Bank from 55- to 60-m depth. No samples of antipatharians or red macroalgae were identified.

GEYER BANK 55-60 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Millepora alcicornis	0.11	0.07
Unidentified Scleractinia	0.03	0.03
Stephanocoenia intersepta	0.06	0.04
Total Coral	**0.20**	**0.10**
ANTIPATHARIANS		
Total Antipatharian	**0.00**	**0.00**
SPONGES		
Agelas clathrodes	0.71	0.31
Unidentified Sponges	1.17	0.30
Xestospongia muta	0.66	0.33
Total Sponge	**2.54**	**0.63**
TURF ALGAE		
Total Turf Algae	**3.94**	**1.12**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	5.97	1.90
Dictyota spp.	15.23	4.24
Lobophora variegata	0.14	0.07
Sargassum spp.	0.23	0.20
Total Brown Macroalgae	**21.57**	**4.96**
RED MACROALGAE		
Total Red Macroalgae	**0.00**	**0.00**
GREEN MACROALGAE		
Green Macroalgae	0.20	0.12
Total Green Macroalgae	**0.20**	**0.12**
OTHER LIVE		
Fish	0.37	0.23
Gastropoda	0.03	0.03
Total Other Live	**0.40**	**0.23**
CORALLINE ALGAE		
Total Coralline Algae	**5.74**	**1.39**
FINE TURF, BARE		
Rubble	43.34	7.56
TB	11.69	1.91
Total TB and Rubble	**55.03**	**6.77**
SAND		
Total Sand	**10.09**	**0.66**
UNKNOWNS		
Total Unknown	**0.29**	**0.07**
Total Live Cover	**34.60**	
TOTAL	**100.0**	

3.5. Bright Bank

Bright Bank was dominated by brown and green macroalgae, turf algae, TB, corals, and coralline algae. A complete list of taxa identified in the video footage is provided with percent cover by depth range in Appendix 1.

Diver video taken in September 2003 from Bright Bank provided qualitative information about the benthic community at that time (Moore 2003b). Macroalgal cover was low and *Lobophora variegata* was the only macroalgal species identifiable in 2003. The substratum videotaped was mostly bare (Figure 3.5.1). Large colonies of *Millepora alcicornis* and *Diploria strigosa* were observed. Sponge species included *Agelas clathrodes*, *Ircinia* spp., and *Xestospongia muta*.

The ROV data were not collected at this bank due to weather. This limited the data collected to diver depths which covered only the 30- to 36.5-m (98- to 120-ft) depth range.

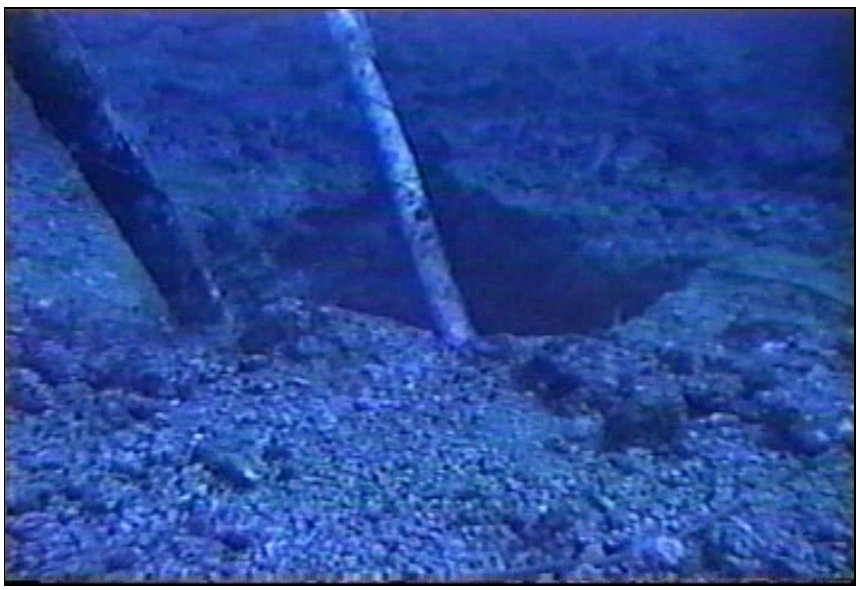


Figure 3.5.1. Captured frame from video recorded at Bright Bank in September 2003 at 36-m depth. Poles in photograph are thought to be part of salvage operations that have occurred at Bright Bank.

30- to 36.5-m Depth

In this depth range, live cover at Bright Bank was ~86%, with brown, green, and turf algae as the dominant groups (Figure 3.1.1; Figure 3.5.2; Figure 3.5.3; Table 3.5.1). Coral cover was ~8% and was comprised of four species, which in order of decreasing cover were *Millepora alcicornis, Diploria strigosa, Stephanocoenia intersepta,* and *Montastraea cavernosa* (Table 3.5.1; Appendix 2). No obvious signs of hurricane damage were documented.

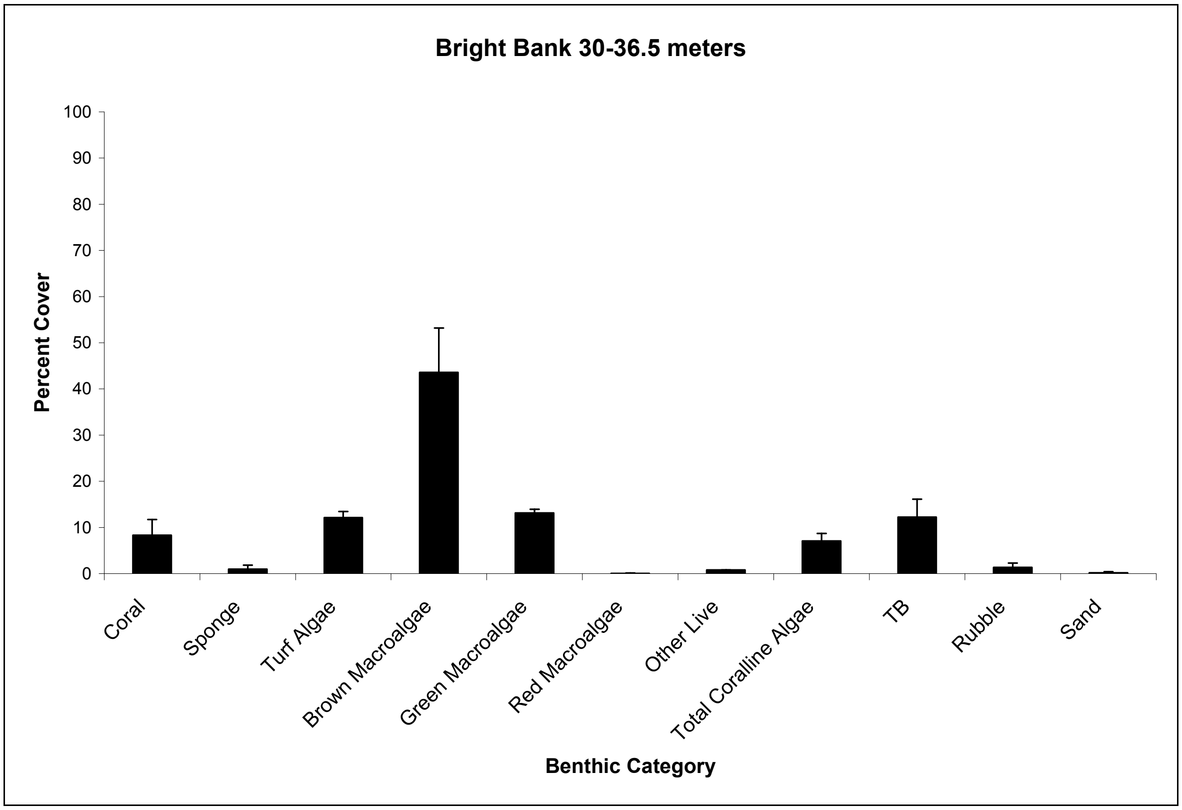


Figure 3.5.2. Percent cover of benthic categories at Bright Bank. Error bars represent one standard error.

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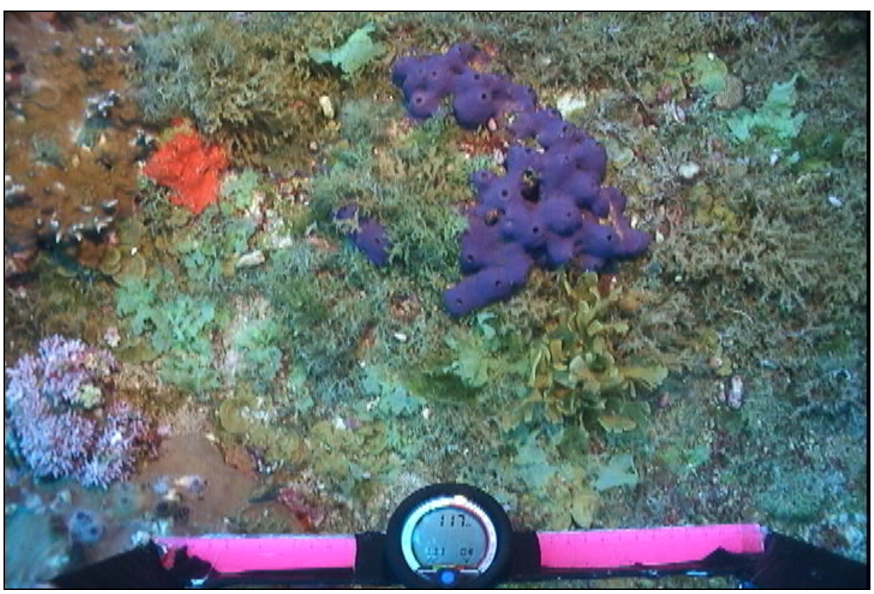


Figure 3.5.3. Frame capture showing diverse benthic cover at Bright Bank in 30- to 36.5-m depth.

Table 3.5.1.

Percent cover of benthic categories at Bright Bank from 30- to 36.5-m depth. No samples of antipatharians were identified.

BRIGHT BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
CORAL		
Diploria strigosa	0.87	0.87
Millepora alcicornis	6.93	2.38
Montastraea cavernosa	0.07	0.07
Stephanocoenia intersepta	0.47	0.29
Total Coral	**8.33**	**3.38**
ANTIPATHARIANS		
Total Antipatharians	**0.00**	**0.00**
SPONGES		
Agelas clathrodes	0.27	0.13
Clathria spp.	0.20	0.20
Spheciospongia sp.	0.07	0.07
Unidentified Sponges	0.13	0.13
Xestospongia muta	0.33	0.33
Total Sponge	**1.00**	**0.81**
TURF ALGAE		
Total Turf Algae	**12.13**	**1.33**
BROWN MACROALGAE		
Unidentified Brown Macroalgae	28.13	6.29
Dictyota spp.	0.33	0.18
Lobophora variegata	14.20	3.53
Padina spp.	0.13	0.07
Sargassum spp.	0.80	0.61
Total Brown Macroalgae	**43.60**	**9.62**
RED MACROALGAE		
Red Macroalgae	0.07	0.07
Total Red Macroalgae	**0.07**	**0.07**
GREEN MACROALGAE		
Green Macroalgae	13.13	0.82
Total Green Macroalgae	**13.13**	**0.82**
OTHER LIVE		
Fish	0.73	0.07
Gastropoda	0.07	0.07
Total Other Live	**0.80**	**0.00**
CORALLINE ALGAE		
Total Coralline Algae	**7.07**	**1.62**
FINE TURF, BARE		
Rubble	1.33	0.93
TB	12.27	3.88
Total TB and Rubble	**13.60**	**4.77**

Table 3.5.1. Percent cover of benthic categories at Bright Bank from 30- to 36.5-m depth (continued).

BRIGHT BANK 30-36.5 METERS		
	Mean Percent Cover	**Standard Error**
SAND		
Total Sand	**0.20**	**0.20**
UNKNOWNS		
Total Unknown	**0.07**	**0.07**
Total Live Cover	**86.13**	
TOTAL	**100.00**	

3.6. Shannon-Wiener Diversity Index (H')

The Shannon-Wiener Diversity Index, H', was calculated for each bank at each depth using the lowest available taxonomic groupings (species or genera). The highest diversity found was at Sonnier Bank from 22-27 m (72-89 ft), due largely to the variety of sponges present there. Diversity decreased with depth at Sonnier Bank (Table 3.6.1). Both Geyer and McGrail Banks exhibited highest diversity values in the 45- to 50-m (148- to 164-ft) depth range. The brown macroalgae accounted for these high diversity values. Notably, diversity at 45-50 m (148-164 ft) was very low at Sonnier Bank compared to Geyer and McGrail Banks. Brown algae distinguishable to genus or species were virtually absent from Sonnier Bank between 45-50 m (148-164 ft). Turf algae, rubble, and sand were the dominant categories at Sonnier Bank from 55-60 m (180-197 ft), accounting for the zero-value of H' in that depth range.

Table 3.6.1.

Shannon-Wiener Diversities (H') at all banks and depths surveyed.

	Bank				
Depth	**Sonnier**	**Geyer**	**McGrail**	**Bright**	**EFGB**
22-27	2.86	–	–	–	2.43
30-36.5	1.55	1.65	–	1.81	2.27
45-50	0.23	2.13	2.08	–	–
55-60	0*	1.47	0.83	–	–
* only turf algae, rubble and sand					

3.7. Multivariate Statistical Results

3.7.1. ANOSIM Analysis

All Sites and Depths (excluding 22- to 27-m dataset)

The lowest taxonomic levels of benthic cover category data including corals, antipatharians, sponges, turf algae (>3-mm), brown macroalgae, green macroalgae, red (non-coralline) macroalgae, crustose coralline algae, "other live" (which consisted of fish, mollusks, and any other living organism that did not fall within one of the above categories), rubble, TB (fine turfs <3-mm and bare space), sand, and unknown were analyzed using multivariate techniques.

One-way Analysis of Similarity (ANOSIM) with site as factor showed that there were significant among-site differences (Global $R = 0.54$, $P = 0.001$). Pairwise tests showed differences between each possible pair of banks (Table 3.7.1). McGrail and Bright Banks were the most dissimilar banks ($R = 0.926$, $P = 0.003$), whereas Geyer and Sonnier Banks were the least dissimilar ($R = 0.318$, $P = 0.001$).

Table 3.7.1.

Results of Pairwise ANOSIM tests with site as the factor.
The closer *R* is to 1, the more dissimilarity between treatments.

Groups	*R*-Statistic	Significance Level	Possible Permutations	Actual Permutations	Number ≥ Observed
McGrail, Bright	0.926	0.003	1771	999	2
McGrail, Geyer	0.691	0.001	Very Large	999	0
McGrail, Sonnier	0.516	0.001	Very Large	999	0
Bright, Geyer	0.734	0.002	1540	999	1
Bright, Sonnier	0.71	0.002	2600	999	1
Geyer, Sonnier	0.318	0.001	Very Large	999	0

One-way ANOSIM was also conducted with depth as the factor. A significant difference was found among depths (Global $R = 0.37$, $P = 0.001$). Pairwise tests showed differences between depths, although depths were not as dissimilar as sites (Table 3.7.2). The 45- to 50-m (148- to 164-ft) and 55- to 60-m (180- to 197-ft) depth ranges were less dissimilar than the dissimilarities between 30-36.5 m (98-120 ft) and 55-60 m, and between 30-36.5 m and 45-50 m (Table 3.7.2). In fact, adjustment of the α-value, to maintain an overall type-I error rate of 0.05, renders the comparison between 45-50 m and 55-60 m non-significant.

Table 3.7.2.

Results of Pairwise ANOSIM tests with depth as the factor.
The closer *R* is to 1, the greater the dissimilarity is between treatments.

Groups (m)	*R*-Statistic	Significance Level	Possible Permutations	Actual Permutations	Number ≥ Observed
45-50/ 30-36.5	0.499	0.001	Very Large	999	0
45-50/ 55-60	0.065	0.05	Very Large	999	49
30-36.5/ 55-60	0.584	0.001	Very Large	999	0

A Two-Way Crossed Analysis was conducted with site and depth as factors. The results showed significant differences among sites across depths (Global $R = 0.9$, $P = 0.001$), as well as differences among depth ranges across sites ($R = 0.77$, $P = 0.001$).

Pairwise tests showed that Bright Bank was most different from Geyer and Sonnier Banks (Table 3.7.3). Pairwise tests between Bright and McGrail Banks were not possible because data did not exist for McGrail Bank from 30-36.5 m (98-120 ft).

Table 3.7.3.

Results of Pairwise ANOSIM tests for differences between sites across all depths. The closer *R* is to 1, the greater the dissimilarity is between treatments.

Groups	***R*-Statistic**	**Significance Level**	**Possible Permutations**	**Actual Permutations**	**Number ≥ Observed**
McGrail/Geyer	0.799	0.001	11711700	999	0
McGrail/ Sonnier	0.866	0.001	151315164	999	0
Bright/Geyer	1	0.006	165	165	1
Bright/Sonnier	1	0.006	165	165	1
Geyer/Sonnier	0.995	0.001	Very Large	199	0

Differences between depth groups were most evident between the 30- to 36.5-m (98- to 120-ft) and 55- to 60-m (180- to 197-ft) depth ranges and between the 45- to 50-m (148- to 164-ft) and 30- to 36.5-m depth ranges. The 45- to 50-m and 55- to 60-m comparison showed more similarity between these depth ranges with respect to benthic composition (Table 3.7.4).

Table 3.7.4.

Results of pairwise ANOSIM tests for differences between depths across all sites. The closer *R* is to 1, the greater the dissimilarity is between treatments.

Groups (m)	***R*-Statistic**	**Significance Level**	**Possible Permutations**	**Actual Permutations**	**Number ≥ Observed**
45-50/ 30-36.5	0.993	0.001	3185325	999	0
45-50/ 55-60	0.609	0.001	Very Large	999	0
30-36.5/ 55-60	0.996	0.001	19324305	999	0

3.7.2. MDS Analysis

Multidimensional scaling (MDS) highlighted the dissimilarities among banks, with depths within sites grouping more closely (Figure 3.7.2). The stress level was low at 0.05, indicating high confidence in the relationships displayed. MDS plots showed transect-level data also grouped, with distinct clusters being formed within depth zones (Figure 3.7.3). McGrail Bank Transect 6 (M46) at 45-50 m (148-164 ft) lies by itself (Figure 3.7.3), due to the high percentage of

Stephanocoenia intersepta in that transect (31.6%). The stress level of 0.13 indicates less confidence in the relationships than in Figure 3.7.2.

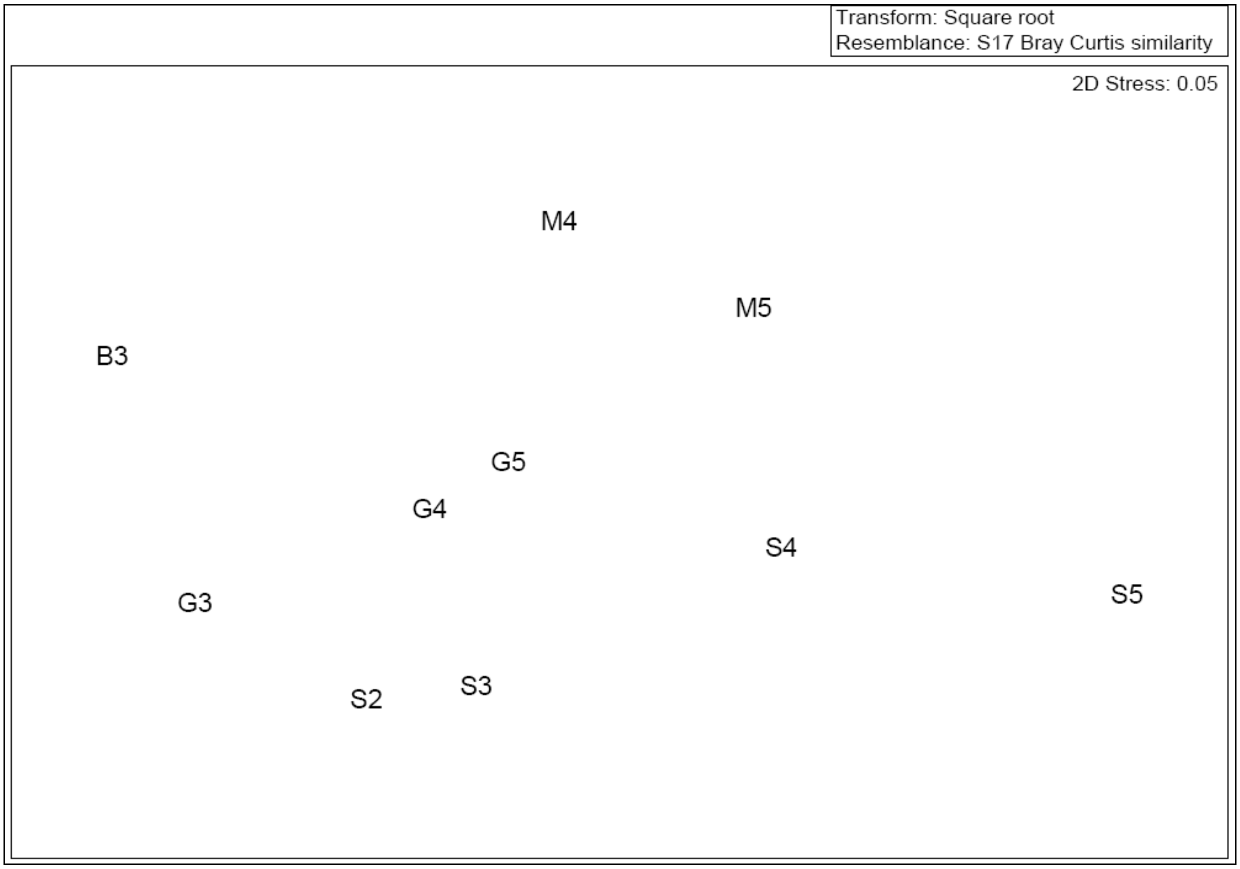


Figure 3.7.2. Two-dimensional MDS plot, based on square-root-transformed Bray-Curtis similarities, comparing multivariate benthic cover data among Sonnier, McGrail, Geyer, and Bright Banks at the depth ranges sampled. Data were pooled within depths at each site. Abbreviations: S2, Sonnier Bank 22-27 m; S3, Sonnier Bank 30-36.5 m; S4, Sonnier Bank 45-50 m; S5, Sonnier Bank 55-60 m; M4, McGrail Bank 45-50 m; M5, McGrail 55-60 m; G3, Geyer Bank 30-36.5 m; G4, Geyer Bank 45-50 m; G5, Geyer Bank 55-60 m; B3, Bright Bank 30-36.5 m.

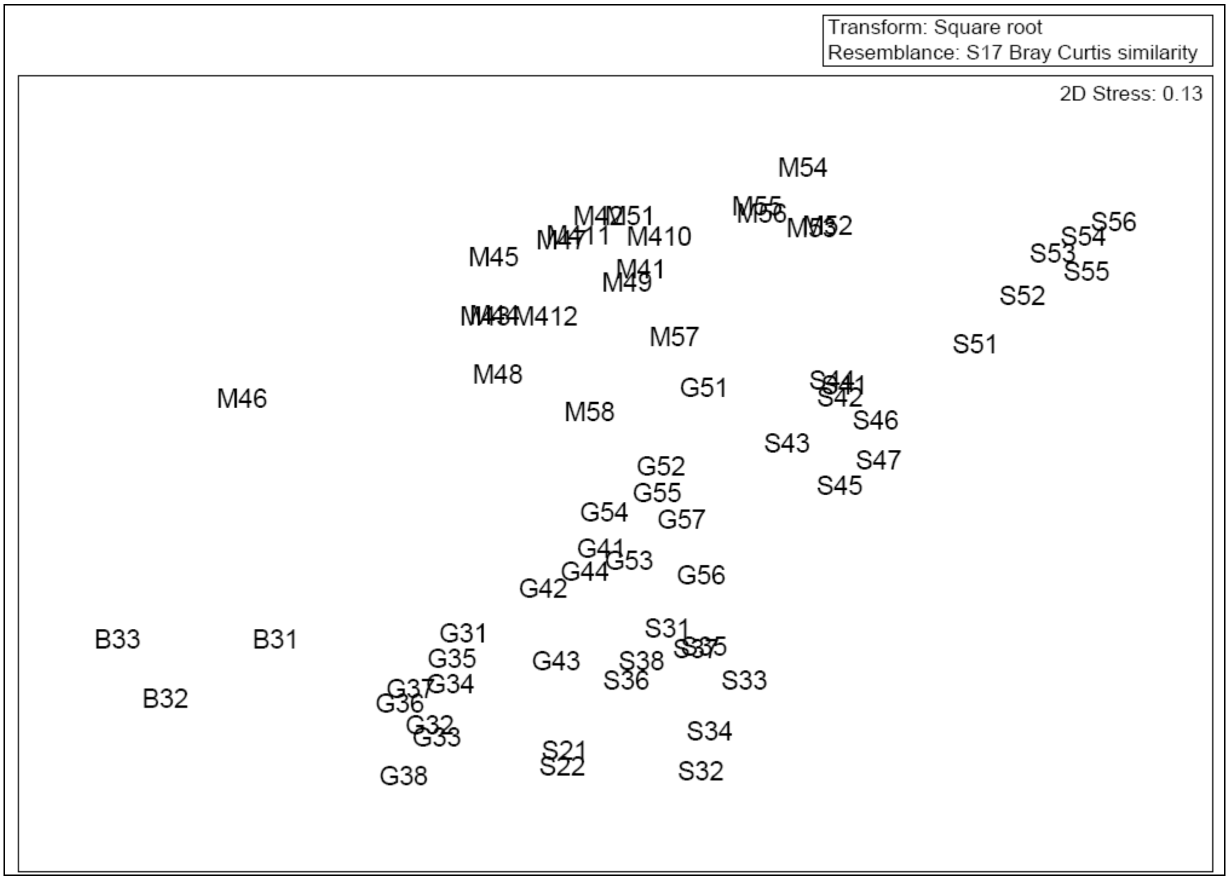


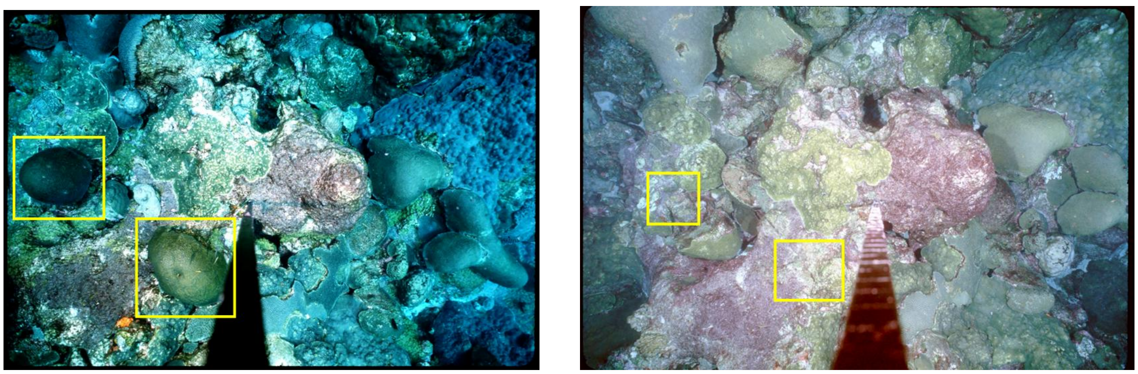
Figure 3.7.3. Two-dimensional MDS plot based on square-root-transformed Bray-Curtis similarity comparing multivariate benthic cover data between Sonnier, McGrail, Geyer, and Bright Banks by transect. Abbreviations were as follows. The first letter stands for the bank (see caption for Figure 3.7.2), and the first number stands for the depth range: 2= 22-27 m, 3= 30-36.5 m, 4= 45-50 m, 5= 55-60 m. The second number is the transect number at that depth (e.g., S21, Sonnier Bank between 22-27 m, transect 1).

