Coral Reefs of Carriacou Island, Grenadines, Grenada: Assessment of Condition and Key Threats

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Carriacou Environmental Committee

Executive Summary

This report summarizes the results of a coral reef monitoring training course and coral reef assessment conducted in the Carriacou Island of the Grenadines in the southern end of the Lesser Antilles between September 18th and 25th, 2005. The goal of this activity was to strengthen the capacity for co-management of the Sandy Island Oyster Bed Marine Protected Area (SIOB-MPA) in the subjects of resource management and zoning and provide a baseline assessment of the condition of coral reefs within and outside the park. Fifteen sites around Carriacou Island were assessed using the benthic and fish surveying methods of the Atlantic and Gulf Rapid Reef Assessment (AGRRA) program. Results indicate that Carriacou reefs are currently is fair shape-characterized by moderate live coral cover (~17%), low macroalgae (~13%), high coral recruitment (~7/m^2), and moderately high black long-spine sea urchin (*Diadema antillarum*) densities (~4/m^2). Of particular note during the surveys was the prevalence of physical damage caused by hurricanes Ivan (2004) and Emily (2005) to many of the reefs along the eastern side of Carriacou. In addition, substantial coral bleaching associated with an anomalously warm water temperatures documented in the eastern Caribbean during the fall of 2005 was observed on nearly all the reefs surveyed (Bleaching Index ~1.0). We estimate that the bleaching event (and associated coral diseases) caused fairly widespread mortality of stony corals (measured at approximately 11% loss in coral cover during a six month period from September, 2005 to January, 2006). Lingering diseases during the spring and early summer of 2006 are suspected to have further reduced coral biodiversity in Carriacou. The recovery of the reefs from last years hurricanes and bleaching impacts will depend on maintaining or enhancing coral recruitment on the reefs and limiting the spread and build-up of seaweed. Large-bodied parrotfishes and surgeonfishes along with long-spined sea urchins are the primary consumers of fleshy macroalgae on Caribbean coral reefs. However, the herbivorous fish biomass on Carriacou reefs is quite low at present (~1000 g/m^2) as is the overall fish biomass (~3100 g/m^2). The low fish biomass is attributed to the lack of large-bodied fishes (parrotfishes, groupers, snappers) during the surveys (as opposed to low fish densities) and overfishing of the reefs is suspected as the principal cause (although the impact of the recent hurricanes may have also contributed). Reducing the harvesting of large-bodied fishes in Carriacou is necessary to bring the reefs back into a healthier state whereby they will be better able to cope with disturbance events such as hurricanes and coral bleaching. Although fish biomass inside SIOB-MPA was higher than outside the park, it is still well below what might be considered a healthy state. Improved regulation of harvesting reef fishes within the SIOB-MPA should be a primary focus of the management plan now under development.