3.8. EAST FLOWER GARDEN BANK REPETITIVE QUADRAT DATA

3.8.1. Study Site Repetitive Quadrat Percent Cover Data

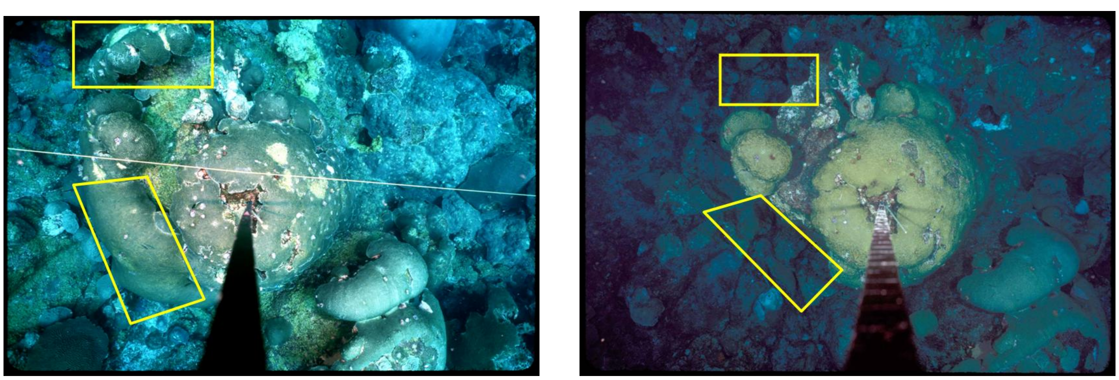
Forty repetitive quadrats (8-m^2) were photographed at the EFGB in November 2005 during the post-hurricane assessment effort, and 39 repetitive quadrat photographs were taken during the annual monitoring in June 2006. Hard coral cover within the repetitive quadrats was stable between November 2005 and June 2006 at 61.34% ± 2.75 SE and 62.87% ± 2.32 SE, respectively. Macroalgal cover increased from November 2005 to June 2006 by ~5.4%, while CTB decreased by~6.9%. Species abundance showed stability with *Montastraea annularis* species complex, *Diploria strigosa*, *Porites astreoides* and *M. cavernosa* as the four dominant species. Appendix 3 presents repetitive quadrat percent cover categories for November 2005 and June 2006.

Approximately 1.5% of coral colonies photographed within repetitive quadrats at the EFGB were missing in November 2005, most likely due to the effects of Hurricane Rita. This did not noticeably affect estimates of coral cover. *Diploria strigosa*, *Porites astreoides*, and *Montastraea* spp. comprised the majority of missing coral colonies, with sizes ranging from 76.38-6498.76-cm^2 (Table 3.8.3). Examples of coral colonies that disappeared or were damaged between June and November 2005 are presented in Figures 3.8.1-3.8.3.



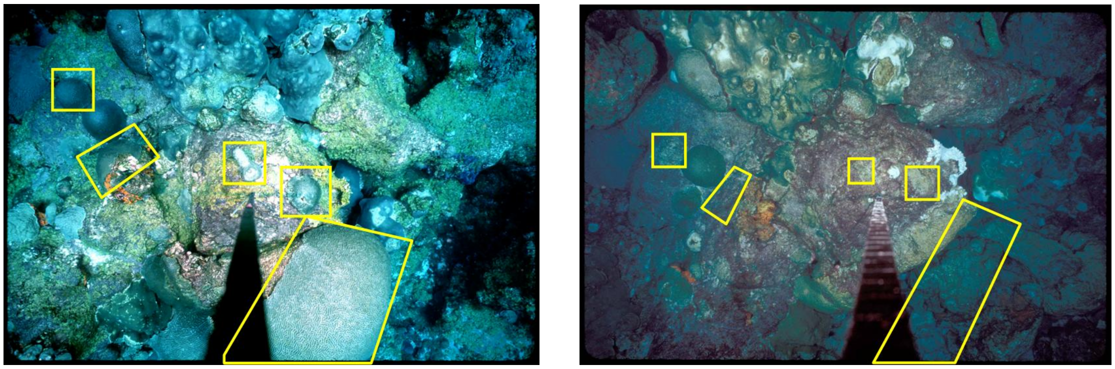
(A) (B)

Figure 3.8.1. (A) Photograph of repetitive quadrat station in June 2005 at the EFGB. (B) Photograph of matching repetitive quadrat station in November 2005. The yellow boxes highlight the locations of likely hurricane impacts.



(A) (B)

Figure 3.8.2. (A) Photograph of repetitive quadrat station in June 2005 at the EFGB. (B) Photograph of matching repetitive quadrat station in November 2005. The yellow boxes highlight the locations of likely hurricane impacts.



(A) (B)

Figure 3.8.3. (A) Photograph of repetitive quadrat station in June 2005 at the EFGB. (B) Photograph of matching repetitive quadrat station in November 2005. The yellow boxes highlight the locations of likely hurricane impacts.

The most noticeable difference between repetitive quadrat photographs at the EFGB in November 2005 and June 2006 was the level of bleaching: 9.74% ± 1.07 SE in November 2005 compared to 0.62% ± 0.24 in June 2006. Most bleaching was observed on colonies of *Montastraea annularis* species complex, *M. cavernosa*, and *Millepora alcicornis* (Table 3.8.1). Measurements of paling and fish biting were low at 1.5% or less, and disease was not observed (Table 3.8.2). The data from June 2006 showed a decrease in the amount of bleaching and paling compared to November 2005 and an increase in the amount of fish biting (Figure 3.8.4). Coral disease was absent from the analyzed photographs (Table 3.8.2). It should be noted that the identification of coral disease in photographs taken at a distance of 2-m from the substrate is unreliable (Zimmer, personal communication, 2005).

Table 3.8.1.

Percent cover by coral species of isolated fish biting (IFB), concentrated fish biting (CFB), paling (P), and bleaching (BL) at the EFGB in November 2005 and June 2006. Data are from random-dot analysis of repetitive quadrats.

Coral Species	EFGB November 2005				EFGB June 2006			
	IFB	**CFB**	**P**	**BL**	**IFB**	**CFB**	**P**	**BL**
Colpophyllia natans	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Diploria strigosa	0.000	0.000	0.126	0.173	0.000	0.000	0.000	0.096
Millepora alcicornis	0.000	0.000	0.000	1.131	0.000	0.000	0.000	0.303
Montastraea species complex	0.424	0.016	0.880	3.284	2.089	0.207	0.016	0.207
Montastraea annularis	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000
Montastraea cavernosa	0.000	0.000	0.471	4.808	0.016	0.000	0.000	0.016
Montastraea faveolata	0.016	0.000	0.079	0.581	0.080	0.032	0.000	0.016
Montastraea franksi	0.408	0.016	0.801	2.687	2.009	0.175	0.016	0.191
Porites astreoides	0.000	0.000	0.000	0.079	0.000	0.000	0.000	0.000
Unidentifiable Coral	0.000	0.000	0.000	0.267	0.000	0.000	0.000	0.000
Total	**0.424**	**0.016**	**1.477**	**9.741**	**2.105**	**0.207**	**0.016**	**0.622**

Table 3.8.2.

Percent cover (±SE) of paling, bleaching, concentrated fish biting, isolated fish biting, and disease at the EFGB in November 2005 and June 2006.
Data are from random-dot analysis of repetitive quadrats.

Observation	EFGB November 2005	EFGB June 2006
Paling	1.48 ± 0.39	0.02 ± 0.01
Bleaching	9.74 ± 1.07	0.62 ± 0.24
Concentrated Fish Biting	0.02 ± 0.01	0.21 ± 0.07
Isolated Fish Biting	0.42 ± 0.09	2.1 ± 0.30
Disease	0	0

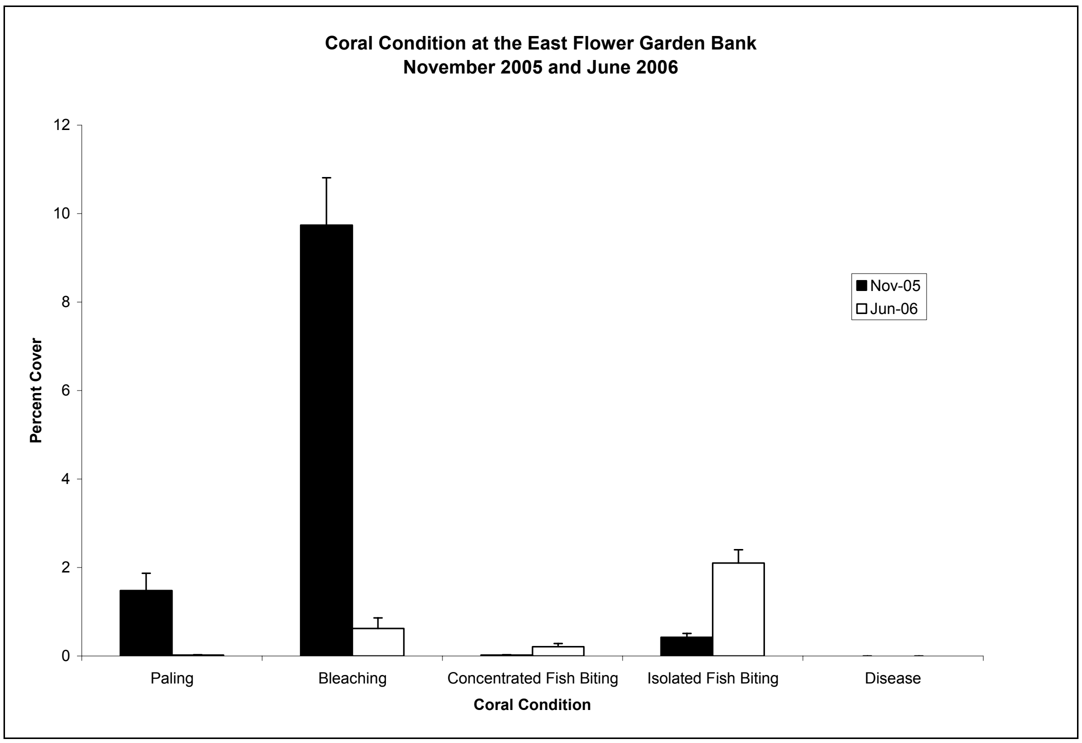


Figure 3.8.4. Percent cover of coral-condition categories. Error bars represent one standard error.

3.8.2. Study Site Repetitive Quadrat Planimetry

Planimetry data from the repetitive quadrats showed stability in lateral growth of the *Montastraea annularis* species complex from June 2005 to November 2005 and from November 2005 to June 2006 (Figure 3.8.5). Appendix 4 contains the planimetry data for coral colonies in the repetitive quadrats from June 2005-June 2006.

Twenty-one coral heads from the 40 repetitive quadrats (8-m^2) photographed were removed between June 2005 and November 2005. Measurements of all missing corals were made from

June 2005 photographs to obtain a total area of living coral that had been lost. An estimated total area of ~3-m^2 of coral was removed from the repetitive quadrat stations between June and November 2005 (Table 3.8.3). This represents a loss of ~1.5% of coral colonies photographed within repetitive quadrat stations at the EFGB, most likely due to the effects of Hurricane Rita.

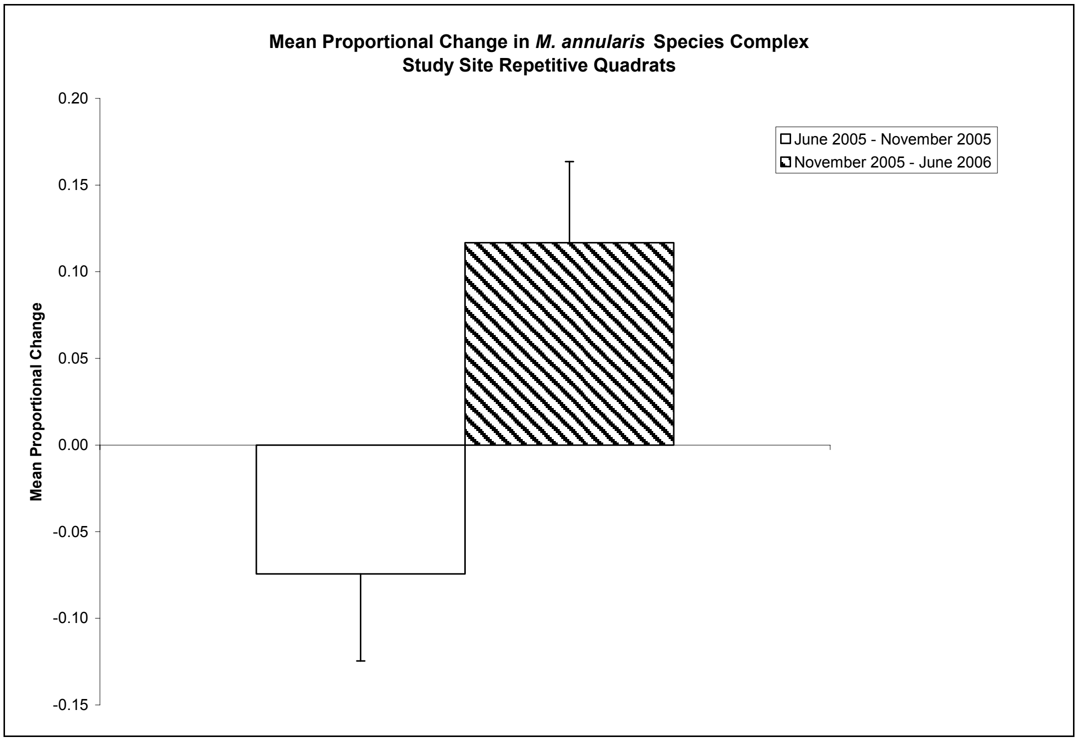


Figure 3.8.5. Mean proportional change in the planar tissue area of *Montastraea annularis* species complex within repetitive quadrat stations at the EFGB between June 2005 and November 2005, and between November 2005 and June 2006. Error bars represent one standard error.

3.8.3. Deep Station Repetitive Quadrat Percent Cover Data

Nine deep stations were analyzed from November 2005 repetitive quadrat (8-m^2) photographs, revealing that 2 coral colonies (0.5% of coral colonies photographed at the deep stations) were missing. Analysis of the deep quadrats revealed less bleaching than in the shallower quadrats in November 2005 (3.05% vs. 9.74%). In 2006, bleaching in the deep station quadrats decreased nearly to zero (0.24%), whereas fish biting increased during the same period (Figure 3.8.6).

Table 3.8.3.

Area of coral colonies missing in November 2005 photographs at the EFGB. Asterisks (*) indicate coral colonies that were not used during the planimetry analysis.

Repetitive Quadrat Station #	**Coral Species**	**Area (cm^2)**	**Area (m^2)**
3	*Diploria strigosa*	2614.25	0.26
4	*Diploria strigosa*	1290.08	0.13
7	*Montastraea sp.*	566.48	0.06
	Porites astreoides	76.38	0.01
	Diploria strigosa	254.46	0.03
14b	*Diploria strigosa* *	6498.76	0.65
	Diploria strigosa	582.75	0.06
18	*Madracis decactis* *	1507.98	0.15
	Porites astreoides *	461.67	0.05
20b	*Montastraea sp*	1335.54	0.13
21b	*Diploria strigosa* *	667.53	0.07
22	*Porites astreoides* *	246.25	0.02
	Porites astreoides *	113.94	0.01
26	*Diploria strigosa*	1669.04	0.17
29	*Diploria strigosa*	3576.90	0.36
	Diploria strigosa	1336.90	0.13
29b	*Diploria strigosa*	1102.40	0.11
30b	*Diploria strigosa*	5780.06	0.58
	Diploria strigosa	396.64	0.04
UNK1	*Diploria strigosa*	1706.04	0.17
UNK12	*Montastraea cavernosa* *	219.03	0.02
	Total	**32003.07**	**3.20**

3.9. Perimeter Videography

Corals observed along perimeter lines (east and north) at the EFGB in November 2005 showed evidence of hurricane impacts (i.e., dislodgement, loss, or deposition of entire coral heads; breaking of corals; and abrasion on the reef) that were not present in the June 2005 perimeter video. Most distressed corals observed in June 2005 were affected by fish biting, with fewer incidences of paling and bleaching. Increased levels of coral stress, manifested as paling and bleaching, were documented in November 2005. The footage from June 2006 showed lower levels of paling and bleaching and an increase in fish biting compared to November 2005. No evidence of disease was observed in June 2005, November 2005, or June 2006 along perimeter lines. Despite hurricane damage and moderate levels of corals stress, the coral population at the EFGB is stable and healthy.

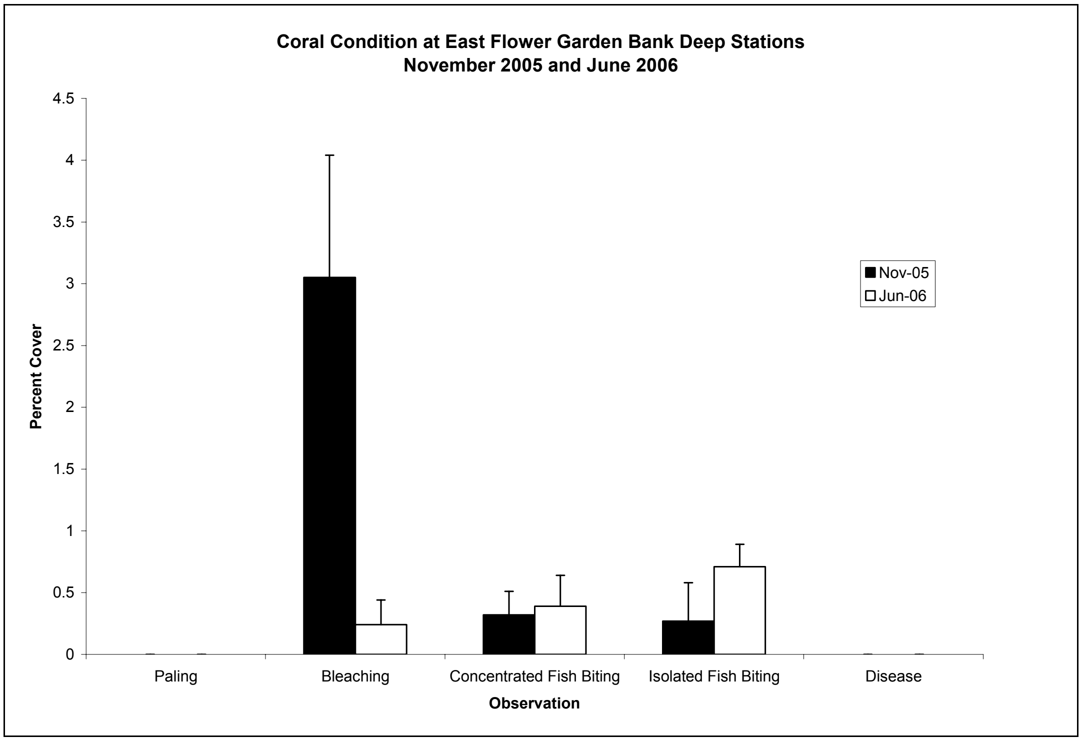


Figure 3.8.6. Coral condition at the EFGB deep stations in November 2005 and June 2006. Error bars represent one standard error.

3.9.1. Perimeter Lines

No incidences of disease were observed at the EFGB in November 2005. Concentrated fish biting was documented on two colonies, isolated fish biting on five colonies, paling on three colonies, and bleaching on 40 colonies along the north and east perimeter lines in November 2005. *Montastraea franksi* and *M. cavernosa* were the two coral species most affected (Table 3.9.1).

In June 2006 no incidences of disease were observed at the EFGB. Stresses included concentrated fish biting in eight colonies, isolated fish biting in four colonies, paling in five colonies, and bleaching in 12 colonies. *Montastraea franksi* and *M. cavernosa* again were the two coral species most affected (Table 3.9.1).

3.9.2. East Flower Garden Bank 360° Panoramic Views

At the northwest corner of the study site, 16 coral colonies exhibited bleaching in November 2005. In June 2006, the majority of these colonies (11) appeared to have recovered from bleaching. The remaining colonies were still bleached (1), exhibited paling (1), or were replaced by turf algae (3) (Table 3.9.2).

Table 3.9.1.

Comparison of observations of the condition of individual coral colonies at the EFGB along perimeter lines and in 360º panoramic views between November 2005 (n = 815 colonies) and June 2006 (n = 736 colonies).
(CFB = Concentrated fish biting, IFB = Isolated fish biting, B = Bleaching, P = Paling, H = Healthy colony, IIFB = increased tissue loss due to isolated fish biting, GI = Growth infilling [tissue regrowth], U = Unchanged condition).

Number of Colonies	**Coral Species**	**EFGB November 2005**	**EFGB June 2006**
1	*Diploria strigosa*	P	H
3	*Diploria strigosa*	B	H
2	*Diploria strigosa*	H	CFB
1	*Diploria strigosa*	H	P
4	*Millepora alcicornis*	B	H
2	*Millepora alcicornis*	B	U
1	*Montastraea annularis*	B	H
2	*Montastraea annularis*	H	CFB
9	*Montastraea cavernosa*	B	H
4	*Montastraea cavernosa*	B	U
2	*Montastraea cavernosa*	B	P
3	*Montastraea faveolata*	B	H
1	*Montastraea faveolata*	H	P
1	*Montastraea faveolata*	H	CFB
1	*Montastraea faveolata*	P	H
2	*Montastraea franksi*	CFB	GI
11	*Montastraea franksi*	B	H
3	*Montastraea franksi*	IFB	IIFB
3	*Montastraea franksi*	H	B
1	*Montastraea franksi*	B	P
1	*Montastraea franksi*	P	H
3	*Montastraea franksi*	H	CFB
1	*Montastraea franksi*	H	IFB
2	*Montastraea franksi*	IFB	GI
3	*Porites astreoides*	H	B

Table 3.9.2.

Affected coral colonies at the northwest corner of the study site in November 2005 and June 2006.
(B = Bleaching, P = Paling, H = Healthy colony, T= turf algae, U = Unchanged condition)

Northwest Corner			
Number of Colonies	**Coral Species**	**EFGB November 2005**	**EFGB June 2006**
2	*Montastraea cavernosa*	B	H
3	Unidentifiable	B	H
3	*Montastraea franksi*	B	H
1	*Montastraea* sp.	B	U
1	*Diploria strigosa*	B	H
1	*Montastraea* sp.	B	P
3	*Millepora alcicornis*	B	T
1	*Millepora alcicornis*	B	H
1	*Colpophyllia natans*	B	H

At the northeast corner, several coral colonies exhibited bleaching, whereas only one colony exhibited isolated fish biting in November 2005 (Table 3.9.3). The northeast corner marker was not in place in November 2005 or June 2006. Therefore, the "corner" shifted from year to year and the same coral colonies were not videotaped. Table 3.9.3, therefore, underestimates the numbers of affected coral colonies at the northeast corner.

At the southeast corner, several coral colonies that exhibited bleaching in November 2005 appeared healthy in June 2006. A single, unidentifiable colony appeared healthy in November 2005 but exhibited paling in June 2006. Similar to the northeast corner, the southeast corner marker was missing in November 2005 and June 2006. Therefore the "corner" shifted from year to year and the same coral colonies were not videotaped. Table 3.9.4, therefore, underestimated the numbers of affected coral colonies at the southeast corner.