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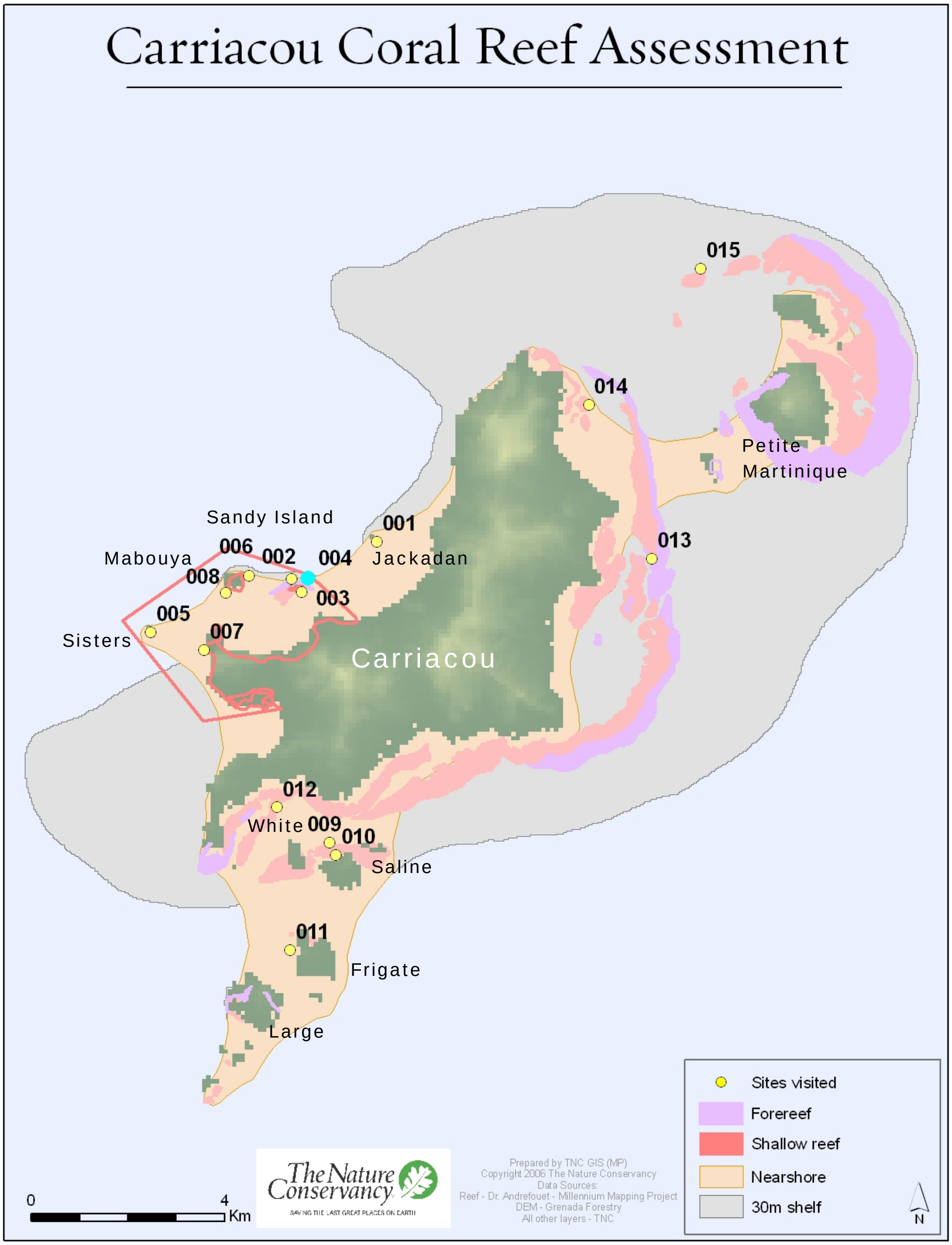
Table of Contents



Map of study area showing Carriacou Island surrounding offshore islands and rocks. Yellow dots show location waypoint numbers of 15 coral reef sites visited during the assessment of coral reefs during September, 2005. Shallow and fore reef classes were derived from Millenium reef maps. The Sandy Island Oyster Bed Marine Protected Area (SIOB-MPA) is shown as a red polygon on the SW side of Carriacou.

1 Introduction

Carriacou is the largest of the Grenadine islands in Grenada and a part of a chain of small islands, rocks and cays situated in between the main islands of Grenada and St. Vincent. The islands are the summits of ancient submerged volcanic mountains formed 50 million years ago. The name Carriacou originated from the original inhabitants, the Caribs, who aptly named it the "land surrounded by reefs." Today Carriacou home to about 8000 residents, most of whom are sustenance agriculturalists or fishermen.

Coral reefs occur around most of the offshore islands that surround Carriacou (Mabouya, Sister Rock, White, Saline, Jackadan, and Frigate). Of these, only the Sandy Island and sand bars around the White Island on the east are biogenic in their origin- that is derived from the sand associated with the shallow Acroporid reefs that surround them. The SIOB-MPA comprises an area of 787 hectares on the southwest coast of Carriacou (see Map). Another large protected area is proposed for the White Island/Saline Island on the southeastern side of Carriacou.