3.10. Results of Hydrodynamic Model Predictions

The REF/DIF model was run for Bright Bank, 47-mi (75-km) away from the track of Hurricane Rita to determine the potential effects of the bank on waves generated by the storm. Results of this modeling exercise showed that wave heights increased dramatically in the vicinity of the banks due to the large difference in water depth between the seabed and the summit of the bank. The model further showed that wave height, the distance from trough to crest, would have been highest directly over the peak of the bank. Per wave theory, the modeled bottom velocity is higher at the summit of the bank and decreases along the bank slope as depth increases.

As discussed in Section 2.7, the guidance provided by the modeling effort suggests that wave heights are potentially increased to just below the wave-breaking point in the vicinity of the banks. Therefore, the wave heights from the hindcast study were increased to just below breaking (approximately 60% of the water depth at each bank location) in order to estimate the water velocities induced by the waves on the banks. These transformed waves were then input into the Stream Function Wave Theory program, discussed in Section 2.7, to estimate water velocity.

At Sonnier Bank, the transformed significant wave height during the passage of Hurricane Rita was estimated as 43-ft (13-m) (Figure 3.10.1) and the maximum bottom velocity predicted was 4-m/s or ~8 knots (Table 3.10.1). Higher waves and water velocities may have occurred at deeper banks (Figure 3.10.2 A-D, Table 3.10.1).

Table 3.9.3.

Affected coral colonies at the northeast corner of the study site in November 2005 and June 2006.
(B = Bleaching, P = Paling, H = Healthy colony, IFB = isolated fish biting, GI = Growth infilling [tissue regrowth]).

Northeast Corner			
Number of Colonies	**Coral Species**	**EFGB November 2005**	**EFGB June 2006**
1	*Montastraea faveolata*	IFB	GI
2	*Diploria strigosa*	B	H
1	*Millepora alcicornis*	B	H
1	*Montastraea cavernosa*	B	H
2	*M. cavernosa*	B	P
1	*M. faveolata*	B	H
1	*Montastraea* spp.	B	H

Table 3.9.4.

Affected coral colonies at the southeast corner in November 2005 and June 2006.
(B = Bleaching, P = Paling, H = Healthy colony).

Southeast Corner			
Number of Colonies	**Coral Species**	**EFGB November 2005**	**EFGB June 2006**
2	*Montastraea franksi*	B	H
1	Unidentifiable	B	H
1	Unidentifiable	H	P

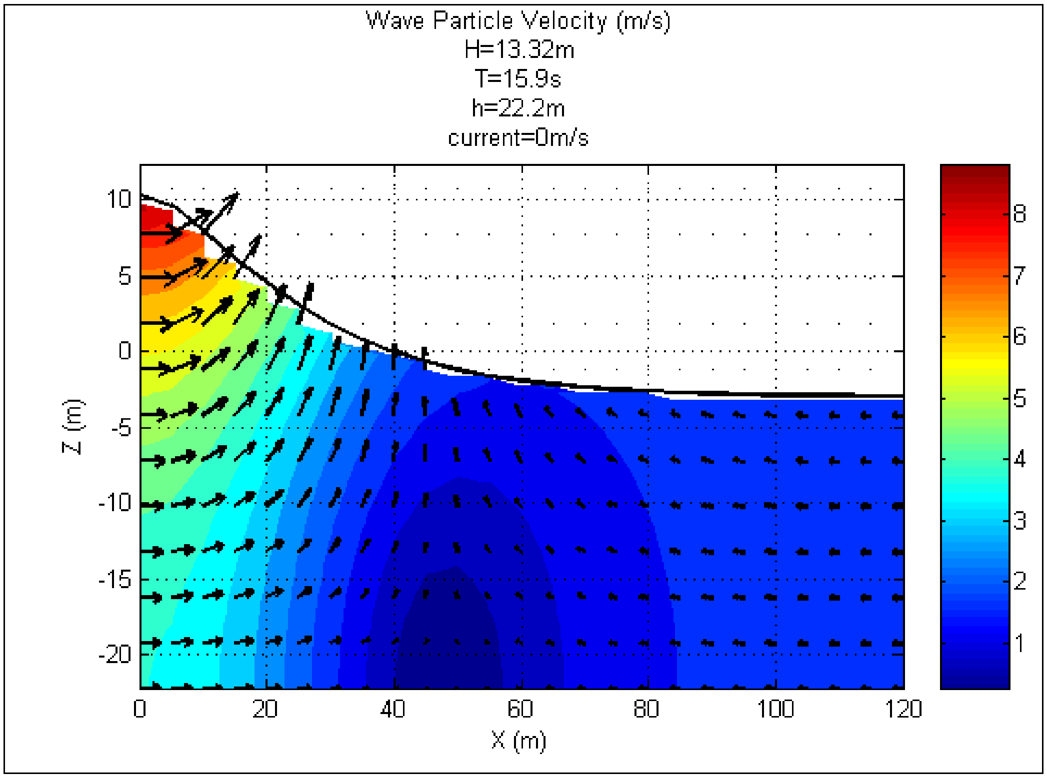
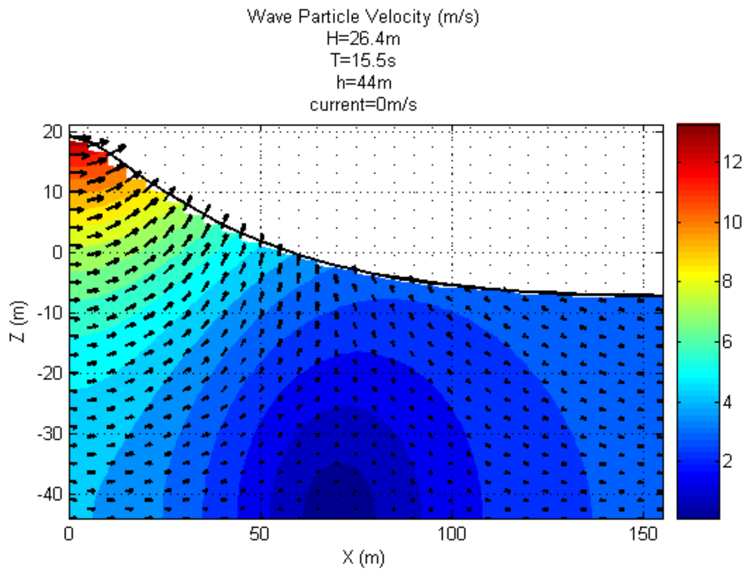
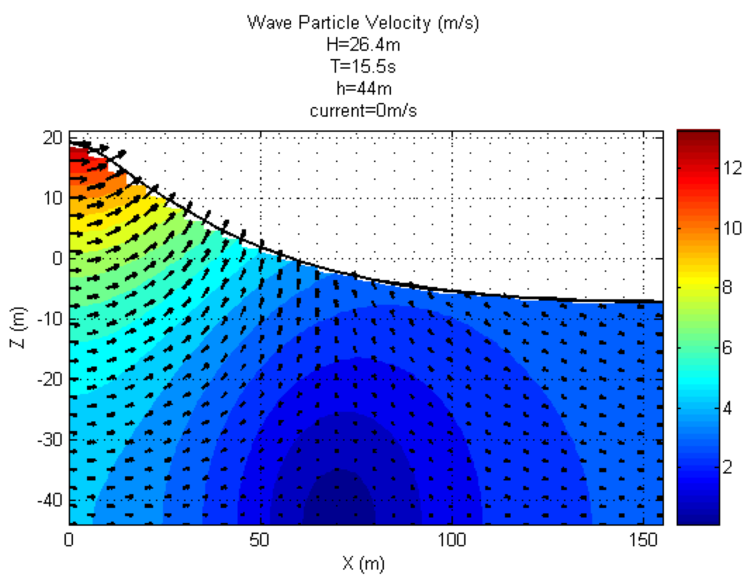


Figure 3.10.1. Predicted wave velocities at Sonnier Bank during passage of Hurricane Rita. The x-axis represents depth and the z-axis represents height above and below sea level. The maximum wave height (H) predicted by the hindcast is 60% of the depth (h) of the top of bank.

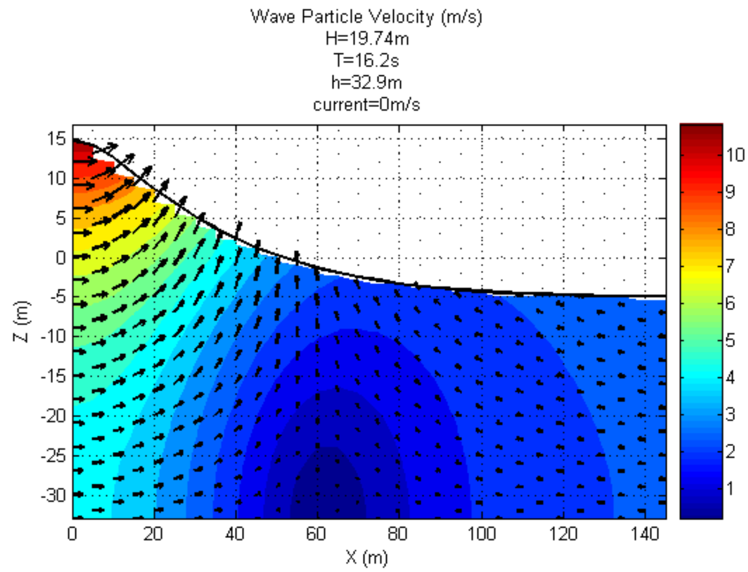


(A) McGrail Bank

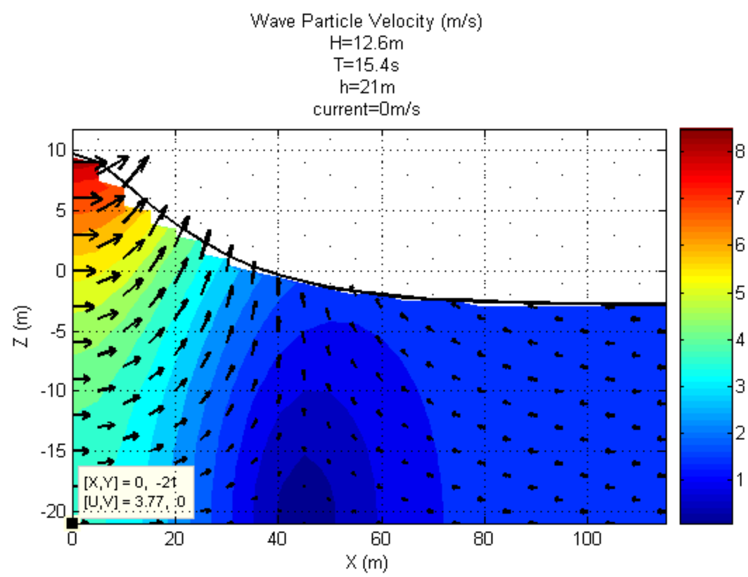


(B) Geyer Bank

Figure 3.10.2. Predicted wave velocities during passage of Hurricane Rita at (A) McGrail Bank, (B) Geyer Bank, (C) Bright Bank, and (D) EFGB. The x-axis represents depth and the z-axis represents height above and below sea level. The maximum wave height (H) predicted by the hindcast is 60% of the depth (h) of the top of bank.



(C) Bright Bank



(D) EFGB

Figure 3.10.2. Predicted wave velocities during passage of Hurricane Rita at (A) McGrail Bank, (B) Geyer Bank, (C) Bright Bank, and (D) EFGB. The x-axis represents depth and the z-axis represents height above and below sea level. The maximum wave height (H) predicted by the hindcast is 60% of the depth (h) of the top of bank (continued).

Table 3.10.1.

Maximum bottom velocities found using stream wave theory.
The maximum wave height (H) predicted by the hindcast is 60% of the depth (h) of the top of bank.

Bank	Maximum Bottom Velocity (m/s, H from hindcast)	Maximum Bottom Velocity (m/s, H = 0.6h)
Sonnier Bank	3.5	4
McGrail Bank	2.5	4
Geyer Bank	2	4
Bright Bank	2.5	4.5
EFGB	3.17	3.77

4.0 DISCUSSION

4.1. HURRICANE EFFECTS

The physical effects of hurricanes on shallow coral reefs have been well documented (Woodley et al. 1981; Rogers et al. 1991; Hughes and Connell 1999; Steneck and Lang 2003). Physical damage to shallow coral reefs can include breaking, smashing, tumbling, and scouring; the destruction of corals and other benthic organisms; and the removal of soft corals and algae (Woodley et al. 1981). Branching and plating corals are in particular jeopardy because of their delicate structure; however, many branching corals capitalize on disturbance for dispersal and asexual reproduction (Woodley et al. 1981; Highsmith 1982). In this way, hurricanes open large areas of substratum. These areas are quickly colonized by fast-growing filamentous algae and macroalgae to the exclusion of corals, which grow at a much slower rate (Woodley et al. 1981; Gardner et al. 2003). Subsequent to hurricane impacts, coral reefs have a greater rate of loss of coral cover than reefs that have not been impacted by hurricanes (Gardner et al. 2005).

The effects of hurricanes on deep coral reefs (18-40 m or 59-131 ft), such as the East and West Flower Garden Banks, which are dominated by large colonies of massive corals and few branching corals, have not been well documented; although, hurricane impacts at the EFGB in November 2005 are described by Precht et al. (2008a) and were anecdotally described in 1980 after Hurricane Allen (Combs, personal communication, 1989). Hurricane impacts observed at the EFGB in October 2005 included substantial mechanical damage, fractured and displaced corals, sediment-scoured corals, and corals scarred and dented by waterborne objects (Hickerson and Schmahl, personal communication, 2005).

Although the water depth of the banks provides some protection, bioeroded coral colonies remain susceptible to breakage and dispersal from the waves and high water velocities associated with hurricanes. At the EFGB, repetitive quadrat data collected in November 2005 showed that 62% of missing coral colonies were *Diploria strigosa*. *D. strigosa* colonies at the East and West Flower Garden Banks experience intense bioerosion, forming mushroom-shaped colonies (Figure 4.1.1). More research is needed to confirm this qualitative assessment of the susceptibility of *D. strigosa* to hurricane damage at the Flower Garden Banks.

4.1.1. Beneficial Aspects of Hurricanes on Coral Reefs

In contrast to the physically destructive aspects of hurricanes, cooling water temperatures associated with the passage of hurricanes has been shown to relieve coral bleaching and thereby benefit coral reefs (Manzello et al. 2007). During the summer of 2005, sea-surface temperatures were elevated (above average) in the Florida Reef Tract and the United States Virgin Islands (U.S.V.I.) (Manzello et al. 2007). Bleaching levels were similar on the Florida Reef and the U.S.V.I. through the end of September 2005. In October 2005, bleaching began to decline on the Florida Reef Tract due to Hurricane Rita and the cool water associated with the passage of that storm. Further cooling occurred on the Florida Reef Tract with the passage of Hurricane Wilma, which accelerated the recovery of bleached corals within ~2 weeks of its passage (Manzello et al.

2007). In contrast to the Florida Reef Tract, no hurricanes passed near the U.S.V.I. during the 2005 hurricane season and bleaching continued unabated. Bleaching in the U.S.V.I. corals lasted well into 2006 (Manzello et al. 2007).

Figure 4.1.1. Typical bioerosion pattern of *Diploria strigosa*, resulting in mushroom-shaped colony at the EFGB. Image courtesy of PBS&J.

Hurricane Rita brought cooler water temperatures to the EFGB in late September 2005 (Figure 4.1.2.). Sea temperatures had been near or above 30° C for approximately two months—from July 2005 until September 23 at 1933 hours local time - when temperature decreased abruptly by 1.5° C. However, Figure 4.1.2 does show that the temperature does climb back up and remains above the mean from previous years for several months. Due to the elevated temperatures, coral bleaching occurred at the Flower Garden Banks during the summer and fall of 2005. Bleaching surveys completed in October 2005 by FGBNMS showed 48% of corals surveyed were bleached or partially bleached (Hickerson, personal communication, 2005). Repetitive quadrat data collected at the EFGB in November 2005 showed that the percent cover of bleached coral was 9.74% ±1.07 SE. This is the highest level of bleaching recorded since the beginning of the long-term monitoring program (Gittings et al. 1992; Continental Shelf Associates Inc. 1996; Dokken et al. 1999; Dokken et al. 2001; Precht et al. 2006). Bleached corals at the EFGB had recovered by June 2006.

4.1.2. Hurricane Effects at Banks Not Dominated by Corals

Little is known about the effects of hurricanes on benthic communities not dominated by corals, such as those at Sonnier, McGrail, Geyer, and Bright Banks. This study suggests that hurricane impacts to algal and sponge dominated banks may be harder to detect more than a year after the hurricane has passed (20 months in this case). Since the passage of Hurricane Rita, algal communities have had time to re-grow and sponges may have healed/regenerated. Furthermore, corals, sponges, and other organisms that may have been removed from these banks during the hurricane were likely fractured and dispersed by the predicted water velocity of ~4-m/s or 8 knots on the reef cap, leaving little or no detectable remnants 20 months after the storm. Vast areas of rubble, documented at Sonnier Bank and at deeper depths on McGrail and Geyer Banks may have represented hurricane effects; however, this may not be the case as normal reef processes also create rubble zones on banks in the northwestern Gulf of Mexico (Rezak et al. 1985).

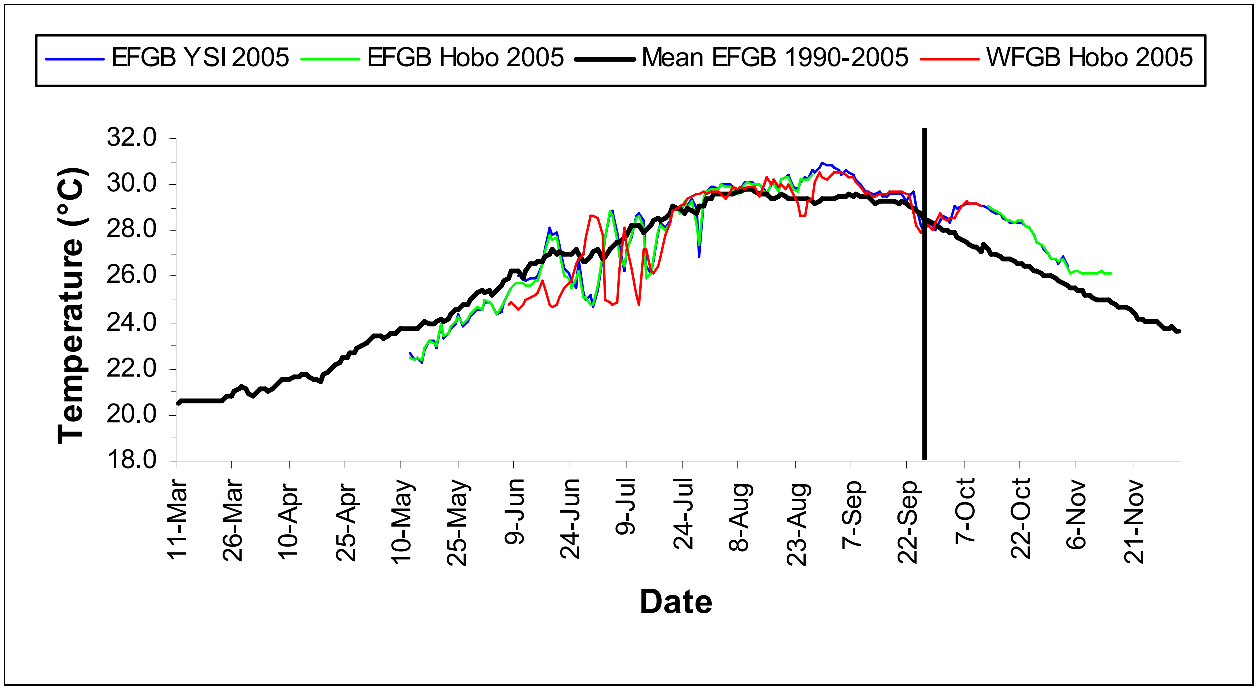


Figure 4.1.2. Water temperature at the Flower Garden Banks in 2005 and mean temperature at the EFGB from 1990 to 2005. Water temperature was measured using YSI 6600 Series datasondes (YSI) and HoboTemp recorders (Hobo). A vertical line drawn through the temperature profiles shows the timing of the passage of Hurricane Rita near the Flower Garden Banks (September 23, 2005). The 1990-1997 temperature data are from Gittings et al. 1992, Continental Shelf Associates 1996, and Dokken et al. 1999. The 1998-2005 data are from Dokken et al. 2003, Precht et al. 2006, and Precht et al. 2008b. Abbreviation: WFGB-West Flower Garden Bank.

4.1.3. Hydrodynamic Modeling Predictions

A wave study was conducted to better understand the wave and current conditions in the vicinity of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks during the passage of Hurricane Rita. A numerical modeling effort (REF/DIF model) was employed to assess the effects of generalized bank bathymetry on storm waves propagating over the banks. It is important to note that this model does not take into account any bank-specific geometry; rather, the model utilizes a simplified bank shape. In addition, wave kinematics were calculated using stream function wave theory to more accurately estimate the bottom current velocity on the banks. This analysis provided a predicted water velocity of ~4-m/s (~8 knots) at all banks included in this study.

Table 4.1.3.

Results of the hydrodynamic modeling effort in relation to bank depth and distance from the Hurricane Rita storm track.

Bank	Bank Depth (m)	Distance from Hurricane Rita storm track (km)	Maximum Bottom Velocity (m/s)	Maximum Wave Height at Top of Bank (m)
McGrail	45	12	4	26
Sonnier	22	24	4	13
Geyer	39	58	4	26
Bright	33	75	4.5	20
East Flower Garden Bank	18	93	3.77	13

The REF/DIF model wave height estimates (Table 4.1.3) represent the largest theoretical wave heights that may have occurred at each bank cap. Based on these results, larger wave heights may have occurred at banks with caps located in deeper water (i.e., McGrail and Geyer Banks). However, it is interesting to note that the analysis of transect video in this study did not show the greatest damages at McGrail and Geyer Banks, as might be expected by the results of the wave model. Furthermore, the shallowest banks included in this study (i.e., EFGB at 18-m and Sonnier Bank at 22-m depth) experienced the most observable damage, with qualitative observations of significant mechanical impacts at EFGB during post-hurricane assessments and the appearance of bare substrate and rubble fields in transect video from Sonnier Bank in 2007.

While one might assume that the greatest damage would likely occur at banks located closest to the storm track, the results of this study do not support this assumption. While McGrail Bank is located closest to the storm track (12-km or 7-mi), no hurricane damages were observed at this bank. Also, the significant damages were noted at the EFGB, which is the bank in this study located furthest from the storm track (93-km or 58-mi). Significant damages were also detected at Sonnier Bank, which is the only bank in this study located east of the Hurricane Rita storm track. It is common knowledge that the right side of a hurricane (relative to its direction of travel) is the most powerful portion of the storm in terms of wind speed and storm surge (USDOC, NOAA 1999). This may be a contributing reason for the damages observed at Sonnier Bank.

4.2. Benthic Characteristics and Hurricane Effects At Sonnier, McGrail, Geyer, and Bright Banks

Sonnier, McGrail, Geyer, and Bright Banks are characterized by unique biological communities, despite their geographic and oceanographic proximity (Figure 4.2.1). This study found that for these banks, within bank variability was lower than among bank variability. Variability among transects within a depth range was lower than the variability among depth ranges, which was less than variability among banks, as shown by the MDS plots in Section 3.7. These results suggest that the variability of the benthic communities is scale-dependent. Variability of coral reef assemblages has been shown to be scale-dependent by other researchers (O'Neill et al. 1986; Hatcher et al. 1987; Wiens 1989; Murdoch and Aronson 1999). The dissimilarity between Sonnier, McGrail, Geyer, and Bright Banks is likely related to the differing influences of oceanographic currents delivering propagules of benthic organisms (Lugo-Fernandez et al. 2001).

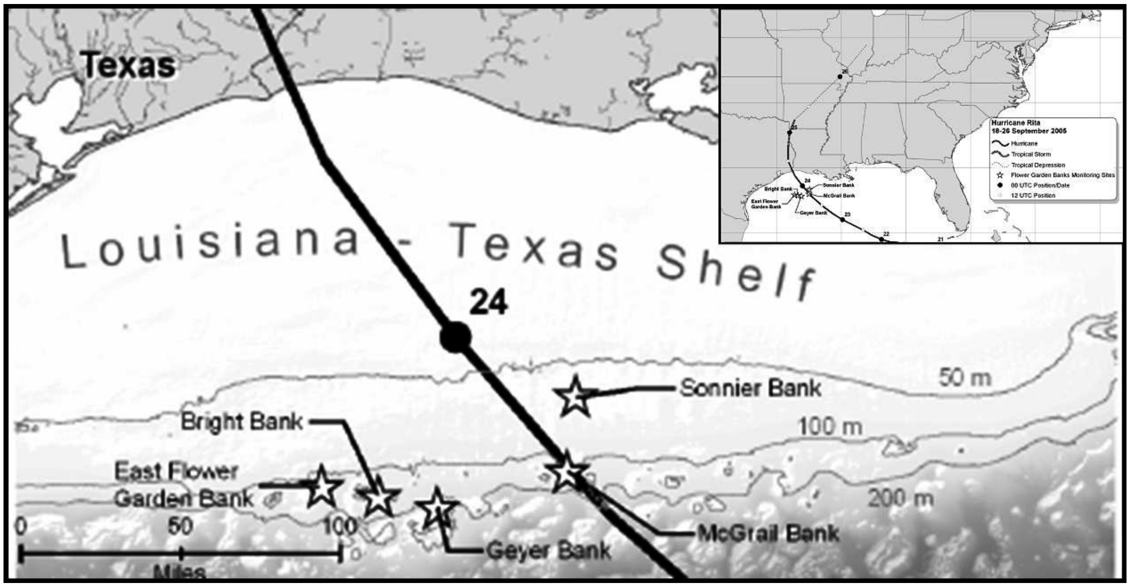


Figure 4.2.1. Location of Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks in the Gulf of Mexico. Black line shows the track of Hurricane Rita.

Observed and simulated drift studies conducted in 1993, 1997, and 1998 suggested that the distribution of coral larvae is driven by five modes in the Flower Garden Banks region (Lugo-Fernandez et al. 2001). Drifters released from the EFGB contacted 10 shallow topographic banks that are suitable for coral recruitment, based on their minimum depths being <180-ft (<55-m). The study showed that banks closest to the EFGB should have the highest coral cover because those close banks, which included McGrail, Geyer, Bright, and Sonnier Banks, were more likely to be contacted by drifters (simulated larvae) from the EFGB. The results of our study show that coral cover was indeed highest at Bright Bank (located ~25-km or ~16-mi east of the EFGB) and decreased in an eastward direction from Geyer (49.3-km or 31-mi), to McGrail (94.4-km or 59-mi), to Sonnier Bank (116.7-km or 73-mi) (Figure 4.2.2). Thus, our initial sampling of these banks supports the conclusions of Lugo-Fernandez et al. (2001). An additional bank that would be interesting to characterize from this standpoint is Rankin -1, which is 7-mi (11-km) from the EFGB and 171-ft (52-m) deep at its highest point. According to Lugo-Fernandez et al. (2001), and if the results of this study are correct, Rankin-1 should have higher coral cover than Bright Bank.

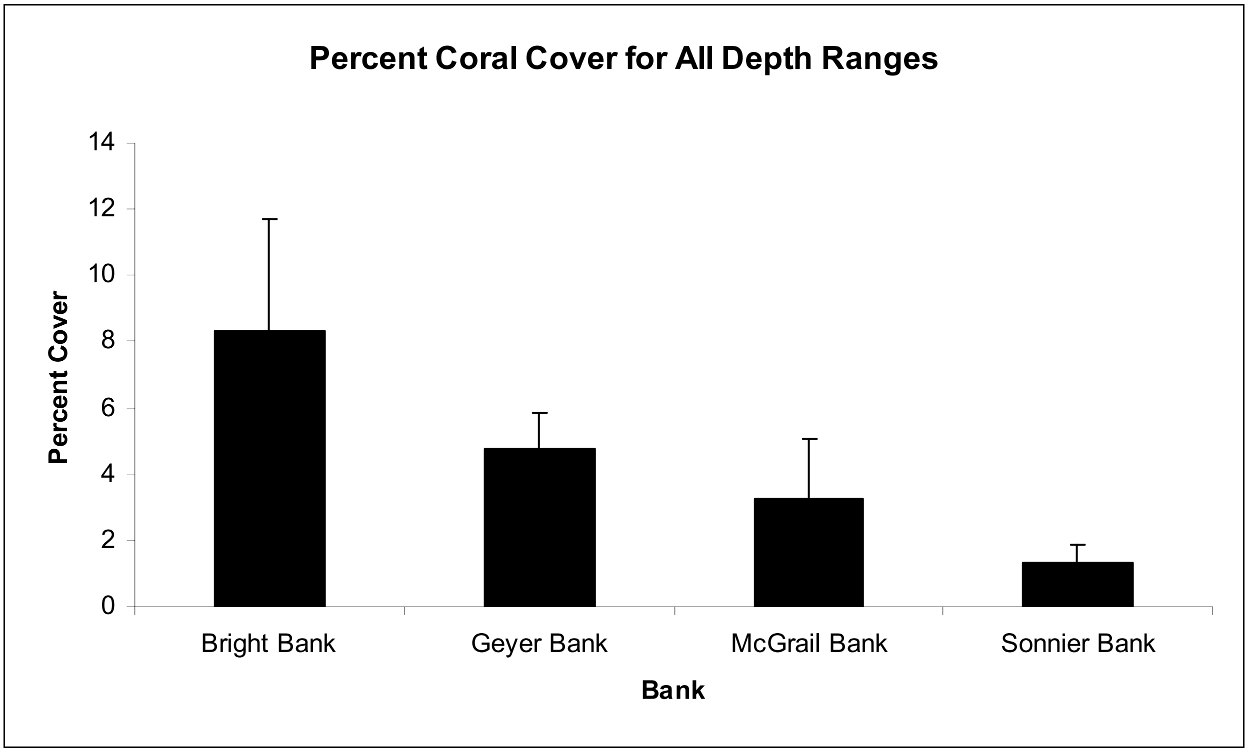


Figure 4.2.2. Total coral cover at each of four banks within the study, displayed from west to east. Error bars represent one standard error.

4.2.1. Sonnier Bank

As the shallowest bank located on the east side of the hurricane track, with hindcast water velocities up to 4-m/s (8-kn), and estimated waves up to 43-ft (13-m), Sonnier Bank likely sustained hurricane damage in late September 2005. Benthic survey results from 2007 showed that Sonnier Bank had lower live cover than any of the other banks in this study (Figure 3.1.1). At the shallowest depth (72-ft or 22-m) on Sonnier Bank, divers with previous experience at Sonnier Bank noted that the bank surface appeared very different from previous visits. Areas of bare bedrock appeared in places where live cover had been before (Hickerson, personal communication, 2007). Although they apparently were strongly affected by Hurricane Rita, algal and sponge populations at Sonnier Bank remain and if left undisturbed should recover to pre-hurricane conditions.

Qualitative analysis of diver video from the reef cap (22-27 m or 72-89 ft) at Sonnier Bank from 1996, 2002, and 2005 showed some differences in benthic cover compared to video taken in the same depth range in 2007. In 1996, video footage showed areas of Sonnier Bank covered with attached flora and fauna, mostly of algae and sponges. Common sponges were individuals of the genera *Neofibularia* and *Ircinia*. Notably, large *Xestospongia muta* colonies inhabited high points along the bank's ridge (Figure 3.2.1.A). An estimated 50 *Xestospongia* colonies were recorded in video footage taken in 1996. In 2002, the substratum was covered in a mix of algae and sponges. Dominant genera were again *Neofibularia* and *Ircinia*. Only one colony of *Xestospongia* was captured on video in 2002 and it appeared to be in poor condition, with discoloration and a loss of rugosity on its pinacoderm (Figure 3.2.1.B). No *Xestospongia* colonies were present in the video footage from 2005 or 2007.

A decline in sponge diversity and abundance has been recorded at different locations around the world in the last 30 years (Wulff 2006). Sponge disease has been implicated in at least some of these rapidly declining sponge populations (Webster 2007). Disease has been disproportionally reported in large sponge species, such as *Xestospongia muta* (Wulff 2006). This may be due to the fact that these large sponges take weeks to months to die from disease, and are therefore more easily documented (Wulff 2006). From 1996-2006, disease was reported across the Caribbean in *X. muta* in Belize (Paz 1997), Curacao (Nagelkerken et al. 2000), Mexico (Gammill and Fenner 2005), and the Florida Keys (Cowart et al. 2006). With the photographic record of an intact but deteriorating *X. muta* in 2002 (Figure 3.2.1.B) and sponge disease documented across the Caribbean during this time, it may be that a water-borne pathogen was responsible for the demise of *X. muta* populations at Sonnier Bank prior to 2002.

4.2.2. McGrail, Geyer, Bright, and East Flower Garden Banks

As shown in MDS plots, Sonnier, McGrail, Geyer, and Bright Banks supported a unique benthic assemblage of algae, sponges, and corals. The EFGB, which was approximately 58-mi (93-km) from the path of Hurricane Rita, sustained measurable damage including: toppled, broken and shattered corals; scouring; shifting of sand flats; and gouging of coral heads by waterborne projectiles. All of these damages were likely related to water movement associated with the Category 3 storm. With McGrail, Bright, and Geyer Banks located in between the EFGB and Sonnier Bank, similar wind and wave activity was hindcast to have acted upon these banks, dependent partially upon their depth (Section 3.10).

The 45- to 50-m (148- to 164-ft) depth range at McGrail Bank contains large colonies of *Stephanocoenia intersepta*. The mean coral cover in this depth range was ~5% and consisted mostly of *S. intersepta* (4.8%). However, the percent cover of *S. intersepta* ranged from 0-32% within the 45- to 50-m transect data. An MDS analysis was performed on the 45- to 50-m transect data, based on multivariate cover of the four hard coral taxa. The MDS analysis revealed that there is a high variability among transects in the composition of the coral assemblage at McGrail Bank in this depth range (Figure 3.3.3). This suggests that the coral cover at McGrail Bank in the 45- to 50-m depth range is patchy in nature.

Vast areas of algal nodules at depth are present at McGrail Bank. The depth of this bank, 148-ft (45-m), may have protected the scleractinians and algal nodules from hurricane damage, even though the hurricane essentially passed over the bank (12-km or 7-mi from the centerline of the storm track). Wave heights of up to 85-ft (26-m) were modeled to have passed over McGrail Bank (Section 3.10). Undoubtedly, the pressure and velocity of water during the storm affected the top of the bank, even at 148-ft (45-m).

The absence of baseline (pre-hurricane) data with which to compare the observations and data gathered at McGrail Bank during this study prevents statistical comparisons and limits our ability to draw inferences from the data. Because ROV footage was taken at night, landscape-scale views were not possible to discern. It may be that hurricane damage was not detected for this reason. The colonies that were observed appeared undamaged; however, the high variability of coral cover observed in the 12 transects in the 45- to 50-m (148- to 164-ft) depth range could have been a consequence of the hurricane. On the other hand, that high variability could reflect the patchiness of the benthic biota caused by variability of coral recruitment or post-settlement processes, or previous perturbations.

Qualitative video from 2003 was analyzed for pre-hurricane conditions at Geyer and Bright Banks. The subject of both videos was the fish populations at these banks; therefore, a thorough characterization of the benthic community structure was not possible. Video from Bright Bank showed largely bare, uncolonized areas, with *Lobophora variegata* being the only discernible macroalgal genus. Underwater blasting at the site of a purported shipwreck was to have taken place at Bright Bank sporadically over the past 30 years (Hickerson, personal communication, 2007). Video from Geyer Bank shot in 2003 showed coverage of the benthos by brown macroalgae, including *Sargassum* spp., which was the dominant macroalgae in 2007. From these pre-hurricane videos we can see: (1) that the unique biological characteristics were not established after the hurricane; and (2) that as of April-May of 2007 the benthic assemblages had recovered to some extent. The types of hurricane impacts observed at the EFGB were not observed at these other banks because they are not dominated by scleractinian corals.

Qualitative observations made one month after the storm at the EFGB indicated the occurrence of substantial mechanical damage: fractured and displaced corals, sediment-scoured corals, and corals scarred by waterborne objects (Hickerson and Schmahl, personal communication, 2005). Data collected in November 2005 revealed that approximately 1.5% of coral colonies photographed within repetitive quadrats at the EFGB were missing, most likely due to the effects of Hurricane Rita. However, this did not noticeably affect estimates of coral cover.

Data collected in June 2005, November 2005, and June 2006 at the EFGB revealed that coral cover within the long-term monitoring site remained relatively constant (62.78% ± 2.60, 61.34% ± 2.75, 62.87% ± 2.32, respectively) and species relative abundance showed stability with *Montastraea annularis* species complex, *Diploria strigosa*, and *Porites* spp. as the dominant species (Figures 4.2.3 and 4.2.4; Precht et al. 2008a). In June 2005 macroalgae was high at 24%, while CTB was lower at 10%. After the hurricane, in November 2005, the inverse relationship between macroalgae and CTB was evident, with 24% CTB and 13% macroalgae (Precht et al. 2008a). Macroalgae cover is seasonally influenced and with the passage of Hurricane Rita it is likely that macroalgae was removed from the substratum. Between November 2005 and June 2006, macroalgae increased by ~5.4%, while CTB decreased by ~6.9%.

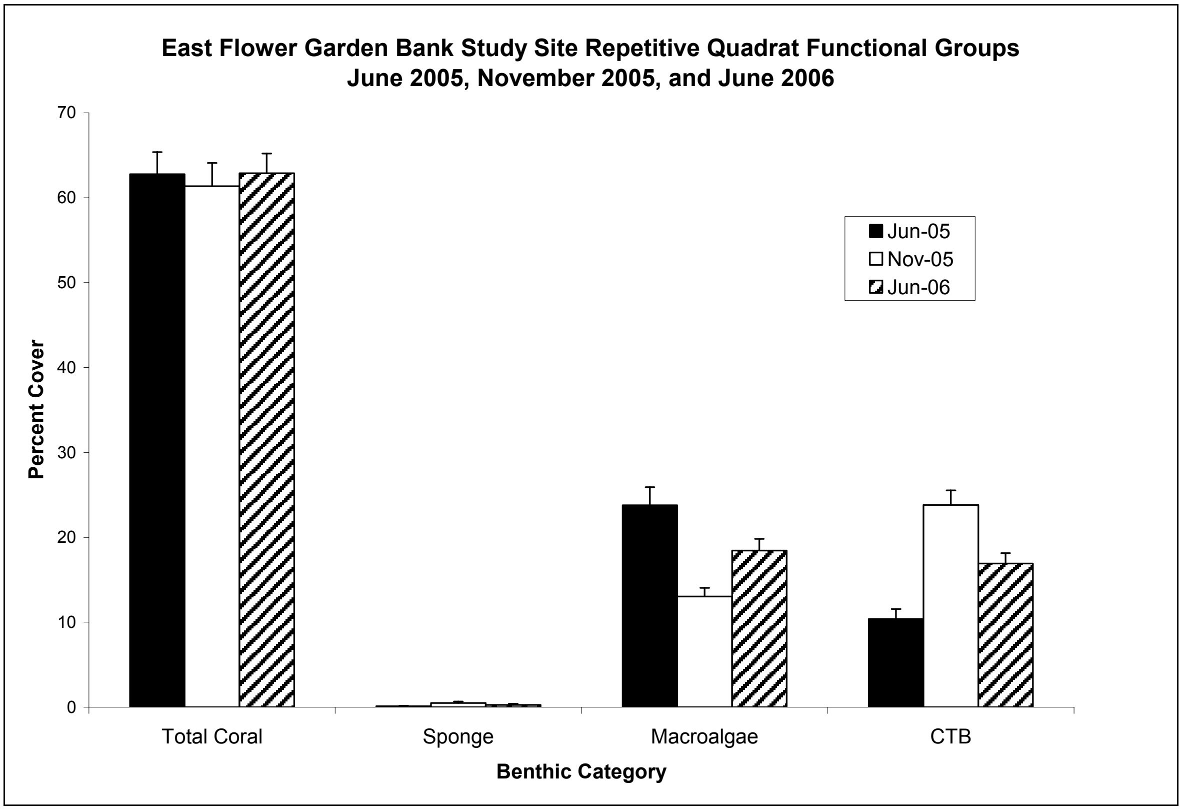


Figure 4.2.3. Percent cover of functional groups from repetitive quadrat stations at the EFGB in June 2005, November 2005, and June 2006. Error bars represent one standard error.

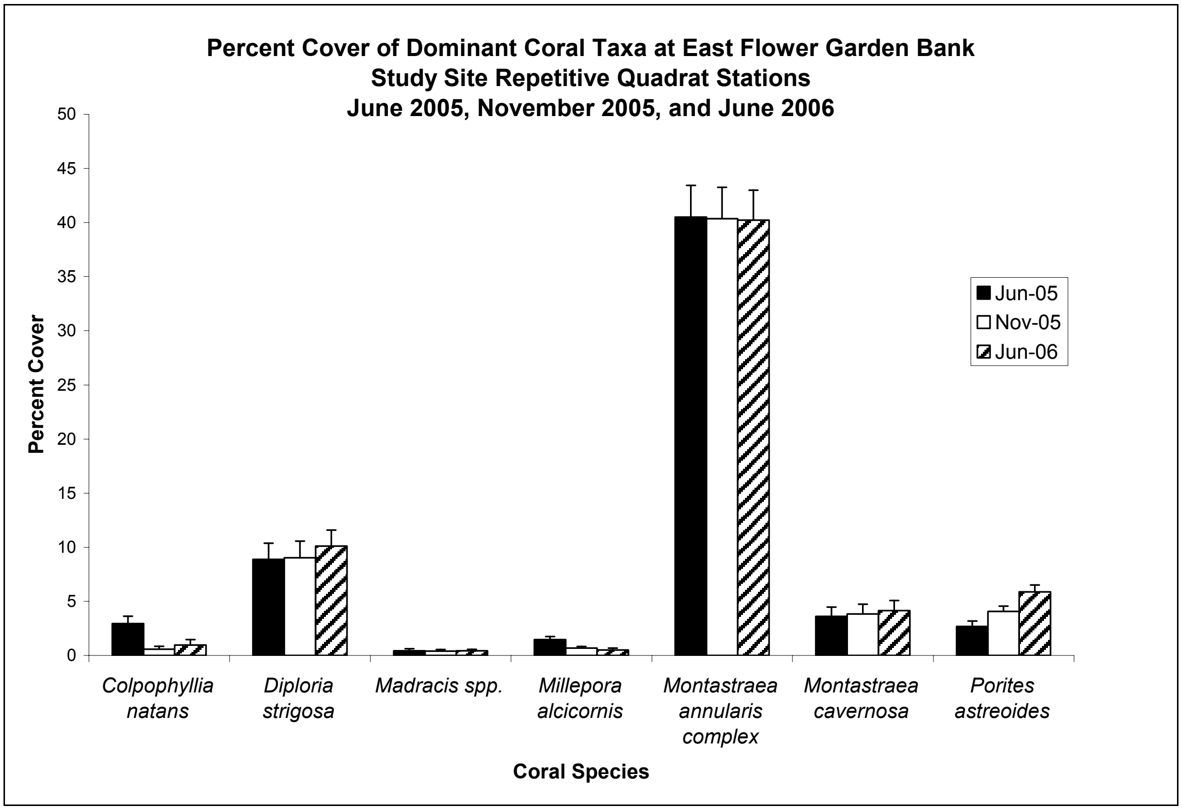


Figure 4.2.4. Percent cover of the dominant coral taxa at the EFGB repetitive quadrat stations in June 2005, November 2005, and June 2006. Error bars represent one standard error.

5.0 CONCLUSION

The unique biological characteristics of the remote benthic communities at Sonnier, McGrail, Geyer, Bright, and East Flower Garden Banks highlight their intrinsic value within the northwestern Gulf of Mexico ecosystem. With predicted wave velocities of 8 knots acting on these banks during the passage of Hurricane Rita, the damage could have been catastrophic. The apparent recovery of corals from bleaching at the EFGB associated with the 2005 warming event was documented in the June 2006 photographic data. The dataset generated for Sonnier, McGrail, Geyer, and Bright Banks suggests that Sonnier Bank suffered a loss of benthic cover but is recovering, with algae and sponges continuing to dominate. It is, however, unknown what impacts can be attributed to prior disturbances, or the passage of the hurricane. No obvious hurricane damage was apparent at McGrail, Geyer, and Bright Banks and because these three banks are dominated by algae and sponges, any recovery from damage might have been completed in the 20 months following the storm. McGrail Bank, with its large *Stephanocoenia intersepta* colonies, had no apparent coral damage and may have been protected by its depth (148-ft or 45-m); however, the absence of baseline (pre-hurricane) data limits the conclusions that can be drawn from the data collected during this study.

This dataset serves as a baseline survey across multiple depth ranges and can be used in the future to compare with follow up studies as well as studies at other locations throughout the region. Although some aspects of the dispersal of coral larvae have been explained (Lugo-Fernandez et al. 2001), the dispersal of other benthic organisms in the northwestern Gulf of Mexico is not well understood. Study of the colonization of these banks by algae and sponges is one area that should be considered for future research. Resource managers should view the present study as a characterization of these banks, which have proven to be biologically unique from one another. Increased protection, combined with a long term monitoring of Sonnier Bank, would benefit documentation of recovery at a mid-shelf bank. Increased protection to Bright Bank would halt treasure salvage activities and stop destruction of the resource. Increased protection for all banks of interest could decrease the pressure on the resources and increase the resiliency of the banks to recover from natural events.

Recommendations

- Conduct additional dispersal or drift studies (especially a study of genetic connections) to understand the oceanographic dynamics that supply the banks with their unique non-coral benthic components.
- Study fish populations of these banks, which appeared from qualitative, visual observations to be robust, but which were not within the scope of this study. Understanding the connectivity of fish populations would be particularly interesting and important.
- Detailed surveys should be conducted at McGrail Bank, including sclerochronology of the *Stephanocoenia intersepta* colonies.
- A GIS mapping initiative is recommended. Video transects shot by divers and ROV should be used to create a GIS benthic cover/habitat database for these banks and other areas.

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Appendix 1: List of Species

SONNIER BANK	**22-27 m**		**30-36.5 m**	
	Percent Cover	**Standard Error**	**Percent Cover**	**Standard Error**
Antipatharians				
Antipatharian spp.	0.00	0.00	0.00	0.00
Stichopathes sp.	0.20	0.20	0.03	0.03
Brown Macroalgae				
Dictyota spp.	8.43	1.93	13.48	0.99
Lobophora variegata	7.75	3.85	1.65	0.56
Padina spp.	0.34	0.24	0.03	0.03
Sargassum spp.*	0.00	0.00	0.00	0.00
Unidentified Brown Macroalgae	2.11	2.09	6.90	3.08
Corals				
Millepora alcicornis	7.98	1.73	1.60	0.55
Octocorallia	0.00	0.00	0.00	0.00
Siderastrea sp.*	0.00	0.00	0.00	0.00
*Stephanocoenia intersepta**	0.00	0.00	0.00	0.00
Coralline Algae				
Coralline Algae	1.41	1.19	0.08	0.05
Other Live				
Cerianthidea	0.00	0.00	0.00	0.00
Diadema antillarum	0.05	0.05	0.00	0.00
Fish	0.00	0.00	0.03	0.03
Hermodice sp.*	0.00	0.00	0.00	0.00
Gastropoda	0.25	0.15	0.03	0.03
Holothuroidea	0.05	0.05	0.00	0.00
Actinopygia agassizii				
*Spirobranchus giganteus**	0.00	0.00	0.00	0.00
Red Macroalgae				
Red Macroalgae	1.06	1.06	0.00	0.00
Sponges				
Agelas clathrodes	0.61	0.09	0.03	0.03
Ircinia spp.	0.33	0.03	0.28	0.13
Ircinia strobilina				
Neofibularia nolitangere	0.46	0.44	0.50	0.33
Niphates erecta	0.05	0.05	0.28	0.14
Spheciospongia sp.	0.25	0.25	0.25	0.17
Unidentified Sponges	0.65	0.45	0.45	0.07
Turf Algae				
Turf Algae	6.34	4.24	4.48	1.78
Total Live Cover	38.32		30.10	

* Species observed but not sampled.

Appendix 1: List of Species

SONNIER BANK	45-50 m		55-60 m	
	Percent Cover	Standard Error	Percent Cover	Standard Error
Antipatharians				
Antipatharian spp.	0.00	0.00	0.17	0.11
Stichopathes sp.	0.00	0.00	0.00	0.00
Brown Macroalgae				
Dictyota spp.	0.31	0.25	0.00	0.00
Lobophora variegata	0.00	0.00	0.00	0.00
Padina spp.	0.00	0.00	0.00	0.00
Sargassum spp.*	0.00	0.00	0.00	0.00
Unidentified Brown Macroalgae	0.49	0.29	0.00	0.00
Corals				
Millepora alcicornis	0.00	0.00	0.00	0.00
Octocorallia	0.34	0.17	0.00	0.00
Siderastrea sp.*	0.00	0.00	0.00	0.00
*Stephanocoenia intersepta**	0.00	0.00	0.00	0.00
Coralline Algae				
Coralline Algae	0.03	0.03	0.03	0.03
Other Live				
Cerianthidea	0.00	0.00	0.03	0.03
Diadema antillarum	0.00	0.00	0.00	0.00
Fish	0.00	0.00	0.00	0.00
Hermodice sp.*	0.00	0.00	0.00	0.00
Gastropoda	0.03	0.03	0.03	0.03
Holothuroidea	0.00	0.00	0.00	0.00
Actinopygia agassizii				
*Spirobranchus giganteus**	0.00	0.00	0.00	0.00
Red Macroalgae				
Red Macroalgae	0.00	0.00	0.00	0.00
Sponges				
Agelas clathrodes	0.00	0.00	0.00	0.00
Ircinia spp.	0.11	0.09	0.00	0.00
Ircinia strobilina				
Neofibularia nolitangere	0.00	0.00	0.00	0.00
Niphates erecta	0.00	0.00	0.00	0.00
Spheciospongia sp.	0.00	0.00	0.00	0.00
Unidentified Sponges	0.43	0.13	0.13	0.07
Turf Algae				
Turf Algae	5.03	0.53	1.40	0.49
Total Live Cover	6.77		1.79	

* Species observed but not sampled.