The coral reefs around Carriacou are recognized as the most diverse and extensive within Grenada and have been the subject of several investigations over the years. These include pioneering studies by Goodwin, et al. (1976) near Sandy and Jackadan islands. More recently, a general characterization of reefs and seagrasses around Carriacou was conducted by Price in 1998. In 2002, the National Oceanographic Atmospheric Administration (NOAA) sponsored a coral reef expedition that examined reefs around Carriacou and other islands in the Grenadines chain (Craig Dahlgren, personal communication).

The main threats causing damage to reefs in Grenada that have been identified in the past include: runoff, dredging, pesticides, coral harvesting, anchor damage from boats, and fishing by using explosives. Other threats included: coastal development, sewage pollution, and sand mining (Johnson, 1988). However, there remains little up-to-date and quantitative data on the condition and more recent threats to the coral reefs around Carriacou or within the SIOB-MPA. The passage of two large hurricanes in 2004 (Ivan) and 2005 (Emily) caused significant reworking of rubble and sediment on the eastern side (as evidenced by the creation of several new coral sand bars), but their effect on the reefs is unknown. The increase in coral bleaching associated with global climate change is also now being recognized as a major new threat facing Caribbean reefs. Large-scale representative reef surveys provide a baseline of reef health indicators and help direct management efforts to conserve coral resources and the services they provide to local stakeholders.

1.1 The Survey Team

The participants for the survey (and training) included: Philip Kramer and James Byrne from TNC, Jerry Mitchell and Paul Phillip from Grenada Fisheries, Clare Morral from St.

George's University, Kenroy Noel—the local fisherman, Cuthbert Snagg—the local water taxi operator, and Werner "Max" Nagel—the local dive operator.

The survey method—the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol, version 4.0 (www.agrra.org/method/methodology.html) was used. See Appendix IV for details on the training. AGRRA is an integrated approach to reef assessment that determines the condition of coral, fish and algae populations. Over 700 sites across most of the wider Caribbean countries have now been assessed using the AGRRA methodology providing a standardized database of indicators with which to compare findings.

1.2 Purpose of the Survey

The first objective of the assessment was to collect much needed information about the status and condition of Carriacou's coral reefs in order to quantitatively describe the fish and coral communities, and to aid in identifying threats and conservation strategies, and map priority sites in need of protection to be included in the formulation of the management plan and monitoring plan for the SIOB-MPA. Furthermore, the status of Carriacou reefs based on several coral reefs indicators can be compared to similar systems across Caribbean basin with the use of the common AGRRA methodology. Information from the assessment will be distributed to the stakeholders of the Carriacou and will serve as a preliminary database for the selection of potential monitoring sites and protected areas within the region. It will serve to increase the improvement of the scientific and socioeconomic basis of coral reef management.

The second objective was to train local representatives from the Grenada Department of Fisheries, St. George University of Grenada, and the Caribbean Environmental Committee (CEC) in order to enable utilization of local surveying crew for the future assessments of the status of coral reefs without reliance on outside sources to conduct the surveys.

2 Methods

2.1 Site Identification

Coral reef survey locations were chosen either strategically based on where previous monitoring had taken place or using randomized stratification strategy based on satellite imagery interpretation of reef geomorphological features from the Millennium Coral Reef Mapping Project [1]. A total of fifteen (15) sites were investigated. Most were located in the vicinity of the pre-existed sites surveyed by the National Oceanic & Atmospheric Administration (NOAA) in 2002. Eight of the sites were spanning the reef development of the central west of Carriacou; four were located in the southwestern part, and three to the east and northeast of the island. The sites were documented with photographs and video footage of reef habitats and organisms.

[1] http://imars.usf.edu/corals/index.html

2.2 Benthic Surveys

Two to four 10m-long benthic transect surveys were performed at each site to assess: (1) the density of the long-spined sea urchin *Diadema antillarum*; (2) the size and condition of coral individuals; (3) the percent cover of the major benthic components; (4) the macroalgae height, reef relief, and density of small (< 2 cm) stony corals termed "recruit".