Appendix 1: List of Species

MCGRAIL BANK	45-50 m		55-60 m	
	Percent Cover	Standard Error	Percent Cover	Standard Error
Antipatharians				
Antipatharian spp.	0.52	0.50	0.00	0.00
Brown Macroalgae				
Dictyota spp.	5.88	1.36	0.76	0.47
Lobophora sp.	2.56	0.77	3.55	2.37
Sargassum spp.	1.10	0.27	0.00	0.00
Unidentified Brown Macroalgae	0.60	0.13	0.24	0.08
Corals				
Agaricia spp.	0.08	0.04	0.00	0.00
Millepora alcicornis	0.59	0.25	0.00	0.00
Montastraea cavernosa	0.02	0.02	0.00	0.00
Siderastrea sp.*	0.00	0.00	0.00	0.00
Octocorallia	0.00	0.00	0.03	0.03
Stephanocoenia intersepta	4.75	2.65	0.00	0.00
Coralline Algae				
Algal Nodules	2.44	0.50	6.51	0.46
Coralline Algae	2.79	0.70	2.95	1.06
Green Macroalgae				
Green Macroalgae	9.50	2.43	2.17	1.65
Halimeda sp.	0.00	0.00	0.03	0.03
Other Live				
Asteroidea/Ophiuroidea	0.02	0.02	0.06	0.04
Cerianthidea	0.00	0.00	0.19	0.10
Diadema antillarum	0.29	0.16	0.00	0.00
Fish	0.08	0.03	0.03	0.03
Gastropoda	0.02	0.02	0.00	0.00
Holothuroidea*	0.00	0.00	0.00	0.00
Red Macroalgae				
Red Macroalgae	4.48	1.61	0.00	0.00
Sponges				
Agelas clathrodes	0.19	0.08	0.00	0.00
Geodia spp.*	0.00	0.00	0.00	0.00
Ircinia spp.	0.26	0.18	0.00	0.00
Pseudoceratina crassa	0.04	0.03	0.00	0.00
Unidentified Sponges	1.02	0.53	0.33	0.11
Xestospongia muta	0.37	0.21	0.00	0.00
Turf Algae				
Turf Algae	0.00	0.00	0.52	0.27
Total Live Cover	37.60		17.37	

* Species observed but not sampled.

Appendix 1: List of Species

GEYER BANK	30-36.5 m		45-50 m	
	Percent Cover	Standard Error	Percent Cover	Standard Error
Antipatharians				
Antipatharian spp.*	0.00	0.00	0.00	0.00
Stichopathes sp.	0.00	0.00	0.10	0.10
Brown Macroalgae				
Dictyota spp.	2.68	0.43	8.30	1.01
Lobophora variegata	12.65	0.90	0.85	0.47
Padina spp.	0.03	0.03	0.05	0.05
Sargassum spp.	26.88	3.38	4.90	0.83
Unidentified Brown Macroalgae	0.08	0.04	8.35	1.21
Corals				
Agaricia spp.*	0.00	0.00	0.00	0.00
Millepora alcicornis	9.15	0.68	2.20	0.92
Porites spp.	0.03	0.03	0.00	0.00
Stephanocoenia intersepta	0.33	0.14	0.20	0.14
Tubastraea coccinea	0.23	0.17	0.00	0.00
Unidentifed Scleractinia	0.18	0.08	0.10	0.06
Coralline Algae				
Coralline Algae	3.43	0.53	0.80	0.73
Green Macroalgae				
Green Macroalgae	0.00	0.00	0.00	0.00
Other Live				
Fish	0.23	0.10	0.35	0.17
Gymnothorax moringa				
Muraena retifera				
Gastropoda	0.00	0.00	0.00	0.00
*Spirobranchus giganteus**	0.00	0.00	0.00	0.00
Sponges				
Agelas clathrodes	0.00	0.00	1.30	0.62
Aplysina spp.	0.23	0.10	0.00	0.00
Aplysina fistularis				
Axinellid sponge*	0.00	0.00	0.00	0.00
Clathria spp.	0.03	0.03	0.00	0.00
Cliona sp.	0.05	0.05	0.00	0.00
Neofibularia nolitangere	0.10	0.10	0.00	0.00
*Niphates erecta**	0.00	0.00	0.00	0.00
Unidentifed Sponges	0.75	0.13	1.55	0.76
Xestospongia muta	0.08	0.08	0.65	0.39
Turf Algae				
Turf Algae	3.18	0.81	0.65	0.33
Total Live Cover	60.25		30.35	

* Species observed but not sampled.

Appendix 1: List of Species

GEYER BANK	55-60 m	
	Percent Cover	Standard Error
Antipatharians		
Antipatharian spp.*	0.00	0.00
Stichopathes sp.	0.00	0.00
Brown Macroalgae		
Dictyota spp.	15.23	4.24
Lobophora variegata	0.14	0.07
Padina spp.	0.00	0.00
Sargassum spp.	0.23	0.20
Unidentified Brown Macroalgae	5.97	1.90
Corals		
Agaricia spp.*	0.00	0.00
Millepora alcicornis	0.11	0.07
Porites spp.	0.00	0.00
Stephanocoenia intersepta	0.06	0.04
Tubastraea coccinea	0.00	0.00
Unidentifed Scleractinia	0.03	0.03
Coralline Algae		
Coralline Algae	5.74	1.39
Green Macroalgae		
Green Macroalgae	0.20	0.12
Other Live		
Fish	0.37	0.23
Gymnothorax moringa		
Muraena retifera		
Gastropoda	0.03	0.03
*Spirobranchus giganteus**	0.00	0.00
Sponges		
Agelas clathrodes	0.71	0.31
Aplysina spp.	0.00	0.00
Aplysina fistularis		
Axinellid sponge*	0.00	0.00
Clathria spp.	0.00	0.00
Cliona sp.	0.00	0.00
Neofibularia nolitangere	0.00	0.00
*Niphates erecta**	0.00	0.00
Unidentifed Sponges	1.17	0.30
Xestospongia muta	0.66	0.33
Turf Algae		
Turf Algae	3.94	1.12
Total Live Cover	34.59	

* Species observed but not sampled.

Appendix 1: List of Species

BRIGHT BANK	**30-36.5 m**	
	Percent Cover	**Standard Error**
Antipatharians		
Stichopathes sp.*	0.00	0.00
Brown Macroalgae		
Dictyota spp.	0.33	0.18
Lobophora sp.	14.20	3.53
Padina spp.	0.13	0.07
Sargassum spp.	0.80	0.61
Unidentified Brown Macroalgae	28.13	6.29
Corals		
Diploria strigosa	0.87	0.87
Millepora alcicornis	6.93	2.38
Montastraea cavernosa	0.07	0.07
Stephanocoenia intersepta	0.47	0.29
Coralline Algae		
Coralline Algae	7.07	1.62
Green Macroalgae		
Green Macroalgae	13.13	0.82
Anadyomene sp.		
Ulva sp.		
Other Live		
Fish	0.73	0.07
Gastropoda	0.07	0.07
*Spirobranchus giganteus**	0.00	0.00
Red Macroalgae		
Red Macroalgae	0.07	0.07
Sponges		
Agelas clathrodes	0.27	0.13
Aplysina spp.*	0.00	0.00
Clathria spp.	0.20	0.20
Ircinia spp.*	0.00	0.00
*Pseudoceratina crassa**	0.00	0.00
Spheciospongia sp.	0.07	0.07
Unidentified Sponges	0.13	0.13
Xestospongia muta	0.33	0.33
Turf Algae		
Turf Algae	12.13	1.33
Total Live Cover	86.13	

* Species observed but not sampled.

Appendix 2: Transect Data

Sonnier Bank 22-27 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Mean	Standard Deviation	Standard Error
CORAL					
Millepora alcicornis	6.25	9.70	7.98	2.44	1.73
Total Coral	**6.25**	**9.70**	**7.98**	**2.44**	**1.73**
ANTIPATHARIANS					
Stichopathes sp.	0.00	0.40	0.20	0.28	0.20
Total Antipatharians	**0.00**	**0.40**	**0.20**	**0.28**	**0.20**
SPONGES					
Agelas clathrodes	0.53	0.70	0.61	0.12	0.09
Ircinia spp.	0.35	0.30	0.33	0.04	0.03
Neofibularia nolitangere	0.03	0.90	0.46	0.62	0.44
Niphates erecta	0.00	0.10	0.05	0.07	0.05
Spheciospongia sp.	0.00	0.50	0.25	0.35	0.25
Unidentified Sponges	1.10	0.20	0.65	0.64	0.45
Total Sponge	**2.00**	**2.70**	**2.35**	**0.49**	**0.35**
TURF ALGAE					
Total Turf Algae	**10.58**	**2.10**	**6.34**	**5.99**	**4.24**
BROWN MACROALGAE					
Dictyota sp.	10.35	6.50	8.43	2.72	1.93
Unidentified Brown macroalgae	0.03	4.20	2.11	2.95	2.09
Lobophora variegata	11.60	3.90	7.75	5.44	3.85
Padina sp.	0.58	0.10	0.34	0.34	0.24
Total Brown Macroalgae	**22.55**	**14.70**	**18.63**	**5.55**	**3.93**
RED MACROALGAE					
Total Red Macroalgae	**2.13**	**0.00**	**1.06**	**1.50**	**1.06**
OTHER LIVE					
Diadema antillarum	0.00	0.10	0.05	0.07	0.05
Holothuroidea	0.10	0.00	0.05	0.07	0.05
Gastropoda	0.40	0.10	0.25	0.21	0.15
Total Other Live	**0.50**	**0.20**	**0.35**	**0.21**	**0.15**

Appendix 2: Transect Data

Sonnier Bank 22-27 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Mean	Standard Deviation	Standard Error
CORALLINE ALGAE					
Total Coralline Algae	**0.23**	**2.60**	**1.41**	**1.68**	**1.19**
FINE TURF, BARE					
TB	35.50	47.40	41.45	8.41	5.95
Rubble	19.18	20.10	19.64	0.65	0.46
Total TB and Rubble	54.68	67.50	61.09	9.07	6.41
SAND					
Total Sand	**1.10**	**0.10**	**0.60**	**0.71**	**0.50**
Total Live Cover	**44.23**	**32.40**	**38.31**		
TOTAL	**100**	**100**	**100**		

Appendix 2: Transect Data

Sonnier Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
CORAL						
Millepora alcicornis	1.40	0.60	0.00	3.20	0.60	3.40
Total Coral	**1.40**	**0.60**	**0.00**	**3.20**	**0.60**	**3.40**
ANTIPATHARIANS						
Stichopathes sp.	0.00	0.00	0.00	0.00	0.00	0.00
Total Antipatharians	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
SPONGES						
Agelas clathrodes	0.20	0.00	0.00	0.00	0.00	0.00
Ircinia spp.	0.20	0.00	0.60	1.00	0.00	0.20
Neofibularia nolitangere	0.00	0.00	1.00	2.60	0.00	0.00
Niphates erecta	0.20	0.00	0.00	0.80	0.00	0.00
Spheciospongia sp.	0.00	0.00	0.00	1.40	0.40	0.00
Unidentified Sponges	0.40	0.20	0.60	0.20	0.40	0.40
Total Sponge	**1.00**	**0.20**	**2.20**	**6.00**	**0.80**	**0.60**
TURF ALGAE						
Total Turf Algae	**16.40**	**2.80**	**0.20**	**2.20**	**3.00**	**3.20**
BROWN MACROALGAE						
Unidentified Brown Macroalgae	0.20	0.00	21.60	19.20	7.60	4.00
Dictyota spp.	9.60	14.00	15.80	18.20	12.00	14.20
Lobophora variegata	0.20	0.60	1.60	0.20	0.40	4.20
Padina spp.	0.00	0.00	0.00	0.00	0.20	0.00
Total Brown Macroalgae	**10.00**	**14.60**	**39.00**	**37.60**	**20.20**	**22.40**
OTHER LIVE						
Fish	0.00	0.20	0.00	0.00	0.00	0.00
Gastropoda	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Live	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**

Appendix 2: Transect Data

Sonnier Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
CORALLINE ALGAE						
Total Coralline Algae	**0.40**	**0.00**	**0.00**	**0.20**	**0.00**	**0.00**
FINE TURF, BARE						
TB	27.00	57.20	11.40	12.60	19.20	39.60
Rubble	42.20	24.40	47.00	37.80	55.80	29.80
Total TB and Rubble	**69.20**	**81.60**	**58.20**	**50.40**	**75.00**	**69.40**
SAND						
Total Sand	**1.60**	**0.00**	**0.40**	**0.40**	**0.40**	**1.00**
Total Live Cover	**29.20**	**18.40**	**41.40**	**49.20**	**24.60**	**29.60**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

Sonnier Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 7	Transect 8	Mean	Standard Deviation	Standard Error
CORAL					
Millepora alcicornis	0.00	3.60	1.60	1.56	0.55
Total Coral	**0.00**	**3.60**	**1.60**	**1.56**	**0.55**
ANTIPATHARIANS					
Stichopathes sp.	0.00	0.20	0.03	0.07	0.03
Total Antipatharians	**0.00**	**0.20**	**0.03**	**0.07**	**0.03**
SPONGES					
Agelas clathrodes	0.00	0.00	0.03	0.07	0.03
Ircinia spp.	0.20	0.00	0.28	0.35	0.13
Neofibularia nolitangere	0.40	0.00	0.50	0.92	0.33
Niphates erecta	0.20	1.00	0.28	0.40	0.14
Spheciospongia sp.	0.00	0.20	0.25	0.49	0.17
Unidentified Sponges	0.60	0.80	0.45	0.21	0.07
Total Sponge	**1.40**	**2.00**	**1.78**	**1.84**	**0.65**
TURF ALGAE					
Total Turf Algae	**5.40**	**2.60**	**4.48**	**5.02**	**1.78**
BROWN MACROALGAE					
Unidentified Brown Macroalgae	1.40	1.20	6.90	8.71	3.08
Dictyota spp.	13.60	10.40	13.48	2.81	0.99
Lobophora variegata	3.40	2.60	1.65	1.58	0.56
Padina spp.	0.00	0.00	0.03	0.07	0.03
Total Brown Macroalgae	**18.40**	**14.20**	**22.06**	**10.75**	**3.80**
OTHER LIVE					
Fish	0.00	0.00	0.03	0.07	0.03
Gastropoda	0.20	0.00	0.03	0.07	0.03
Total Other Live	**0.20**	**0.00**	**0.05**	**0.09**	**0.03**

Appendix 2: Transect Data

Sonnier Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 7	Transect 8	Mean	Standard Deviation	Standard Error
CORALLINE ALGAE					
Total Coralline Algae	**0.00**	**0.00**	**0.08**	**0.15**	**0.05**
FINE TURF, BARE					
TB	24.80	39.60	28.90	15.66	5.54
Rubble	49.40	36.00	40.30	10.42	3.68
Total TB and Rubble	**74.20**	**75.60**	**69.20**	**10.20**	**3.61**
SAND					
Total Sand	**0.40**	**1.80**	**0.75**	**0.65**	**0.23**
Total Live Cover	**25.40**	**22.60**	**30.05**		
TOTAL	**100**	**100**	**100**		

Appendix 2: Transect Data

Sonnier Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORAL							
Octocorallia	0.00	0.00	0.80	1.00	0.60	0.00	0.00
Total Coral	**0.00**	**0.00**	**0.80**	**1.00**	**0.60**	**0.00**	**0.00**
SPONGES							
Ircinia spp.	0.00	0.00	0.20	0.00	0.00	0.60	0.00
Unidentified Sponges	0.60	0.60	0.20	0.00	1.00	0.20	0.40
Total Sponge	**0.60**	**0.60**	**0.40**	**0.00**	**1.00**	**0.80**	**0.40**
TURF ALGAE							
Total Turf Algae	**4.60**	**2.60**	**6.80**	**4.40**	**5.80**	**4.80**	**6.20**
BROWN MACROALGAE							
Unidentified Brown Macroalgae	1.40	1.80	0.20	0.00	0.00	0.00	0.00
Dictyota spp.	0.00	0.00	1.80	0.20	0.20	0.00	0.00
Total Brown Macroalgae	**1.40**	**1.80**	**2.00**	**0.20**	**0.20**	**0.00**	**0.00**
OTHER LIVE							
Gastropoda	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Total Other Live	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.20**
CORALLINE ALGAE							
Total Coralline Algae	**0.00**	**0.00**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**
FINE TURF, BARE							
TB	5.00	7.00	12.80	8.20	6.20	10.20	19.00
Rubble	44.40	42.00	52.20	52.20	78.80	33.40	26.00
Total TB and Rubble	**49.40**	**49.00**	**65.00**	**60.40**	**85.00**	**43.60**	**45.00**
SAND							
Total Sand	**44.00**	**46.00**	**25.00**	**33.80**	**7.20**	**50.60**	**48.20**
UNKNOWNS							
Total Unknown	**0.00**	**0.00**	**0.00**	**0.00**	**0.20**	**0.20**	**0.00**
Total Live Cover	**6.60**	**5.00**	**10.00**	**5.80**	**7.60**	**5.60**	**6.80**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

Sonnier Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
CORAL			
Octocorallia	0.34	0.44	0.17
Total Coral	**0.34**	**0.44**	**0.17**
SPONGES			
Ircinia spp.	0.11	0.23	0.09
Unidentified Sponges	0.43	0.34	0.13
Total Sponge	**0.54**	**0.32**	**0.12**
TURF ALGAE			
Total Turf Algae	**5.03**	**1.39**	**0.53**
BROWN MACROALGAE			
Unidentified Brown Macroalgae	0.49	0.77	0.29
Dictyota spp.	0.31	0.66	0.25
Total Brown Macroalgae	**0.80**	**0.89**	**0.34**
OTHER LIVE			
Gastropoda	0.03	0.08	0.03
Total Other Live	**0.03**	**0.08**	**0.03**
CORALLINE ALGAE			
Total Coralline Algae	**0.03**	**0.08**	**0.03**
FINE TURF, BARE			
TB	9.77	4.83	1.83
Rubble	47.00	16.95	6.41
Total TB and Rubble	**56.77**	**14.75**	**5.57**
SAND			
Total Sand	**36.40**	**15.71**	**5.94**
UNKNOWNS			
Total Unknown	**0.06**	**0.10**	**0.04**
Total Live Cover	**6.77**		
TOTAL	**100**		

Appendix 2: Transect Data

Sonnier Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
ANTIPATHARIANS						
Antipatharia spp.	0.00	0.00	0.00	0.40	0.60	0.00
Total Antipatharian	**0.00**	**0.00**	**0.00**	**0.40**	**0.60**	**0.00**
SPONGES						
Unidentified Sponges	0.20	0.00	0.00	0.20	0.40	0.00
Total Sponge	**0.20**	**0.00**	**0.00**	**0.20**	**0.40**	**0.00**
TURF ALGAE						
Total Turf Algae	**3.80**	**1.00**	**0.60**	**0.60**	**1.20**	**1.20**
OTHER LIVE						
Cerianthidea	0.20	0.00	0.00	0.00	0.00	0.00
Gastropoda	0.00	0.00	0.20	0.00	0.00	0.00
Total Other Live	**0.20**	**0.00**	**0.20**	**0.00**	**0.00**	**0.00**
CORALLINE ALGAE						
Crustose Coralline Algae	0.20	0.00	0.00	0.00	0.00	0.00
Total Coralline Algae	**0.20**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
FINE TURF, BARE						
TB	2.60	2.20	1.40	1.00	1.20	0.00
Rubble	13.80	12.20	10.40	6.40	5.00	8.40
Total TB and Rubble	**16.40**	**14.40**	**11.80**	**7.40**	**6.20**	**8.40**
SAND						
Fish Hole	0.00	0.00	0.20	0.60	0.00	0.00
Sand	79.20	84.60	87.20	90.80	91.60	90.40
Total Sand	**79.20**	**84.60**	**87.40**	**91.40**	**91.60**	**90.40**
Total Live Cover	**4.40**	**1.00**	**0.80**	**1.20**	**2.20**	**1.20**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

Sonnier Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
ANTIPATHARIANS			
Antipatharia spp.	0.17	0.27	0.11
Total Antipatharian	**0.17**	**0.27**	**0.11**
SPONGES			
Unidentified Sponges	0.13	0.16	0.07
Total Sponge	**0.13**	**0.16**	**0.07**
TURF ALGAE			
Total Turf Algae	**1.40**	**1.21**	**0.49**
OTHER LIVE			
Cerianthidea	0.03	0.08	0.03
Gastropoda	0.03	0.08	0.03
Total Other Live	**0.07**	**0.10**	**0.04**
CORALLINE ALGAE			
Crustose Coralline Algae	0.03	0.08	0.03
Total Coralline Algae	**0.03**	**0.08**	**0.03**
FINE TURF, BARE			
TB	1.40	0.92	0.38
Rubble	9.37	3.39	1.39
Total TB and Rubble	**10.77**	**4.09**	**1.67**
SAND			
Fish Hole	0.13	0.24	0.10
Sand	87.30	4.76	1.94
Total Sand	**87.43**	**4.85**	**1.98**
Total Live Cover	**1.80**		
TOTAL	**100**		

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORAL							
Agaricia sp.	0.00	0.00	0.00	0.00	0.00	0.46	0.00
Millepora alcicornis	0.00	0.45	1.11	1.11	0.00	1.84	0.00
Montastraea cavernosa	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Stephanocoenia intersepta	0.00	0.22	12.03	6.22	2.32	31.57	2.08
Total Coral	**0.00**	**0.67**	**13.36**	**7.33**	**2.32**	**33.87**	**2.08**
ANTIPATHARIANS							
Antipatharia spp.	0.00	0.00	0.00	0.00	0.00	0.00	6.00
Total Antipathrians	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**6.00**
SPONGES							
Agelas clathrodes	0.00	0.00	0.45	0.00	0.21	0.92	0.46
Ircinia spp.	0.00	0.00	0.00	1.33	0.00	1.84	0.00
Pseudoceratina crassa	0.00	0.00	0.00	0.22	0.00	0.00	0.00
Unidentified Sponges	0.00	0.00	0.67	0.22	0.21	5.76	1.39
Xestospongia muta	0.00	0.00	0.67	0.00	1.90	1.84	0.00
Total Sponge	**0.00**	**0.00**	**1.78**	**1.78**	**2.32**	**10.37**	**1.85**
BROWN MACROALGAE							
Unidentified Brown Macroalgae	0.68	0.67	0.67	0.67	0.21	0.00	1.62
Dictyota spp.	7.94	4.24	7.80	16.44	12.66	2.07	6.00
Lobophora variegata	3.40	0.89	1.56	0.44	0.00	0.00	0.00
Sargassum spp.	0.00	0.00	0.67	2.44	1.48	0.23	1.85
Total Brown Macroalgae	**12.02**	**5.80**	**10.69**	**20.00**	**14.35**	**2.30**	**9.47**
GREEN MACROALGAE							
Green Macroalgae	5.90	11.61	18.04	12.89	31.22	1.84	9.70
Total Green Macroalgae	**5.90**	**11.61**	**18.04**	**12.89**	**31.22**	**1.84**	**9.70**
RED MACROALGAE							
Red Macroalgae	0.91	3.35	0.00	0.00	0.00	0.00	0.23
Total Red Macroalgae	**0.91**	**3.35**	**0.00**	**0.00**	**0.00**	**0.00**	**0.23**

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
OTHER LIVE							
Diadema antillarum	0.00	0.00	0.67	0.44	0.00	1.84	0.00
Fish	0.00	0.22	0.00	0.22	0.00	0.00	0.23
Asteroidea/Ophiuroidea	0.00	0.00	0.00	0.22	0.00	0.00	0.00
Gastropoda	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Total Other Live	**0.00**	**0.22**	**0.67**	**0.89**	**0.00**	**2.07**	**0.23**
CORALLINE ALGAE							
Crustose Coralline Algae	1.59	0.89	2.00	1.78	3.38	8.99	0.46
Algal Nodules	5.44	4.46	2.45	2.67	1.05	0.00	2.77
Total Coralline Algae	**7.03**	**5.36**	**4.45**	**4.44**	**4.43**	**8.99**	**3.23**
FINE TURF, BARE							
TB	1.13	0.22	2.67	2.22	1.48	28.80	0.92
Rubble	47.39	53.57	30.07	34.44	27.64	4.38	46.88
Total TB and Rubble	**48.53**	**53.79**	**32.74**	**36.67**	**29.11**	**33.18**	**47.81**
SAND							
Total Sand	**25.17**	**19.20**	**18.04**	**15.78**	**16.24**	**7.37**	**19.40**
UNKNOWNS							
Total Unknown	**0.45**	**0.00**	**0.22**	**0.22**	**0.00**	**0.00**	**0.00**
Total Live Cover	**25.85**	**27.01**	**49.00**	**47.33**	**54.64**	**59.45**	**32.79**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 8	Transect 9	Transect 10	Transect 11	Transect 12
CORAL					
Agaricia sp.	0.23	0.00	0.00	0.22	0.00
Millepora alcicornis	2.56	0.00	0.00	0.00	0.00
Montastraea cavernosa	0.00	0.00	0.00	0.00	0.00
Stephanocoenia intersepta	2.56	0.00	0.00	0.00	0.00
Total Coral	**5.36**	**0.00**	**0.00**	**0.22**	**0.00**
ANTIPATHARIANS					
Antipatharia spp.	0.00	0.00	0.00	0.22	0.00
Total Antipathrians	**0.00**	**0.00**	**0.00**	**0.22**	**0.00**
SPONGES					
Agelas clathrodes	0.00	0.22	0.00	0.00	0.00
Ircinia spp.	0.00	0.00	0.00	0.00	0.00
Pseudoceratina crassa	0.23	0.00	0.00	0.00	0.00
Unidentified Sponges	3.73	0.00	0.00	0.00	0.23
Xestospongia muta	0.00	0.00	0.00	0.00	0.00
Total Sponge	**3.96**	**0.22**	**0.00**	**0.00**	**0.23**
BROWN MACROALGAE					
Unidentified Brown Macroalgae	0.23	0.22	0.22	0.88	1.15
Dictyota spp.	2.80	2.69	2.21	0.44	5.29
Lobophora variegata	2.33	4.93	3.10	8.13	5.98
Sargassum spp.	1.40	1.12	0.00	1.54	2.53
Total Brown Macroalgae	**6.76**	**8.97**	**5.53**	**10.99**	**14.94**
GREEN MACROALGAE					
Green Macroalgae	6.53	3.14	1.77	3.96	7.36
Total Green Macroalgae	**6.53**	**3.14**	**1.77**	**3.96**	**7.36**
RED MACROALGAE					
Red Macroalgae	4.90	5.38	15.27	12.97	10.80
Total Red Macroalgae	**4.90**	**5.38**	**15.27**	**12.97**	**10.80**

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	**Transect 8**	**Transect 9**	**Transect 10**	**Transect 11**	**Transect 12**
OTHER LIVE					
Diadema antillarum	0.47	0.00	0.00	0.00	0.00
Fish	0.23	0.00	0.00	0.00	0.00
Asteroidea/Ophiuroidea	0.00	0.00	0.00	0.00	0.00
Gastropoda	0.00	0.00	0.00	0.00	0.00
Total Other Live	**0.70**	**0.00**	**0.00**	**0.00**	**0.00**
CORALLINE ALGAE					
Crustose Coralline Algae	5.59	1.57	0.88	2.86	3.45
Algal Nodules	0.47	1.35	1.99	1.76	4.83
Total Coralline Algae	**6.06**	**2.91**	**2.88**	**4.62**	**8.28**
FINE TURF, BARE					
TB	8.86	2.91	2.21	2.64	2.99
Rubble	38.23	49.78	50.44	44.62	43.68
Total TB and Rubble	**47.09**	**52.69**	**52.65**	**47.25**	**46.67**
SAND					
Total Sand	**18.65**	**26.68**	**21.90**	**19.78**	**11.49**
UNKNOWNS					
Total Unknown	**0.00**	**0.00**	**0.00**	**0.00**	**0.23**
Total Live Cover	**34.27**	**20.63**	**25.44**	**32.97**	**41.61**
TOTAL	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
CORAL			
Agaricia sp.	0.08	0.15	0.04
Millepora alcicornis	0.59	0.88	0.25
Montastraea cavernosa	0.02	0.06	0.02
Stephanocoenia intersepta	4.75	9.17	2.65
Total Coral	**5.43**	**9.84**	**2.84**
ANTIPATHARIANS			
Antipatharia spp.	0.52	1.73	0.50
Total Antipathrians	**0.52**	**1.73**	**0.50**
SPONGES			
Agelas clathrodes	0.19	0.29	0.08
Ircinia spp.	0.26	0.63	0.18
Pseudoceratina crassa	0.04	0.09	0.03
Unidentified Sponges	1.02	1.84	0.53
Xestospongia muta	0.37	0.73	0.21
Total Sponge	**1.88**	**2.96**	**0.85**
BROWN MACROALGAE			
Unidentified Brown Macroalgae	0.60	0.46	0.13
Dictyota spp.	5.88	4.73	1.36
Lobophora variegata	2.56	2.65	0.77
Sargassum spp.	1.10	0.92	0.27
Total Brown Macroalgae	**10.15**	**4.84**	**1.40**
GREEN MACROALGAE			
Green Macroalgae	9.50	8.40	2.43
Total Green Macroalgae	**9.50**	**8.40**	**2.43**
RED MACROALGAE			
Red Macroalgae	4.48	5.57	1.61
Total Red Macroalgae	**4.48**	**5.57**	**1.61**

Appendix 2: Transect Data

McGrail Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
OTHER LIVE			
Diadema antillarum	0.29	0.55	0.16
Fish	0.08	0.11	0.03
Asteroidea/Ophiuroidea	0.02	0.06	0.02
Gastropoda	0.02	0.07	0.02
Total Other Live	**0.40**	**0.62**	**0.18**
CORALLINE ALGAE			
Crustose Coralline Algae	2.79	2.42	0.70
Algal Nodules	2.44	1.72	0.50
Total Coralline Algae	**5.22**	**2.01**	**0.58**
FINE TURF, BARE			
TB	4.76	7.88	2.27
Rubble	39.26	13.73	3.96
Total TB and Rubble	**44.01**	**8.67**	**2.50**
SAND			
Total Sand	**18.31**	**5.32**	**1.54**
UNKNOWNS			
Total Unknown	**0.09**	**0.15**	**0.04**
Total Live Cover	**37.58**		
TOTAL	**100**		

Appendix 2: Transect Data

McGrail Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORAL							
Octocorallia	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Total Coral	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.25**
SPONGES							
Unidentified Sponges	0.00	0.22	0.00	0.00	0.49	0.71	0.76
Total Sponge	**0.00**	**0.22**	**0.00**	**0.00**	**0.49**	**0.71**	**0.76**
TURF ALGAE							
Total Turf Algae	**0.00**	**0.22**	**0.24**	**0.00**	**0.25**	**0.00**	**1.78**
BROWN MACROALGAE							
Unidentified Brown Macroalgae	0.45	0.00	0.48	0.00	0.25	0.48	0.25
Dictyota spp.	0.45	0.00	0.00	0.00	0.00	0.00	2.03
Lobophora variegata	4.92	0.00	0.00	0.00	0.00	0.00	4.06
Total Brown Macroalgae	**5.82**	**0.00**	**0.48**	**0.00**	**0.25**	**0.48**	**6.35**
GREEN MACROALGAE							
Green Macroalgae	13.65	1.55	0.00	0.00	0.25	0.48	0.25
Halimeda sp.	0.00	0.00	0.24	0.00	0.00	0.00	0.00
Total Green Macroalgae	**13.65**	**1.55**	**0.24**	**0.00**	**0.25**	**0.48**	**0.25**
OTHER LIVE							
Cerianthidea	0.00	0.00	0.00	0.75	0.00	0.24	0.51
Fish	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asteroidea/Ophiuroidea	0.00	0.00	0.00	0.25	0.00	0.00	0.25
Total Other Live	**0.00**	**0.00**	**0.00**	**1.00**	**0.00**	**0.24**	**0.76**
CORALLINE ALGAE							
Crustose coralline algae	4.03	0.00	0.96	1.25	1.72	0.95	6.35
Algal Nodules	6.49	4.42	7.69	7.77	8.09	5.48	6.60
Total Coralline Algae	**10.51**	**4.42**	**8.65**	**9.02**	**9.80**	**6.43**	**12.94**

Appendix 2: Transect Data

McGrail Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
FINE TURF, BARE							
TB	1.12	1.55	1.20	1.25	0.49	1.19	2.54
Rubble	46.09	50.22	51.92	60.40	69.61	66.90	51.27
Total TB and Rubble	**47.20**	**51.77**	**53.13**	**61.65**	**70.10**	**68.10**	**53.81**
SAND							
Total Sand	**22.82**	**41.59**	**37.02**	**28.32**	**18.87**	**23.57**	**22.84**
UNKNOWNS							
Total Unknown	**0.00**	**0.22**	**0.24**	**0.00**	**0.00**	**0.00**	**0.25**
Total Live Cover	**29.98**	**6.42**	**9.62**	**10.03**	**11.03**	**8.33**	**23.10**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data
McGrail Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 8	Mean	Standard Deviation	Standard Error
CORAL				
Octocorallia	0.00	0.03	0.09	0.03
Total Coral	**0.00**	**0.03**	**0.09**	**0.03**
SPONGES				
Unidentified Sponges	0.48	0.33	0.32	0.11
Total Sponge	**0.48**	**0.33**	**0.32**	**0.11**
TURF ALGAE				
Total Turf Algae	**1.67**	**0.52**	**0.75**	**0.27**
BROWN MACROALGAE				
Unidentified Brown Macroalgae	0.00	0.24	0.22	0.08
Dictyota spp.	3.59	0.76	1.34	0.47
Lobophora variegata	19.38	3.55	6.72	2.37
Total Brown Macroalgae	**22.97**	**4.54**	**7.90**	**2.79**
GREEN MACROALGAE				
Green Macroalgae	1.20	2.17	4.67	1.65
Halimeda sp.	0.00	0.03	0.08	0.03
Total Green Macroalgae	**1.20**	**2.20**	**4.66**	**1.65**
OTHER LIVE				
Cerianthidea	0.00	0.19	0.29	0.10
Fish	0.24	0.03	0.08	0.03
Asteroidea/Ophiuroidea	0.00	0.06	0.12	0.04
Total Other Live	**0.24**	**0.28**	**0.39**	**0.14**
CORALLINE ALGAE				
Crustose coralline algae	8.37	2.95	3.00	1.06
Algal Nodules	5.50	6.51	1.30	0.46
Total Coralline Algae	**13.88**	**9.46**	**3.12**	**1.10**

Appendix 2: Transect Data

McGrail Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 8	Mean	Standard Deviation	Standard Error
FINE TURF, BARE				
TB	7.18	2.06	2.14	0.76
Rubble	43.54	54.99	9.57	3.38
Total TB and Rubble	**50.72**	**57.06**	**8.49**	**3.00**
SAND				
Total Sand	**8.61**	**25.46**	**10.33**	**3.65**
UNKNOWNS				
Total Unknown	**0.24**	**0.12**	**0.13**	**0.05**
Total Live Cover	**40.43**	**17.37**		
TOTAL	**100**	**100**		

Appendix 2: Transect Data

Geyer Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORAL							
Millepora alcicornis	7.80	8.80	8.60	8.40	10.00	7.00	13.40
Porites sp.	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Unidentified Scleractinia	0.00	0.00	0.20	0.00	0.00	0.40	0.20
Stephanocoenia intersepta	0.80	0.40	0.40	0.00	0.00	0.00	1.00
Tubastraea coccinea	1.40	0.00	0.20	0.00	0.20	0.00	0.00
Total Coral	**10.00**	**9.20**	**9.40**	**8.60**	**10.20**	**7.40**	**14.60**
SPONGES							
Aplysina spp.	0.40	0.60	0.00	0.00	0.00	0.20	0.60
Clathria spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cliona sp.	0.00	0.00	0.40	0.00	0.00	0.00	0.00
Neofibularia nolitangere	0.00	0.00	0.80	0.00	0.00	0.00	0.00
Unidentified Sponges	1.20	1.20	0.40	0.20	0.80	0.60	0.60
Xestospongia muta	0.00	0.00	0.00	0.00	0.00	0.60	0.00
Total Sponge	**1.60**	**1.80**	**1.60**	**0.20**	**0.80**	**1.40**	**1.20**
TURF ALGAE							
Total Turf Algae	**7.80**	**1.80**	**2.00**	**2.60**	**2.60**	**0.40**	**3.20**
BROWN MACROALGAE							
Unidentified Brown Macroalgae	0.20	0.00	0.00	0.00	0.20	0.20	0.00
Dictyota spp.	3.60	3.00	1.00	3.60	1.60	2.80	1.40
Lobophora variegata	10.60	12.60	9.80	12.60	12.80	12.20	12.20
Padina spp.	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Sargassum spp.	7.00	25.60	30.00	32.40	27.00	38.40	21.40
Total Brown Macroalgae	**21.40**	**41.20**	**40.80**	**48.80**	**41.60**	**53.60**	**35.00**
OTHER LIVE							
Fish	0.40	0.80	0.00	0.20	0.20	0.20	0.00
Total Other Live	**0.40**	**0.80**	**0.00**	**0.20**	**0.20**	**0.20**	**0.00**

Appendix 2: Transect Data

Geyer Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORALLINE ALGAE							
Total Coralline Algae	**5.00**	**1.40**	**2.20**	**2.00**	**3.60**	**3.60**	**5.80**
FINE TURF, BARE							
TB	25.60	32.80	31.40	21.20	19.20	19.20	26.20
Rubble	27.20	8.80	7.80	13.20	20.40	13.80	11.80
Total TB and Rubble	**52.80**	**41.60**	**39.20**	**34.40**	**39.60**	**33.00**	**38.00**
SAND							
Total Sand	**0.80**	**2.00**	**4.80**	**3.00**	**1.40**	**0.40**	**2.00**
UNKNOWNS							
Total Unknown	**0.20**	**0.20**	**0.00**	**0.20**	**0.00**	**0.00**	**0.20**
Total Live Cover	**46.20**	**56.20**	**56.00**	**62.40**	**59.00**	**66.60**	**59.80**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

Geyer Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 8	Mean	Standard Deviation	Standard Error
CORAL				
Millepora alcicornis	9.20	9.15	1.94	0.68
Porites sp.	0.00	0.03	0.07	0.03
Unidentified Scleractinia	0.60	0.18	0.23	0.08
Stephanocoenia intersepta	0.00	0.33	0.40	0.14
Tubastraea coccinea	0.00	0.23	0.48	0.17
Total Coral	**9.80**	**9.90**	**2.10**	**0.74**
SPONGES				
Aplysina spp.	0.00	0.23	0.27	0.10
Clathria spp.	0.20	0.03	0.07	0.03
Cliona sp.	0.00	0.05	0.14	0.05
Neofibularia nolitangere	0.00	0.10	0.28	0.10
Unidentified Sponges	1.00	0.75	0.37	0.13
Xestospongia muta	0.00	0.08	0.21	0.08
Total Sponge	**1.20**	**1.23**	**0.52**	**0.18**
TURF ALGAE				
Total Turf Algae	**5.00**	**3.18**	**2.28**	**0.81**
BROWN MACROALGAE				
Unidentified Brown Macroalgae	0.00	0.08	0.10	0.04
Dictyota spp.	4.40	2.68	1.22	0.43
Lobophora variegata	18.40	12.65	2.56	0.90
Padina spp.	0.00	0.03	0.07	0.03
Sargassum spp.	33.20	26.88	9.56	3.38
Total Brown Macroalgae	**56.00**	**42.30**	**11.03**	**3.90**
OTHER LIVE				
Fish	0.00	0.23	0.27	0.10
Total Other Live	**0.00**	**0.23**	**0.27**	**0.10**

Appendix 2: Transect Data

Geyer Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 8	Mean	Standard Deviation	Standard Error
CORALLINE ALGAE				
Total Coralline Algae	**3.80**	**3.43**	**1.51**	**0.53**
FINE TURF, BARE				
TB	17.20	24.10	5.85	2.07
Rubble	6.60	13.70	6.97	2.46
Total TB and Rubble	**23.80**	**37.80**	**8.24**	**2.91**
SAND				
Total Sand	**0.20**	**1.83**	**1.52**	**0.54**
UNKNOWNS				
Total Unknown	**0.20**	**0.13**	**0.10**	**0.04**
Total Live Cover	**75.80**	**60.25**		
TOTAL	**100**	**100**		

Appendix 2: Transect Data

Geyer Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Mean	Standard Deviation	Standard Error
CORAL							
Unidentified Scleractinia	0.20	0.00	0.00	0.20	0.10	0.12	0.06
Millepora alcicornis	0.00	4.00	3.40	1.40	2.20	1.84	0.92
Stephanocoenia intersepta	0.60	0.00	0.20	0.00	0.20	0.28	0.14
Total Coral	**0.80**	**4.00**	**3.60**	**1.60**	**2.50**	**1.54**	**0.77**
ANTIPATHARIANS							
Stichopathes sp.	0.00	0.40	0.00	0.00	0.10	0.20	0.10
Total Antipatharians	**0.00**	**0.40**	**0.00**	**0.00**	**0.10**	**0.20**	**0.10**
SPONGES							
Agelas clathrodes	0.00	1.80	2.80	0.60	1.30	1.25	0.62
Unidentified Sponges	0.60	1.80	3.60	0.20	1.55	1.53	0.76
Xestospongia muta	0.00	1.60	0.00	1.00	0.65	0.79	0.39
Total Sponge	**0.60**	**5.20**	**6.40**	**1.80**	**3.50**	**2.74**	**1.37**
TURF ALGAE							
Total Turf Algae	**0.20**	**1.40**	**1.00**	**0.00**	**0.65**	**0.66**	**0.33**
BROWN MACROALGAE							
Unidentified Brown macroalgae	6.40	11.80	7.00	8.20	8.35	2.42	1.21
Dictyota spp.	6.20	7.20	10.80	9.00	8.30	2.03	1.01
Lobophora variegata	0.60	0.00	2.20	0.60	0.85	0.94	0.47
Padina spp.	0.20	0.00	0.00	0.00	0.05	0.10	0.05
Sargassum spp.	7.20	5.00	3.60	3.80	4.90	1.65	0.83
Total Brown Macroalgae	**20.60**	**24.00**	**23.60**	**21.60**	**22.45**	**1.62**	**0.81**
OTHER LIVE							
Fish	0.20	0.80	0.40	0.00	0.35	0.34	0.17
Total Other Live	**0.20**	**0.80**	**0.40**	**0.00**	**0.35**	**0.34**	**0.17**
CORALLINE ALGAE							
Total Coralline Algae	**0.00**	**3.00**	**0.20**	**0.00**	**0.80**	**1.47**	**0.73**

Appendix 2: Transect Data

Geyer Bank 45-50 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Mean	Standard Deviation	Standard Error
FINE TURF, BARE							
TB	31.60	22.80	37.00	32.80	31.05	5.97	2.98
Rubble	36.80	33.40	26.00	33.00	32.30	4.53	2.27
Total TB and Rubble	**68.40**	**56.20**	**63.00**	**65.80**	**63.35**	**5.25**	**2.63**
SAND							
Total Sand	**9.00**	**5.00**	**1.80**	**9.20**	**6.25**	**3.54**	**1.77**
UNKNOWNS							
Total Unknown	**0.20**	**0.00**	**0.00**	**0.00**	**0.05**	**0.10**	**0.05**
Total Live Cover	**22.40**	**38.80**	**35.20**	**25.00**	**30.35**		
TOTAL	**100**	**100**	**100**	**100**	**100**		

Appendix 2: Transect Data

Geyer Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
CORAL							
Millepora alcicornis	0.00	0.40	0.00	0.40	0.00	0.00	0.00
Unidentified Scleractinia	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Stephanocoenia intersepta	0.20	0.00	0.00	0.20	0.00	0.00	0.00
Total Coral	**0.40**	**0.40**	**0.00**	**0.60**	**0.00**	**0.00**	**0.00**
SPONGES							
Agelas clathrodes	0.00	0.20	1.00	0.40	2.40	0.40	0.60
Unidentified Sponges	0.00	1.40	0.40	1.60	1.20	1.20	2.40
Xestospongia muta	0.00	0.00	2.00	1.00	1.60	0.00	0.00
Total Sponge	**0.00**	**1.60**	**3.40**	**3.00**	**5.20**	**1.60**	**3.00**
TURF ALGAE							
Total Turf Algae	**0.60**	**2.00**	**2.20**	**3.80**	**9.00**	**6.80**	**3.20**
BROWN MACROALGAE							
Unidentified Brown Macroalgae	1.20	2.60	15.60	8.20	1.60	5.80	6.80
Dictyota spp.	1.40	4.20	12.00	14.00	17.40	34.20	23.40
Lobophora variegata	0.40	0.00	0.00	0.40	0.00	0.00	0.20
Sargassum spp.	0.00	0.00	0.20	1.40	0.00	0.00	0.00
Total Brown Macroalgae	**3.00**	**6.80**	**27.80**	**24.00**	**19.00**	**40.00**	**30.40**
GREEN MACROALGAE							
Green Macroalgae	0.80	0.20	0.00	0.00	0.40	0.00	0.00
Total Green Macroalgae	**0.80**	**0.20**	**0.00**	**0.00**	**0.40**	**0.00**	**0.00**
OTHER LIVE							
Fish	0.00	0.00	0.00	0.00	0.20	1.60	0.80
Gastropoda	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Total Other Live	**0.20**	**0.00**	**0.00**	**0.00**	**0.20**	**1.60**	**0.80**
CORALLINE ALGAE							
Total Coralline Algae	**0.80**	**5.00**	**7.20**	**6.60**	**10.40**	**9.00**	**1.20**

Appendix 2: Transect Data

Geyer Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7
FINE TURF, BARE							
TB	7.00	11.00	22.60	9.60	9.20	12.00	10.40
Rubble	75.20	63.80	28.00	44.20	34.20	18.20	39.80
Total TB and Rubble	**82.20**	**74.80**	**50.60**	**53.80**	**43.40**	**30.20**	**50.20**
SAND							
Total Sand	**11.80**	**9.00**	**8.40**	**7.80**	**12.40**	**10.60**	**10.60**
UNKNOWNS							
Total Unknown	**0.20**	**0.20**	**0.40**	**0.40**	**0.00**	**0.20**	**0.60**
Total Live Cover	**5.80**	**16.00**	**40.60**	**38.00**	**44.20**	**59.00**	**38.60**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2: Transect Data

Geyer Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
CORAL			
Millepora alcicornis	0.11	0.20	0.07
Unidentified Scleractinia	0.03	0.08	0.03
Stephanocoenia intersepta	0.06	0.10	0.04
Total Coral	**0.20**	**0.26**	**0.10**
SPONGES			
Agelas clathrodes	0.71	0.81	0.31
Unidentified Sponges	1.17	0.79	0.30
Xestospongia muta	0.66	0.87	0.33
Total Sponge	**2.54**	**1.66**	**0.63**
TURF ALGAE			
Total Turf Algae	**3.94**	**2.95**	**1.12**
BROWN MACROALGAE			
Unidentified Brown Macroalgae	5.97	5.03	1.90
Dictyota spp.	15.23	11.23	4.24
Lobophora variegata	0.14	0.19	0.07
Sargassum spp.	0.23	0.52	0.20
Total Brown Macroalgae	**21.57**	**13.11**	**4.96**
GREEN MACROALGAE			
Green Macroalgae	0.20	0.31	0.12
Total Green Macroalgae	**0.20**	**0.31**	**0.12**
OTHER LIVE			
Fish	0.37	0.62	0.23
Gastropoda	0.03	0.08	0.03
Total Other Live	**0.40**	**0.60**	**0.23**
CORALLINE ALGAE			
Total Coralline Algae	**5.74**	**3.67**	**1.39**

Appendix 2: Transect Data

Geyer Bank 55-60 meters

MAJOR CATEGORY (% of transect)	Mean	Standard Deviation	Standard Error
FINE TURF, BARE			
TB	11.69	5.06	1.91
Rubble	43.34	19.99	7.56
Total TB and Rubble	**55.03**	**17.91**	**6.77**
SAND			
Total Sand	**10.09**	**1.74**	**0.66**
UNKNOWNS			
Total Unknown	**0.29**	**0.20**	**0.07**
Total Live Cover	**34.60**		
TOTAL	**100**		

Appendix 2: Transect Data

Bright Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Mean	Standard Deviation	Standard Error
CORAL						
Diploria strigosa	0.00	2.60	0.00	0.87	1.50	0.87
Millepora alcicornis	7.40	10.80	2.60	6.93	4.12	2.38
Montastraea cavernosa	0.00	0.20	0.00	0.07	0.12	0.07
Stephanocoenia intersepta	0.00	1.00	0.40	0.47	0.50	0.29
Total Coral	**7.40**	**14.60**	**3.00**	**8.33**	**5.86**	**3.38**
SPONGES						
Agelas clathrodes	0.40	0.40	0.00	0.27	0.23	0.13
Clathria spp.	0.00	0.60	0.00	0.20	0.35	0.20
Spheciospongia sp.	0.00	0.20	0.00	0.07	0.12	0.07
Unidentified Sponges	0.00	0.40	0.00	0.13	0.23	0.13
Xestospongia muta	0.00	1.00	0.00	0.33	0.58	0.33
Total Sponge	**0.40**	**2.60**	**0.00**	**1.00**	**1.40**	**0.81**
TURF ALGAE						
Total Turf Algae	**10.80**	**14.80**	**10.80**	**12.13**	**2.31**	**1.33**
BROWN MACROALGAE						
Unidentified Brown Macroalgae	25.80	18.60	40.00	28.13	10.89	6.29
Dictyota spp.	0.40	0.60	0.00	0.33	0.31	0.18
Lobophora variegata	8.40	13.60	20.60	14.20	6.12	3.53
Padina spp.	0.20	0.00	0.20	0.13	0.12	0.07
Sargassum spp.	0.40	0.00	2.00	0.80	1.06	0.61
Total Brown Macroalgae	**35.20**	**32.80**	**62.80**	**43.60**	**16.67**	**9.62**
GREEN MACROALGAE						
Green Macroalgae	14.40	13.40	11.60	13.13	1.42	0.82
Total Green Macroalgae	**14.40**	**13.40**	**11.60**	**13.13**	**1.42**	**0.82**
RED MACROALGAE						
Red Macroalgae	0.20	0.00	0.00	0.07	0.12	0.07
Total Red Macroalgae	**0.20**	**0.00**	**0.00**	**0.07**	**0.12**	**0.07**

Appendix 2: Transect Data

Bright Bank 30-36.5 meters

MAJOR CATEGORY (% of transect)	Transect 1	Transect 2	Transect 3	Mean	Standard Deviation	Standard Error
OTHER LIVE						
Fish	0.80	0.80	0.60	0.73	0.12	0.07
Gastropoda	0.00	0.00	0.20	0.07	0.12	0.07
Total Other Live	**0.80**	**0.80**	**0.80**	**0.80**	**0.00**	**0.00**
CORALLINE ALGAE						
Total Coralline Algae	**7.20**	**9.80**	**4.20**	**7.07**	**2.80**	**1.62**
FINE TURF, BARE						
TB	19.60	10.80	6.40	12.27	6.72	3.88
Rubble	3.20	0.40	0.40	1.33	1.62	0.93
Total TB and Rubble	**22.80**	**11.20**	**6.80**	**13.60**	**8.27**	**4.77**
SAND						
Total Sand	**0.60**	**0.00**	**0.00**	**0.20**	**0.35**	**0.20**
UNKNOWNS						
Total Unknown	**0.20**	**0.00**	**0.00**	**0.07**	**0.12**	**0.07**
Total Live Cover	**76.40**	**88.80**	**93.20**	**86.13**		
TOTAL	**100**	**100**	**100**	**100**		