2.2.1 The long-spined sea urchin *Diadema antillarum*

The density of the long-spined sea urchin *Diadema antillarum* was assessed by counting the total number of individuals within 0.5m of the each side of the transect line, encompassing 10 square meters of total transect area. The classification into adults and juveniles was based on the coloration of spines of individuals: juveniles—with black and white markings on the spines, while adults—with only black coloration.

2.2.2 Coral size and condition

The corals in each transect were recorded if the coral colony measured more than 10cm in diameter and was directly located beneath the transect line. The information recorded included: (1) species name; (2) depth; (3) size (diameter and height perpendicular to the axis of growth); (4) substrate type; (5) percent living under the transect line; (6) "recent partial mortality" (corallite structure identifiable to genera), or "old partial mortality" (corallite structure non-identifiable or covered thickly by organisms); (7) disease type if infected (identification of diseases based on the Coral Disease Identification and Information webpage found in the NOAA Coral Health and Monitoring Program website (www.coral.noaa.gov/coral_disease); and (8) percent bleached if affected. Coral bleaching was quantified as either pale, partly bleached or bleached and results rolled up into a Bleaching Index (BI) that ranged from 0 to 3 based on a weighted average for the number of colonies with normal =0, pale =1), partly bleached = 2 and bleached = 3 (McClanahan et al., 2005).

2.2.3 Percent cover of major benthic components

The percent cover was estimated for each of the major benthic components directly under the transect line, and included: sand, live coral, crustose coralline algae, fleshy macroalgae, calcareous macroalgae, and any other sessile benthic animals (e.g. gorgonians, sponges, zoanthids, tunicates, etc.). The percent cover was determined by recording and talling the total length (in cm) of each benthic component directly under the transect tape.

2.2.4 Macroalgae height, reef relief, and recruitment

The macroalgae height, reef relief (i.e. rugosity), and recruitment was assessed by placing a 25x25cm quadrat every 2 meters along the transect line (at 1,3,5,7, and 9m marks), directly under the meter mark. The information for each quadrat included: (1) the substratum (pavement, live coral, dead coral, rubble, or sand); (2) the approximate average canopy height (cm) of all fleshy macroalgae, using a plastic ruler; (3) the approximate average canopy height (cm) of all calcareous macroalgae; (4) the maximum reef relief (cm), measured as the height of the tallest coral or reef rock above the lowest point in the underlying substratum within the quadrat; and (5) the total number of stony coral recruits (< 2cm), and the genus or species identification for each recruit.

2.3 Fish Surveys

The fish surveying method used 60m^2 belts transects survey to assess fish species and size and provides a quantitative and standardized measurement of fish density. Two divers conducted 5-10 haphazardly-positioned belt transects at each site. Divers swam the 30m distance within 5-8minutes, counting all fish from a predetermined list within an imaginary 2 meter wide area extending 2m up from the benthic floor. The fish species counted represent common species identified by the AGRRA program (see Table 2). Fish were assigned to one of six size categories (<5cm, 5-10, 10-20, 20-30,30-40, and >40cm) using a 1m "T-bar" with 5cm increment to help in assessing sizes. Juvenile grunts and parrotfish, were not counted if <5cm since species identification can be difficult within this size category. Biomass conversions were derived from standardized length-weight conversion coefficients from AGRRA spreadsheets.

3 Results

A number of different reef types were sampled during the course of the survey. For presentation of the results, these were grouped into two reef types- shallow (< 5 m) and deep (> 5 m). Furthermore, in order to observe the degree of effectiveness of the existing marine protected area, the survey sites were chosen for two categories: within and outside of the SIOB-MPA, located on the southwestern side of Carriacou Island.

3.1 Reef Zones

The Millennium Coral Reef Mapping Project identifies several reef types which have been grouped into a "deep reef zone" category—these include lagoon terrace, fore-reef, intertidal reef flat (faru), outer slope, and undetermined envelop. The majority of all surveyed sites (11) were found within the deep reef zone. Seven sites were located in the western region of Carriacou, and six of them were within the Sandy Island MPA. The remaining four were outside of the MPA, including two in the southwestern region—the Saline Island Channel (WPT10) and the Frigate Island (WPT11), and two in the eastern and northeastern parts off the Coast of Carriacou Island—NE Pass (WPT13) and Shoal (WPT15) (Table 1). The average depth of deep reef zone sites ranged between 5.9 and 15.5 meters, with an average of 8.9 meters. The rugosity of the deep reef zone ranged from 49 to 101cm, with an average relief of the substrate equaling to 67.5 cm (Table 3).

"Shallow reef zone" category included: intertidal reef flat and reef flat of the Millennium Project level 3 classes. Four sites were classified as shallow reef sites. The only site surveyed in the western region was the Sandy Island Shallow (WPT3) site found within the Sandy Island Marine Protected Area. Three other sites were located outside of protected area; White Island Shallow (WPT9) and Cassada Bay (WPT12) were situated south of the MPA in the southwestern region of Carriacou, and the High North-Shallow (WPT14)—in the northeastern region of the island. The average depth of shallow reef sites ranged between 2.4 and 3.3meters, with an average of 2.7m (Table 1). The average relief of the substrate equaled 86.5cm, ranging from 72 to 104cm (Table 3).

3.2 Coral

A total of 476 coral colonies were evaluated on deep reef (Table 3). Average live coral cover was 23.1%, and ranged from 6.2% at the NE Pass (WPT13) to 40.1% at the Frigate Island (WPT11) (Figure 1). The condition of coral colonies was evaluated using estimates of partial colony mortality categorized into old partial mortality (no corallite structure identifiable) and recent partial mortality (corallite structure still identifiable or covered by a thin layer of filamentous algae). Old partial mortality averaged 26.1%, making it lower on deep reefs than the shallow ones, and ranged from 14% at the NE Pass (WPT13) to 38% at Jackadan Island (WPT1) located outside of the MPA and at the Point Cistern (WPT7) located within the MPA (Table 4; Figure 2). Recent partial mortality was lower than at the shallow reef sites averaging 2.7% cover, while the percent of the colonies that were 100% dead equaled 4.3% (Table 4; Figure 2). Coral bleaching (pale to fully bleached) was observed at all the sites surveyed. The Bleaching Index was slightly higher for deeper reef (1.2) with partly bleached colonies being the most frequently observed (Figure 3). Coral diseases were fairly low (~1%) and observed at only five sites and included red band (red cyanophytic overgrowth), black band, and white plague (Table 4; Figure 4).

Overall, 81 coral colonies were evaluated in the shallow reef zone (Table 3). As exemplified in Table 3, Sandy Island Shallow (WPT3)—the shallow reef zone within the MPA averaged 21.2% of live coral covering the available substrate. Contrastingly to all of the assessed zones in this category, the live coral cover for the sites located outside the MPA, White Island Shallow (WPT9), Cassada Bay (WPT12), and High North-Shallow (WPT14), was almost non-existent, ranging from 1.9% to 3.6%. In all, the shallow zone averaged only 7.2%. The average old partial mortality for was double than the average for the deep reef category—with the 57.8%, equaling high 88% at the High North-Shallow (WPT14), the recent partial mortality was almost double averaging 4.6% with the highest percentage of 15.1 at the Cassada Bay (WPT12) (Table 4). Furthermore, the assessed shallow reef colonies recorded as standing dead, were quadruple of the number at the deep reefs, equaling 18.9%, with the highest being at the White Island Shallow (WPT9)—35.1%, and the lowest one being at the MPA protected Sandy Island Shallow (WPT3)—5.6%. The disease factor was non-existent for Sandy Island Shallow (WPT3) and quite insignificant (1.1%) for the three sites located outside of MPA (Table 4; Figure 4).