Appendix 3: Repetitive Quadrat Percent Cover Data

Study Site Repetitive Quadrat Stations

	EAST BANK NOVEMBER 2005		EAST BANK JUNE 2006	
	MEAN	STANDARD ERROR	MEAN	STANDARD ERROR
CORAL				
Agaricia agaricites	0.00	0.00	0.02	0.01
Colpophyllia natans	0.59	0.27	0.96	0.50
Diploria strigosa	9.02	1.55	10.11	1.49
Madracis spp.	0.40	0.15	0.44	0.14
Millepora alcicornis	0.68	0.16	0.51	0.17
Montastraea cavernosa	3.85	0.88	4.14	0.93
Montastraea annularis spp. complex	40.34	2.91	40.20	2.77
Mussa angulosa	0.02	0.01	0.03	0.03
Porites astreoides	4.06	0.51	5.88	0.64
Siderastrea siderea	0.09	0.08	0.11	0.10
Stephanocoenia intersepta	0.24	0.11	0.13	0.05
Unidentified Scleractinia	2.06	0.33	0.34	0.09
TOTAL CORAL	**61.34**	**2.75**	**62.87**	**2.32**
SPONGE				
Agelas clathrodes	0.17	0.08	0.13	0.09
Pseudoceratina crassa	0.07	0.03	0.00	0.00
Unidentified Sponges	0.19	0.06	0.05	0.03
Xestospongia muta	0.06	0.04	0.08	0.08
TOTAL SPONGE	**0.49**	**0.16**	**0.26**	**0.13**
MACROALGAE				
Dictyota spp.	0.42	0.19	4.18	0.75
General Macroalgae	1.40	0.35	0.00	0.00
Lobophora variegata	0.00	0.00	14.12	1.25
Turf Algae	11.22	0.82	0.15	0.07
TOTAL MACROALGAE	**13.04**	**1.02**	**18.45**	**1.36**
OTHER LIVE				
Other	0.12	0.05	0.45	0.09
Serpulidae	0.19	0.05	0.16	0.04
TOTAL OTHER LIVE	**0.31**	**0.06**	**0.61**	**0.10**
CRUSTOSE CORALLINE, TURF, BARE				
Coralline Algae	3.29	0.57	10.50	0.94
CTB	20.53	1.65	6.42	0.88
TOTAL CTB	**23.81**	**1.73**	**16.91**	**1.24**
SAND AND RUBBLE				
TOTAL SAND AND RUBBLE	**0.79**	**0.44**	**0.74**	**0.36**
UNKNOWNS				
TOTAL UNKNOWN	**0.21**	**0.06**	**0.15**	**0.05**
TOTAL COVER	**100.00**		**100.00**	

Appendix 3: Repetitive Quadrat Percent Cover Data

Deep Repetitive Quadrat Stations

	EAST BANK NOVEMBER 2005		EAST BANK JUNE 2006	
	MEAN	STANDARD ERROR	MEAN	STANDARD ERROR
CORAL				
Colpophyllia natans	8.86	3.16	3.57	1.95
Diploria strigosa	2.91	1.15	3.17	2.35
Madracis spp.	0.24	0.17	0.00	0.00
Millepora alcicornis	0.68	0.46	0.68	0.31
Montastraea cavernosa	15.84	3.02	17.74	3.11
Montastraea annularis spp. complex	42.02	4.81	41.21	4.40
Mussa angulosa	2.71	1.38	3.63	1.78
Porites astreoides	0.00	0.00	0.28	0.29
Scolymia cubensis	0.00	0.00	0.11	0.13
Stephanocoenia intersepta	0.00	0.00	0.85	0.48
Unidentified Scleractinia	1.24	1.17	0.74	0.39
TOTAL CORAL	**74.50**	**4.44**	**72.00**	**4.60**
SPONGE				
Agelas clathrodes	0.00	0.00	0.74	0.36
Unidentified Sponges	0.28	0.29	0.28	0.16
TOTAL SPONGE	**0.28**	**0.29**	**1.02**	**0.46**
MACROALGAE				
Dictyota spp.	0.00	0.00	3.68	0.86
General Macroalgae	0.36	0.23	0.00	0.00
Lobophora variegata	0.00	0.00	3.63	1.11
Turf Algae	8.98	4.18	0.45	0.46
TOTAL MACROALGAE	**9.34**	**4.38**	**7.77**	**2.07**
OTHER LIVE				
Other	0.04	0.05	0.17	0.09
TOTAL OTHER LIVE	**0.04**	**0.05**	**0.17**	**0.09**
CRUSTOSE CORALLINE, TURF, BARE				
Coralline Algae	4.51	2.23	13.83	2.53
CTB	7.74	2.50	1.93	0.97
TOTAL CTB	**12.25**	**2.91**	**15.76**	**2.75**
SAND AND RUBBLE				
TOTAL SAND AND RUBBLE	**2.11**	**2.22**	**3.00**	**1.58**
UNKNOWNS				
TOTAL UNKNOWN	**1.48**	**1.46**	**0.28**	**0.20**
TOTAL COVER	**100.00**		**100.00**	

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
1	1	*Montastraea* sp.	17.73	17.28	-0.44	-0.05	-2.51	-5.22	-0.55	-0.03
	2	*Diploria strigosa*	4.83	4.94	0.11	0.01	2.24			0.02
	3	*Montastraea* sp.	6.71	4.89	-1.82	-0.19	-27.17			-0.27
	4	*Montastraea* sp.	9.67	7.39	-2.28	-0.24	-23.62			-0.24
	5	*Montastraea* sp.	6.47	5.69	-0.78	-0.08	-12.08			-0.12
2	1	*Montastraea* sp.	35.58	37.65	2.08	0.22	5.84	1.20	0.13	0.06
	2	*Montastraea* sp.	19.30	21.08	1.79	0.19	9.25			0.09
	3	*Montastraea* sp.	10.62	11.60	0.98	0.10	9.22			0.09
	4	*Montastraea* sp.	12.99	9.35	-3.64	-0.38	-28.02			-0.28
2b	1	*Diploria strigosa*	86.86	67.62	-19.24	-2.01	-22.15	-35.70	-3.74	-0.22
	2	*Montastraea* sp.	27.46	17.75	-9.71	-1.02	-35.37			-0.35
	3	*Diploria strigosa*	11.36	11.83	0.47	0.05	4.18			0.04
	4	*Montastraea* sp.	44.88	37.66	-7.22	-0.76	-16.09			-0.16
3	1	*Diploria strigosa*	14.22	16.28	2.05	0.21	14.43	-19.26	-2.02	0.14
	2	*Montastraea* sp.	46.66	59.23	12.57	1.32	26.94			0.27
	3	*Diploria strigosa*	7.74	10.49	2.75	0.29	35.60			0.36
	4	*Diploria strigosa*	32.43	0.00	-32.43	-3.40	-100.00			-1.00
	5	*Montastraea* sp.	33.67	29.47	-4.21	-0.44	-12.49			-0.12
4	1	*Montastraea* sp.	29.65	30.97	1.32	0.14	4.46	25.54	2.67	0.04
	2	*Montastraea* sp.	18.85	20.21	1.36	0.14	7.20			0.07
	3	*Montastraea* sp.	53.09	57.01	3.92	0.41	7.38			0.07
	4	*Diploria strigosa*	11.62	13.52	1.91	0.20	16.40			0.16
	5	*Montastraea* sp.	236.46	253.49	17.04	1.78	7.21			0.07

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	15.88	15.02	-0.86	-0.09	-5.44			-0.05
	2	*Montastraea* sp.	24.71	9.27	-15.44	-1.62	-62.48			-0.62
4b	3	*Diploria strigosa*	16.00	0.00	-16.00	-1.68	-100.00	-46.10	-4.83	-1.00
	4	*Montastraea* sp.	17.86	8.18	-9.67	-1.01	-54.18			-0.54
	5	*Montastraea* sp.	12.20	8.08	-4.12	-0.43	-33.78			-0.34
	1	*Montastraea* sp.	19.55	24.35	4.81	0.50	24.58			0.25
	2	*Montastraea* sp.	29.20	36.77	7.57	0.79	25.94			0.26
5	3	*Montastraea* sp.	11.95	12.90	0.95	0.10	7.93	12.45	1.30	0.08
	4	*Montastraea* sp.	47.37	46.25	-1.11	-0.12	-2.35			-0.02
	5	*Montastraea* sp.	5.95	6.19	0.24	0.03	4.06			0.04
	1	*Montastraea* sp.	27.32	48.58	21.26	2.23	77.83			0.78
	2	*Montastraea* sp.	7.03	0.00	-7.03	-0.74	-100.00			-1.00
7	3	*Porites astreoides*	0.95	0.00	-0.95	-0.10	-100.00	10.44	1.09	-1.00
	4	*Diploria strigosa*	3.16	0.00	-3.16	-0.33	-100.00			-1.00
	5	*Diploria strigosa*	4.32	4.63	0.31	0.03	7.17			0.07
	1	*Montastraea* sp.	21.76	49.25	27.49	0.29	126.32			1.26
	2	*Montastraea* sp.	27.54	30.70	3.15	0.03	11.45			0.11
9	3	*Montastraea* sp.	67.66	76.42	8.77	0.09	12.96	34.21	0.36	0.13
	4	*Montastraea* sp.	34.14	41.86	7.73	0.08	22.63			0.23
	5	*Montastraea* sp.	137.73	124.80	-12.93	-0.14	-9.39			-0.09
	1	*Diploria strigosa*	17.67	13.12	-4.55	-0.48	-25.76			-0.26
10	2	*Diploria strigosa*	11.21	16.93	5.73	0.60	51.13	-32.08	-3.36	0.51
	3	*Montastraea* sp.	110.87	79.94	-30.93	-3.24	-27.90			-0.28
	4	*Diploria strigosa*	19.52	17.19	-2.33	-0.24	-11.95			-0.12

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Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
11	1	*Diploria strigosa*	11.55	7.86	-3.69	-0.39	-31.98	-26.72	-2.80	-0.32
	2	*Montastraea* sp.	107.26	99.41	-7.85	-0.82	-7.32			-0.07
	3	*Montastraea* sp.	52.30	50.28	-2.02	-0.21	-3.86			-0.04
	4	*Montastraea* sp.	45.93	32.78	-13.16	-1.38	-28.64			-0.29
12	1	*Porites astreoides*	4.36	4.53	0.17	0.02	4.00	0.04	0.00	0.04
	2	*Porites astreoides*	3.57	3.91	0.34	0.04	9.59			0.10
	3	*Diploria strigosa*	5.27	6.07	0.80	0.08	15.14			0.15
	4	*Diploria strigosa*	3.41	4.12	0.71	0.07	20.98			0.21
	5	*Diploria strigosa*	15.87	13.88	-1.99	-0.21	-12.55			-0.13
12b	1	*Diploria strigosa*	46.10	47.49	1.39	0.15	3.02	-27.49	-2.88	0.03
	2	*Montastraea* sp.	2.75	3.45	0.70	0.07	25.40			0.25
	3	*Diploria strigosa*	84.50	82.50	-2.00	-0.21	-2.37			-0.02
	4	*Montastraea cavernosa*	28.74	1.16	-27.58	-2.89	-95.97			-0.96
14	1	*Montastraea* sp.	13.40	20.64	7.24	0.76	54.06	-13.05	-1.37	0.54
	2	*Montastraea* sp.	24.30	18.72	-5.57	-0.58	-22.94			-0.23
	3	*Diploria strigosa*	2.37	2.30	-0.07	-0.01	-2.75			-0.03
	4	*Montastraea* sp.	22.62	25.11	2.49	0.26	10.99			0.11
	5	*Montastraea cavernosa*	17.73	0.59	-17.14	-1.79	-96.68			-0.97
14b	1	*Diploria strigosa*	8.58	9.74	1.16	0.12	13.57	-1.34	-0.14	0.14
	2	*Montastraea* sp.	1.81	2.83	-5.75	-0.60	-316.77			-3.17
	3	*Montastraea* sp.	14.02	19.59	17.77	1.86	126.82			1.27
	4	*Diploria strigosa*	8.63	6.72	-7.30	-0.76	-84.57			-0.85
	5	*Diploria strigosa*	7.23	0.00	-7.23	-0.76	-100.00			-1.00

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Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
15	1	*Montastraea* sp.	22.75	32.33	9.58	1.00	42.08	6.72	0.70	0.42
	2	*Montastraea* sp.	12.35	11.08	-1.27	-0.13	-10.31			-0.10
	3	*Montastraea* sp.	19.61	18.00	-1.61	-0.17	-8.20			-0.08
	4	*Montastraea* sp.	5.83	5.86	0.03	0.00	0.52			0.01
17	1	*Montastraea* sp.	32.86	33.67	0.81	0.08	2.45	14.84	1.55	0.02
	2	*Diploria strigosa*	20.86	20.61	-0.25	-0.03	-1.18			-0.01
	3	*Diploria strigosa*	30.35	34.95	4.60	0.48	15.17			0.15
	4	*Diploria strigosa*	66.91	77.25	10.34	1.08	15.46			0.15
	5	*Montastraea* sp.	13.85	13.19	-0.67	-0.07	-4.80			-0.05
18	1	*Montastraea* sp.	69.60	59.14	-10.46	-1.10	-15.03	-8.31	-0.87	-0.15
	2	*Montastraea* sp.	185.00	192.76	7.76	0.81	4.19			0.04
	3	*Diploria strigosa*	14.85	14.83	-0.02	0.00	-0.13			0.00
	4	*Diploria strigosa*	20.88	18.18	-2.71	-0.28	-12.96			-0.13
	5	*Montastraea* sp.	67.54	64.66	-2.88	-0.30	-4.26			-0.04
18b	1	*Montastraea* sp.	4.51	5.01	0.49	0.05	10.92	0.18	0.02	0.11
	2	*Diploria strigosa*	1.07	1.28	0.21	0.02	19.42			0.19
	3	*Montastraea* sp.	5.13	4.65	-0.47	-0.05	-9.22			-0.09
	4	*Diploria strigosa*	5.46	5.41	-0.05	0.00	-0.84			-0.01
20	1	*Montastraea* sp.	89.40	85.19	-4.21	-0.44	-4.71	-71.41	-7.48	-0.05
	2	*Montastraea cavernosa*	43.21	0.07	-43.14	-4.52	-99.84			-1.00
	3	*Diploria strigosa*	22.50	23.91	1.41	0.15	6.29			0.06
	4	*Montastraea cavernosa*	25.52	0.05	-25.47	-2.67	-99.81			-1.00

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Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	2.47	2.67	0.20	0.02	8.09			0.08
	2	*Diploria strigosa*	3.33	3.36	0.03	0.00	0.93			0.01
20b	3	*Diploria strigosa*	4.29	3.80	-0.50	-0.05	-11.55	-12.96	-1.36	-0.12
	4	*Montastraea* sp.	9.39	9.59	0.20	0.02	2.17			0.02
	5	*Montastraea* sp.	12.90	0.00	-12.90	-1.35	-100.03			-1.00
	1	*Montastraea* sp.	22.38	17.82	-4.57	-0.48	-20.40			-0.20
	2	*Montastraea* sp.	15.50	6.09	-9.41	-0.99	-60.71			-0.61
21	3	*Montastraea* sp.	22.26	23.81	1.55	0.16	6.98	-49.71	-5.20	0.07
	4	*Montastraea cavernosa*	52.87	59.47	-52.51	-5.50	-99.31			-0.99
	5	*Montastraea* sp.	53.20	68.43	15.23	1.59	28.63			0.29
	1	*Montastraea* sp.	83.30	44.85	-38.45	-4.03	-46.16			-0.46
	2	*Montastraea cavernosa*	13.55	12.17	-1.39	-0.15	-10.25			-0.10
21b	3	*Diploria strigosa*	46.30	54.58	8.29	0.87	17.90	-31.61	-3.31	0.18
	4	*Diploria strigosa*	46.36	49.96	3.61	0.38	7.78			0.08
	5	*Diploria strigosa*	21.78	18.12	-3.66	-0.38	-16.81			-0.17
	1	*Montastraea* sp.	10.62	20.51	9.89	1.04	93.20			0.93
	2	*Diploria strigosa*	22.98	21.50	-1.47	-0.15	-6.42			-0.06
22	3	*Colpophyllia natans*	11.47	0.06	-11.41	-1.20	-99.47	-26.26	-2.75	-0.99
	4	*Diploria strigosa*	34.89	31.59	-3.30	-0.35	-9.45			-0.09
	5	*Montastraea* sp.	53.94	33.97	-19.97	-2.09	-37.02			-0.37
	1	*Montastraea* sp.	28.48	22.35	-6.13	-0.64	-21.53			-0.22
	2	*Montastraea* sp.	64.89	48.27	-16.62	-1.74	-25.61			-0.26
23	3	*Montastraea* sp.	21.68	18.61	-3.08	-0.32	-14.18	-27.11	-2.84	-0.14
	4	*Diploria strigosa*	7.28	8.67	1.39	0.15	19.10			0.19
	5	*Diploria strigosa*	20.11	17.44	-2.68	-0.28	-13.31			-0.13

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Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
24	1	*Montastraea* sp.	23.02	16.58	-6.44	-0.67	-27.97	-7.39	-0.77	-0.28
	2	*Montastraea cavernosa*	20.62	0.01	-20.60	-2.16	-99.93			-1.00
	3	*Montastraea* sp.	48.33	43.81	-4.52	-0.47	-9.34			-0.09
	4	*Diploria strigosa*	9.37	11.01	1.64	0.17	17.53			0.18
	5	*Montastraea* sp.	62.26	84.79	22.53	2.36				0.00
25	1	*Montastraea* sp.	1.49	1.60	0.11	0.01	7.14	2.79	0.29	0.07
	2	*Montastraea* sp.	7.82	9.66	1.84	0.19	23.49			0.23
	3	*Montastraea* sp.	1.91	2.40	0.49	0.05	25.64			0.26
	4	*Montastraea* sp.	3.69	4.05	0.36	0.04	9.78			0.10
26	1	*Diploria strigosa*	8.83	10.48	1.65	0.17	18.71	-27.29	-2.86	0.19
	2	*Diploria strigosa*	19.70	21.73	2.03	0.21	10.31			0.10
	3	*Diploria strigosa*	7.94	7.35	-0.59	-0.06	-7.49			-0.07
	4	*Diploria strigosa*	20.70	0.00	-20.70	-2.17	-100.00			-1.00
	5	*Diploria strigosa*	15.04	5.37	-9.67	-1.01	-64.29			-0.64
26b	1	*Montastraea* sp.	12.52	11.14	-1.38	-0.14	-11.03	-3.48	-0.36	-0.11
	2	*Montastraea* sp.	8.26	8.51	0.25	0.03	3.03			0.03
	3	*Diploria strigosa*	4.42	3.97	-0.45	-0.05	-10.23			-0.10
	4	*Diploria strigosa*	20.25	18.78	-1.47	-0.15	-7.28			-0.07
	5	*Diploria strigosa*	10.84	10.41	-0.43	-0.04	-3.93			-0.04
27	1	*Montastraea* sp.	4.60	5.11	-3.72	-0.39	-80.85	-45.73	-4.79	-0.81
	2	*Montastraea* sp.	16.68	22.18	2.48	0.26	14.90			0.15
	3	*Montastraea* sp.	11.01	12.17	4.23	0.44	38.38			0.38
	4	*Diploria strigosa*	15.16	18.64	-2.06	-0.22	-13.60			-0.14
	5	*Montastraea* sp.	241.20	184.83	169.79	17.78	70.39			0.70

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Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Diploria strigosa*	21.76	27.56	5.80	0.61	26.67			0.27
	2	*Diploria strigosa*	26.91	30.70	3.79	0.40	14.10			0.14
29	3	*Diploria strigosa*	97.97	92.35	-5.62	-0.59	-5.73	-56.97	-5.96	-0.06
	4	*Diploria strigosa*	44.37	0.00	-44.37	-4.65	-100.00			-1.00
	5	*Diploria strigosa*	16.58	0.00	-16.58	-1.74	-100.00			-1.00
	1	*Diploria strigosa*	11.23	10.66	-0.57	-0.06	-5.09			-0.05
29b	2	*Montastraea* sp.	10.26	10.93	0.67	0.07	6.57	-84.92	-8.89	0.07
	3	*Montastraea cavernosa*	71.95	0.61	-71.34	-7.47	-99.16			-0.99
	4	*Diploria strigosa*	13.67	0.00	-13.67	-1.43	-100.00			-1.00
	1	*Montastraea cavernosa*	53.02	1.26	-51.76	-5.42	-97.62			-0.98
	2	*Colpophyllia natans*	56.14	56.05	-0.09	-0.01	-0.16			0.00
30	3	*Montastraea cavernosa*	82.55	0.48	-82.06	-8.59	-99.42	-185.24	-19.40	-0.99
	4	*Montastraea cavernosa*	32.05	3.02	-29.03	-3.04	-90.57			-0.91
	5	*Diploria strigosa*	49.65	27.35	-22.31	-2.34	-44.92			-0.45
	1	*Montastraea* sp.	16.46	8.48	-7.98	-0.84	-48.46			-0.48
	2	*Diploria strigosa*	71.70	0.00	-71.70	-7.51	-100.00			-1.00
30b	3	*Diploria strigosa*	4.92	0.00	-4.92	-0.52	-100.00	-83.58	-8.75	-1.00
	4	*Diploria strigosa*	7.62	7.58	-0.03	0.00	-0.42			0.00
	5	*Diploria strigosa*	9.59	10.63	1.04	0.11	10.84			0.11
	1	*Montastraea* sp.	23.67	26.94	3.27	0.34	13.83			0.14
	2	*Montastraea* sp.	1.96	2.22	0.26	0.03	13.11			0.13
31	3	*Montastraea* sp.	5.46	6.60	1.14	0.12	20.91	3.55	0.37	0.21
	4	*Montastraea* sp.	6.98	7.68	0.71	0.07	10.15			0.10
	5	*Montastraea* sp.	25.58	23.76	-1.83	-0.19	-7.14			-0.07

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Study Site Repetitive Quadrat Stations

June 2005 - November 2005

RQS #*	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
33	1	*Montastraea* sp.	10.58	10.38	-0.20	-0.02	-1.88	-24.48	-2.56	-0.02
	2	*Montastraea* sp.	15.47	11.89	-3.59	-0.38	-23.18			-0.23
	3	*Montastraea* sp.	55.16	55.49	0.33	0.03	0.60			0.01
	4	*Montastraea cavernosa*	21.42	0.40	-21.03	-2.20	-98.14			-0.98
36	1	*Montastraea* sp.	121.54	48.42	-73.12	-7.66	-60.16	-210.98	-22.09	-0.60
	2	*Montastraea* sp.	78.55	0.35	-78.20	-8.19	-99.55			-1.00
	3	*Montastraea* sp.	47.03	2.31	-44.73	-4.68	-95.10			-0.95
	4	*Montastraea* sp.	15.12	0.19	-14.93	-1.56	-98.77			-0.99
38	1	*Diploria strigosa*	74.52	62.14	-12.38	-1.30	-16.61	6.96	0.73	-0.17
	2	*Diploria strigosa*	15.18	15.00	-0.18	-0.02	-1.18			-0.01
	3	*Colpophyllia natans*	78.89	91.83	12.94	1.36	16.40			0.16
	4	*Diploria strigosa*	10.33	11.26	0.93	0.10	9.04			0.09
	5	*Diploria strigosa*	26.31	30.66	4.35	0.46	16.53			0.17
	6	*Diploria strigosa*	41.88	43.17	1.30	0.14	3.09			0.03
UNK1**	1	*Montastraea* sp.	7.95	8.34	0.40	0.04	4.97	-19.97	-2.09	0.05
	2	*Diploria strigosa*	19.15	22.04	2.89	0.30	15.07			0.15
	3	*Montastraea* sp.	26.47	26.14	-0.33	-0.03	-1.25			-0.01
	4	*Diploria strigosa*	21.16	0.00	-21.16	-2.22	-100.00			-1.00
	5	*Montastraea* sp.	14.68	12.91	-1.76	-0.18	-12.01			-0.12
UNK2**	1	*Colpophyllia natans*	11.94	11.71	-0.23	-0.02	-1.91	4.61	0.48	-0.02
	2	*Diploria strigosa*	15.52	26.76	11.23	1.18	72.38			0.72
	3	*Montastraea* sp.	25.25	16.12	-9.13	-0.96	-36.17			-0.36
	4	*Diploria strigosa*	20.26	22.01	1.75	0.18	8.63			0.09
	5	*Montastraea* sp.	26.49	27.47	0.99	0.10	3.72			0.04

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

**unknown repetitive quadrat number

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
1	1	*Montastraea* sp.	17.28	20.39	3.11	0.33	18.00	8.43	0.88	0.18
	2	*Diploria strigosa*	4.94	5.68	0.74	0.08	14.90			0.15
	3	*Montastraea* sp.	4.89	7.05	2.16	0.23	44.28			0.44
	4	*Montastraea* sp.	7.39	8.36	0.97	0.10	13.13			0.13
	5	*Montastraea* sp.	5.69	7.13	1.45	0.15	25.42			0.25
2**	1	*Montastraea* sp.	37.65	43.71	6.05	0.63	16.08	7.45	0.78	0.16
	2	*Montastraea* sp.	21.08	19.19	-1.90	-0.20	-8.99			-0.09
	3	*Montastraea* sp.	11.60	11.98	0.38	0.04	3.30			0.03
	4	*Montastraea* sp.	9.35	12.26	2.91	0.30	31.11			0.31
2b	1	*Diploria strigosa*	67.62	85.13	17.51	1.83	25.90	38.45	4.03	0.26
	2	*Montastraea* sp.	17.75	34.76	17.02	1.78	95.87			0.96
	3	*Diploria strigosa*	11.83	11.28	-0.55	-0.06	-4.64			-0.05
	4	*Montastraea* sp.	37.66	42.12	4.47	0.47	11.86			0.12
3	1	*Diploria strigosa*	16.28	15.02	-1.26	-0.13	-7.73	-6.50	-0.68	-0.08
	2	*Montastraea* sp.	59.23	50.24	-8.99	-0.94	-15.19			-0.15
	3	*Diploria strigosa*	10.49	10.64	0.15	0.02	1.43			0.01
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
	5	*Montastraea* sp.	29.47	33.07	3.60	0.38	12.21			0.12
4	1	*Montastraea* sp.	30.97	34.47	3.49	0.37	11.28	1.64	0.17	0.11
	2	*Montastraea* sp.	20.21	21.50	1.30	0.14	6.42			0.06
	3	*Montastraea* sp.	57.01	60.13	3.12	0.33	5.48			0.05
	4	*Diploria strigosa*	13.52	12.45	-1.07	-0.11	-7.91			-0.08
	5	*Montastraea* sp.	253.49	248.29	-5.21	-0.55	-2.05			-0.02

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

** Measurements from June 2005 (rather than November 2005)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
5	1	*Montastraea* sp.	24.35	26.20	1.84	0.19	7.57	5.09	0.53	0.08
	2	*Montastraea* sp.	36.77	42.38	5.61	0.59	15.26			0.15
	3	*Montastraea* sp.	12.90	12.53	-0.37	-0.04	-2.84			-0.03
	4	*Montastraea* sp.	46.25	44.78	-1.47	-0.15	-3.19			-0.03
	5	*Montastraea* sp.	6.19	5.67	-0.52	-0.05	-8.44			-0.08
7	1	*Montastraea* sp.	48.58	44.76	-3.82	-0.40	-7.86	-4.27	-0.45	-0.08
	2	*Montastraea* sp.	0.00	0.00	0.00	0.00	0.00			0.00
	3	*Porites astreoides*	0.00	0.00	0.00	0.00	0.00			0.00
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
	5	*Diploria strigosa*	4.63	4.17	-0.46	-0.05	-9.85			-0.10
10	1	*Diploria strigosa*	13.12	12.46	-0.66	-0.07	-5.04	37.86	3.96	-0.05
	2	*Diploria strigosa*	16.93	16.75	-0.18	-0.02	-1.07			-0.01
	3	*Montastraea* sp.	79.94	119.15	39.21	4.10	49.04			0.49
	4	*Diploria strigosa*	17.19	16.69	-0.51	-0.05	-2.94			-0.03
11	1	*Diploria strigosa*	7.86	10.71	2.85	0.30	36.28	22.80	2.39	0.36
	2	*Montastraea* sp.	99.41	102.93	3.52	0.37	3.54			0.04
	3	*Montastraea* sp.	50.28	54.50	4.22	0.44	8.39			0.08
	4	*Montastraea* sp.	32.78	44.98	12.21	1.28	37.25			0.37
12	1	*Porites astreoides*	4.53	5.08	0.55	0.06	12.04	2.65	0.28	0.12
	2	*Porites astreoides*	3.91	4.38	0.47	0.05	12.02			0.12
	3	*Diploria strigosa*	6.07	6.52	0.45	0.05	7.35			0.07
	4	*Diploria strigosa*	4.12	4.52	0.40	0.04	9.59			0.10
	5	*Diploria strigosa*	13.88	14.67	0.79	0.08	5.70			0.06

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
12b	1	*Diploria strigosa*	47.49	50.65	3.16	0.33	6.66	2.30	0.24	0.07
	2	*Montastraea* sp.	3.45	2.79	-0.66	-0.07	-19.01			-0.19
	3	*Diploria strigosa*	82.50	83.03	0.53	0.06	0.64			0.01
	4	*Montastraea cavernosa*	21.78	21.05	-0.74	-0.08	-3.39			-0.03
14	1	*Diploria strigosa*	9.74	10.40	0.66	0.07	6.77	6.65	0.70	0.07
	2	*Montastraea* sp.	2.83	2.05	-0.78	-0.08	-27.40			-0.27
	3	*Montastraea* sp.	19.59	24.57	4.98	0.52	25.42			0.25
	4	*Diploria strigosa*	6.72	8.51	1.79	0.19	26.66			0.27
	5	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
15	1	*Montastraea* sp.	32.33	34.15	1.82	0.19	5.64	8.14	0.85	0.06
	2	*Montastraea* sp.	11.08	14.90	3.82	0.40	34.46			0.34
	3	*Montastraea* sp.	18.00	19.55	1.55	0.16	8.61			0.09
	4	*Montastraea* sp.	5.86	6.81	0.95	0.10	16.21			0.16
17	1	*Montastraea* sp.	33.67	32.59	-1.07	-0.11	-3.18	-25.41	-2.66	-0.03
	2	*Diploria strigosa*	20.61	18.25	-2.37	-0.25	-11.48			-0.11
	3	*Diploria strigosa*	34.95	29.19	-5.76	-0.60	-16.49			-0.16
	4	*Diploria strigosa*	77.25	69.69	-7.56	-0.79	-9.78			-0.10
	5	*Montastraea* sp.	13.19	4.54	-8.65	-0.91	-65.59			-0.66
17b**	1	*Montastraea* sp.	12.42	13.74	1.32	0.14	10.58	4.35	0.46	0.11
	2	*Diploria strigosa*	6.24	7.29	1.05	0.11	16.90			0.17
	3	*Montastraea* sp.	41.55	30.34	-11.21	-1.17	-26.98			-0.27
	4	*Diploria strigosa*	48.76	48.81	0.06	0.01	0.12			0.00
	5	*Diploria strigosa*	94.53	107.67	13.13	1.38	13.89			0.14

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

** Measurements from June 2005 (rather than November 2005)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
18	1	*Montastraea* sp.	59.14	68.22	9.09	0.95	15.37	25.05	2.62	0.15
	2	*Montastraea* sp.	192.76	198.23	5.47	0.57	2.84			0.03
	3	*Diploria strigosa*	14.83	16.26	1.43	0.15	9.63			0.10
	4	*Diploria strigosa*	18.18	18.36	0.19	0.02	1.02			0.01
	5	*Montastraea* sp.	64.66	73.54	8.88	0.93	13.73			0.14
18b	1	*Montastraea* sp.	5.01	4.46	-0.54	-0.06	-10.86	3.28	0.34	-0.11
	2	*Diploria strigosa*	1.28	1.20	-0.09	-0.01	-6.78			-0.07
	3	*Montastraea* sp.	4.65	8.52	3.87	0.41	83.12			0.83
	4	*Diploria strigosa*	5.41	5.46	0.04	0.00	0.82			0.01
20	1	*Montastraea* sp.	85.19	90.82	5.63	0.59	6.61	17.78	1.86	0.07
	2	*Montastraea cavernosa*	33.48	42.96	9.48	0.99	28.32			0.28
	3	*Diploria strigosa*	23.91	24.73	0.82	0.09	3.44			0.03
	4	*Montastraea cavernosa*	28.18	30.03	1.85	0.19	6.56			0.07
20b	1	*Diploria strigosa*	2.67	2.59	-0.08	-0.01	-3.09	0.84	0.09	-0.03
	2	*Diploria strigosa*	3.36	3.89	0.53	0.06	15.78			0.16
	3	*Diploria strigosa*	3.80	4.23	0.43	0.05	11.41			0.11
	4	*Montastraea* sp.	9.59	9.55	-0.04	0.00	-0.41			0.00
	5	*Montastraea* sp.	0.00	0.00	0.00	0.00	0.00			0.00
21	1	*Montastraea* sp.	17.82	24.32	6.51	0.68	36.51	-3.79	-0.40	0.37
	2	*Montastraea* sp.	6.09	4.15	-1.95	-0.20	-31.95			-0.32
	3	*Montastraea* sp.	23.81	25.14	1.32	0.14	5.56			0.06
	4	*Montastraea cavernosa*	59.47	58.16	-1.31	-0.14	-2.21			-0.02
	5	*Montastraea* sp.	68.43	60.07	-8.36	-0.88	-12.22			-0.12

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	44.85	45.85	1.00	0.11	2.24			0.02
	2	*Montastraea cavernosa*	12.17	14.05	1.89	0.20	15.50			0.16
21b	3	*Diploria strigosa*	54.58	46.21	-8.37	-0.88	-15.33	-1.58	-0.17	-0.15
	4	*Diploria strigosa*	49.96	50.47	0.51	0.05	1.02			0.01
	5	*Diploria strigosa*	18.12	21.51	3.39	0.36	18.71			0.19
	1	*Montastraea* sp.	20.51	18.16	-2.35	-0.25	-11.45			-0.11
	2	*Diploria strigosa*	21.50	21.09	-0.42	-0.04	-1.93			-0.02
22	3	*Colpophyllia natans*	10.86	12.91	2.05	0.21	18.91	12.75	1.34	0.19
	4	*Diploria strigosa*	31.59	32.22	0.63	0.07	1.99			0.02
	5	*Montastraea* sp.	33.97	46.81	12.83	1.34	37.78			0.38
	1	*Montastraea* sp.	22.35	27.45	5.11	0.53	22.85			0.23
	2	*Montastraea* sp.	48.27	63.24	14.97	1.57	31.01			0.31
23	3	*Montastraea* sp.	18.61	27.71	9.10	0.95	48.90	39.36	4.12	0.49
	4	*Diploria strigosa*	8.67	8.00	-0.67	-0.07	-7.74			-0.08
	5	*Diploria strigosa*	17.44	28.29	10.86	1.14	62.26			0.62
	1	*Montastraea* sp.	16.58	24.69	8.10	0.85	48.87			0.49
	2	*Montastraea cavernosa*	16.02	18.71	2.70	0.28	16.83			0.17
24	3	*Montastraea* sp.	43.81	45.04	1.23	0.13	2.82	6.39	0.67	0.03
	4	*Diploria strigosa*	11.01	11.12	0.12	0.01	1.05			0.01
	5	*Montastraea* sp.	84.79	79.03	-5.76	-0.60	-6.79			-0.07
	1	*Montastraea* sp.	1.60	1.66	0.06	0.01	3.64			0.04
25	2	*Montastraea* sp.	9.66	10.22	0.56	0.06	5.79	-1.99	-0.21	0.06
	3	*Montastraea* sp.	2.40	0.00	-2.40	-0.25	-100.00			-1.00
	4	*Montastraea* sp.	4.05	3.84	-0.21	-0.02	-5.14			-0.05

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm²)	Area of coral head in June 2006 (cm²)	Change in Area (cm²)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm²)	Total % change in Area within Quadrat	Proportional Change
26	1	*Diploria strigosa*	10.48	11.73	1.25	0.13	11.92	5.60	0.59	0.12
	2	*Diploria strigosa*	21.73	24.51	2.78	0.29	12.78			0.13
	3	*Diploria strigosa*	7.35	8.11	0.77	0.08	10.43			0.10
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
	5	*Diploria strigosa*	5.37	6.18	0.81	0.08	15.07			0.15
26b	1	*Montastraea* sp.	11.14	4.26	-6.88	-0.72	-61.74	-2.56	-0.27	-0.62
	2	*Montastraea* sp.	8.51	8.51	0.00	0.00	0.03			0.00
	3	*Diploria strigosa*	3.97	4.73	0.76	0.08	19.29			0.19
	4	*Diploria strigosa*	18.78	20.98	2.20	0.23	11.74			0.12
	5	*Diploria strigosa*	10.41	11.76	1.35	0.14	12.93			0.13
29	1	*Diploria strigosa*	27.56	13.24	-14.32	-1.50	-51.95	7.74	0.81	-0.52
	2	*Diploria strigosa*	30.70	31.90	1.20	0.13	3.90			0.04
	3	*Diploria strigosa*	92.35	113.21	20.86	2.18	22.58			0.23
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
	5	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
29b	1	*Diploria strigosa*	10.66	10.33	-0.34	-0.04	-3.14	8.56	0.90	-0.03
	2	*Montastraea* sp.	10.93	10.49	-0.44	-0.05	-4.07			-0.04
	3	*Montastraea cavernosa*	66.97	76.30	9.34	0.98	13.95			0.14
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
30	1	*Montastraea cavernosa*	35.61	12.57	-23.04	-2.41	-64.69	-18.01	-1.89	-0.65
	2	*Colpophyllia natans*	56.05	71.58	15.53	1.63	27.71			0.28
	3	*Montastraea cavernosa*	55.00	49.09	-5.91	-0.62	-10.75			-0.11
	4	*Montastraea cavernosa*	36.50	46.98	10.48	1.10	28.72			0.29
	5	*Diploria strigosa*	27.35	12.27	-15.08	-1.58	-55.13			-0.55

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	15.59	14.98	-0.61	-0.06	-3.90			-0.04
	2	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
30b	3	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00	1.54	0.16	0.00
	4	*Diploria strigosa*	7.58	8.84	1.25	0.13	16.52			0.17
	5	*Diploria strigosa*	10.63	11.53	0.90	0.09	8.44			0.08
	1	*Montastraea* sp.	26.94	23.21	-3.72	-0.39	-13.83			-0.14
	2	*Montastraea* sp.	2.22	2.18	-0.04	0.00	-1.94			-0.02
31	3	*Montastraea* sp.	6.60	6.86	0.26	0.03	3.98	2.13	0.22	0.04
	4	*Montastraea* sp.	7.68	8.38	0.70	0.07	9.11			0.09
	5	*Montastraea* sp.	23.76	28.69	4.93	0.52	20.76			0.21
	1	*Montastraea* sp.	10.38	14.03	3.65	0.38	35.15			0.35
33	2	*Montastraea* sp.	11.89	13.55	1.66	0.17	13.98	-1.48	-0.16	0.14
	3	*Montastraea* sp.	55.49	49.56	-5.93	-0.62	-10.68			-0.11
	4	*Montastraea cavernosa*	35.41	34.54	-0.86	-0.09	-2.44			-0.02
	1	*Montastraea* sp.	48.42	94.34	45.92	4.81	94.85			0.95
36	2	*Montastraea* sp.	0.35	0.85	0.50	0.05	141.24	43.93	4.60	1.41
	3	*Montastraea* sp.	2.31	0.00	-2.31	-0.24	-100.00			-1.00
	4	*Montastraea* sp.	0.19	0.00	-0.19	-0.02	-100.00			-1.00
	1	*Diploria strigosa*	62.14	72.52	10.38	1.09	16.70			0.17
	2	*Diploria strigosa*	15.00	16.67	1.67	0.18	11.16			0.11
38	3	*Colpophyllia natans*	91.83	113.04	21.21	2.22	23.09	47.18	4.94	0.23
	4	*Diploria strigosa*	11.26	12.78	1.52	0.16	13.51			0.14
	5	*Diploria strigosa*	30.66	35.59	4.93	0.52	16.07			0.16
	6	*Diploria strigosa*	43.17	50.65	7.48	0.78	17.32			0.17

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Study Site Repetitive Quadrats

November 2005 - June 2006

RQS #*	Coral Head #	Species	Area of coral head in Nov 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	8.34	8.97	0.63	0.07	7.51			0.08
	2	*Diploria strigosa*	22.04	20.57	-1.47	-0.15	-6.66			-0.07
UNK1***	3	*Montastraea* sp.	26.14	22.47	-3.67	-0.38	-14.05	-3.31	-0.35	-0.14
	4	*Diploria strigosa*	0.00	0.00	0.00	0.00	0.00			0.00
	5	*Montastraea* sp.	12.91	14.11	1.20	0.13	9.29			0.09
	1	*Colpophyllia natans*	11.71	11.17	-0.54	-0.06	-4.58			-0.05
	2	*Diploria strigosa*	26.76	17.47	-9.29	-0.97	-34.71			-0.35
UNK2***	3	*Montastraea* sp.	16.12	23.21	7.09	0.74	43.97	0.70	0.07	0.44
	4	*Diploria strigosa*	22.01	21.92	-0.09	-0.01	-0.41			0.00
	5	*Montastraea* sp.	27.47	31.00	3.52	0.37	12.83			0.13

* The RQS # is an identifier used during planimetry analysis (not necessarily corresponding to the station number)

*** unknown repetitive quadrat number

Note: Montastraea sp. refers to colonies belonging to the Montastraea annularis species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Deep Repetitive Quadrat Stations

June 2005 - November 2005

Station #	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
81	1	*Colpophyllia natans*	89.49	86.65	-2.84	-0.30	-3.17	-1.07	-0.11	-0.03
	2	*Colpophyllia natans*	4.11	5.06	0.95	0.10	22.99			0.23
	3	*Diploria strigosa*	68.85	55.06	-13.78	-1.44	-20.02			-0.20
	4	*Montastraea* sp.	62.28	76.90	14.61	1.53	23.46			0.23
82	1	*Montastraea cavernosa*	2.50	3.39	0.90	0.09	35.89	7.80	0.82	0.36
	2	*Montastraea cavernosa*	16.90	24.07	7.16	0.75	42.38			0.42
	3	*Colpophyllia natans*	15.51	15.24	-0.27	-0.03	-1.75			-0.02
	4	*Montastraea* sp.	29.71	29.72	0.01	0.00	0.04			0.00
83	1	*Montastraea* sp.	13.36	14.08	0.71	0.07	5.34	12.87	1.35	0.05
	2	*Montastraea cavernosa*	5.33	4.98	-0.35	-0.04	-6.55			-0.07
	3	*Montastraea* sp.	25.10	29.15	4.05	0.42	16.13			0.16
	4	*Montastraea cavernosa*	23.45	28.50	5.05	0.53	21.53			0.22
	5	*Montastraea* sp.	23.00	26.42	3.41	0.36	14.83			0.15
84	1	*Montastraea cavernosa*	39.48	32.72	-6.76	-0.71	-17.12	-2.92	-0.31	-0.17
	2	*Montastraea cavernosa*	19.47	18.64	-0.82	-0.09	-4.23			-0.04
	3	*Colpophyllia natans*	11.22	11.43	0.21	0.02	1.91			0.02
	4	*Montastraea* sp.	22.78	25.74	2.96	0.31	13.01			0.13
	5	*Montastraea cavernosa*	6.03	7.51	1.48	0.16	24.64			0.25
85	1	*Montastraea* sp.	1.97	2.23	0.26	0.03	13.44	0.12	0.01	0.13
	2	*Montastraea cavernosa*	0.63	1.09	0.46	0.05	72.46			0.72
	3	*Montastraea cavernosa*	39.87	37.30	-2.58	-0.27	-6.46			-0.06
	4	*Montastraea* sp.	13.55	16.34	2.78	0.29	20.53			0.21
	5	*Montastraea cavernosa*	17.00	16.19	-0.81	-0.08	-4.75			-0.05

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Deep Repetitive Quadrat Stations

June 2005 - November 2005

Station #	Coral Head #	Species	Area of coral head in June 2005 (cm^2)	Area of coral head in Nov 2005 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
86	1	*Colpophyllia natans*	159.85	183.68	23.83	2.50	14.91	31.00	3.25	0.15
	2	*Montastraea cavernosa*	49.02	68.44	19.42	2.03	39.62			0.40
	3	*Montastraea cavernosa*	25.29	27.52	2.22	0.23	8.79			0.09
	4	*Montastraea cavernosa*	43.83	29.35	-14.48	-1.52	-33.03			-0.33
87	1	*Montastraea* sp.	30.63	26.62	-4.02	-0.42	-13.12	-1.50	-0.16	-0.13
	2	*Montastraea* sp.	11.30	10.10	-1.20	-0.13	-10.66			-0.11
	3	*Montastraea* sp.	34.94	38.58	3.64	0.38	10.41			0.10
	4	*Montastraea* sp.	22.44	22.68	0.25	0.03	1.11			0.01
	5	*Diploria strigosa*	1.74	1.57	-0.17	-0.02	-9.58			-0.10
88	1	*Montastraea* sp.	15.48	15.72	0.24	0.03	1.56	4.35	0.46	0.02
	2	*Montastraea cavernosa*	31.38	31.39	0.01	0.00	0.04			0.00
	3	*Montastraea* sp.	12.74	15.60	2.86	0.30	22.44			0.22
	4	*Colpophyllia natans*	7.09	5.79	-1.30	-0.14	-18.32			-0.18
	5	*Montastraea* sp.	30.43	32.97	2.54	0.27	8.34			0.08
89	1	*Montastraea* sp.	11.11	10.62	-0.48	-0.05	-4.36	0.05	0.01	-0.04
	2	*Montastraea cavernosa*	4.26	3.66	-0.60	-0.06	-14.18			-0.14
	3	*Montastraea cavernosa*	42.11	41.38	-0.73	-0.08	-1.73			-0.02
	4	*Montastraea* sp.	4.87	3.66	-1.21	-0.13	-24.82			-0.25
	5	*Montastraea cavernosa*	10.20	13.27	3.08	0.32	30.16			0.30

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Deep Repetitive Quadrat Stations

November 2005 - June 2006

Station #	Coral Head #	Species	Area of coral head in November 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
82	1	*Montastraea cavernosa*	3.39	2.85	-0.54	-0.06	-15.93	-14.35	-1.50	-0.16
	2	*Montastraea cavernosa*	24.07	12.42	-11.65	-1.22	-48.40			-0.48
	3	*Colpophyllia natans*	15.24	11.88	-3.36	-0.35	-22.06			-0.22
	4	*Montastraea* sp.	29.72	30.92	1.20	0.13	4.04			0.04
83	1	*Montastraea* sp.	14.08	11.04	-3.03	-0.32	-21.54	-18.31	-1.92	-0.22
	2	*Montastraea cavernosa*	4.98	3.85	-1.13	-0.12	-22.64			-0.23
	3	*Montastraea* sp.	29.15	22.40	-6.75	-0.71	-23.15			-0.23
	4	*Montastraea cavernosa*	28.50	23.09	-5.41	-0.57	-19.00			-0.19
	5	*Montastraea* sp.	26.42	24.42	-1.99	-0.21	-7.54			-0.08
84	1	*Montastraea cavernosa*	32.72	38.51	5.79	0.61	17.69	5.37	0.56	0.18
	2	*Montastraea cavernosa*	18.64	21.64	3.00	0.31	16.09			0.16
	3	*Colpophyllia natans*	11.43	11.48	0.05	0.01	0.43			0.00
	4	*Montastraea* sp.	25.74	23.56	-2.19	-0.23	-8.49			-0.08
	5	*Montastraea cavernosa*	7.51	6.23	-1.28	-0.13	-16.99			-0.17
85	1	*Montastraea* sp.	2.23	1.85	-0.39	-0.04	-17.33	2.74	0.29	-0.17
	2	*Montastraea cavernosa*	1.09	0.83	-0.26	-0.03	-24.17			-0.24
	3	*Montastraea cavernosa*	37.30	39.51	2.21	0.23	5.93			0.06
	4	*Montastraea* sp.	16.34	12.90	-3.44	-0.36	-21.05			-0.21
	5	*Montastraea cavernosa*	16.19	20.81	4.62	0.48	28.54			0.29
86	1	*Colpophyllia natans*	183.68	143.07	-40.61	-4.25	-22.11	-34.63	-3.63	-0.22
	2	*Montastraea cavernosa*	68.44	70.29	1.85	0.19	2.70			0.03
	3	*Montastraea cavernosa*	27.52	24.07	-3.45	-0.36	-12.53			-0.13
	4	*Montastraea cavernosa*	29.35	36.93	7.58	0.79	25.81			0.26

Note: *Montastraea* sp. refers to colonies belonging to the *Montastraea annularis* species complex

Appendix 4: Repetitive Quadrat Planimetry Data

Deep Repetitive Quadrat Stations

November 2005 - June 2006

Station #	Coral Head #	Species	Area of coral head in November 2005 (cm^2)	Area of coral head in June 2006 (cm^2)	Change in Area (cm^2)	% Change in Area	% change in coral colony area	Total change in Area within Quadrat (cm^2)	Total % change in Area within Quadrat	Proportional Change
	1	*Montastraea* sp.	26.62	32.42	5.81	0.61	21.82			0.22
	2	*Montastraea* sp.	10.10	11.87	1.78	0.19	17.61			0.18
87	3	*Montastraea* sp.	38.58	38.40	-0.18	-0.02	-0.47	9.62	1.01	0.00
	4	*Montastraea* sp.	22.68	24.72	2.03	0.21	8.97			0.09
	5	*Diploria strigosa*	1.57	1.76	0.18	0.02	11.67			0.12
	1	*Montastraea* sp.	10.62	11.69	1.07	0.11	10.03			0.10
	2	*Montastraea cavernosa*	3.66	5.44	1.79	0.19	48.83			0.49
89	3	*Montastraea cavernosa*	41.38	42.05	0.67	0.07	1.61	3.59	0.38	0.02
	4	*Montastraea* sp.	3.66	4.81	1.14	0.12	31.25			0.31
	5	*Montastraea cavernosa*	13.27	12.20	-1.07	-0.11	-8.05			-0.08

Note: *Montastraea sp*. refers to colonies belonging to the *Montastraea annularis* species complex

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.