3.3 Algae (seaweed)

Macro-algal abundance was evaluated for all deep reef sites (Table 5A). The average crustose coralline algal abundance ranged from 1.7% at the NE Pass site (WPT13) site to 10.9% at the Sister Rocks (WPT5), with a total average of 5.0%. Fleshy macro-algal abundance was quite variable at the deep reef sites, varying from 0.8% at the Mabouya-North (WPT6) site to 35.5% at the Lighthouse (WPT4), with an average of 17.2%. The average calcareous macro-algae was almost non-existent at many deep reef sites, except for the Sister Rocks (WPT5), the Saline Island Channel (WPT10), and the Frigate Island (WPT11), and averaging only 0.3% (Figure 5). Fleshy Macro Index showed a high disparity between the deep and shallow reef sites, averaging 46. for the deep reef and only 1.6 for the shallow reef sites, while the Calcareous Macro Index was almost 30 times lower for the deep reef zone equaling 0.5, while the one for the shallow reef zone equaled 14 (Table 5B).

The average crustose coralline algal abundance on shallow reefs ranged from 6.6% at Sandy Island (WPT3) site to 26% at White Island (WPT9), averaging 14.6% at all shallow reef sites—triple amount of that at the deep reef category (Table 5A). The average fleshy macro-algal cover was five-times lower than that of deep reef category and equaled 3.2% and only varied slightly (about 5%) between the extreme sites. The calcareous macro-algae at the shallow reef zone averaged 4.8%, with the highest percentage at the High North-Shallow (WPT14), however was not observed at the Sandy Island Shallow (WPT3).

3.4 Coral Recruits and Sea Urchin (*Diadema antillarum*) Populations

Coral recruits quantified as the density of small (<2cm) corals within 25x25 cm quadrats placed along the transect line. The small total area of bottom surveyed at each site (~1 m) is not considered sufficient for accurate assessment of actual recruitment densities. The results indicate recruitment densities ranged from 1 to 14/m^2 with an average of 6.9/ m^2 (Table 5B; Figure 7). The most frequently observed recruits were *Porites* and *Agaricia*, both of which include species of fast-growing corals that often settle in high densities. Other individuals identified included those belonging to the genera *Favia*, *Millepora Siderastrea*, *Diploria*. No recruits were of the *Monastrea* species complex, species. The long-spined sea urchin, *Diadema antillarum*, was observed at five of the fifteen sites up to densities of 22/10m^2 at the shallow Cassada Bay (WPT12) site (Table 5B; Figure 6). The average density for all reefs combined was 3.8/m^2, with significantly higher densities observed at shallower depths.

3.5 Fish

The average total density of all target fishes combined for deep sites averaged 59 individuals per 100 square meters, with the lowest density at Jackadan Island (WPT1)—21.7, and highest at the Shoal (WPT15), averaging 119.4 individuals per 100 square meters (Table 6). Fish density was higher on shallow reef zones than deep reef zones. The average biomass calculated in grams per 100 square meters was higher in the deep reef zones ~3444 g/100m^2) than the shallow ones (~555 g/100m^2). The highest biomass occurred at the Mabouya-North (WPT6)—8060 g/100m^2. The low biomass and density at the Jackadan Island results from much lower number of transects at this site. Sizes of large-bodied growing fishes were skewed towards smaller sizes with very few parrotfish, groupers, or snappers observed larger than 20 cm (Figures 9, 10)

For shallow sites, the average total density of all target fish combined averaged 80.8 individuals per 100 square meters, with the lowest one at the Cassada Bay (WPT12)—63.9, and the highest, at the similarly unprotected area—the High North-Shallow (WPT14), averaging 101.3 individuals per 100 square meters (Table 6). The average biomass averaged 2266.5 grams per 100 square meters, with the lowest mass at the unprotected by the MPA— High-North-Shallow (WPT14), equaling 1231.07, and the highest biomass at the protected Sandy Island Shallow (WPT3), and equaling 3087.55 grams per 100 square meters

4. Discussion

The AGRRA survey undertaken in Carriacou represents one of the first comprehensive surveys of both— the benthic and fish communities in the area. Comparisons to pre-existing coral reef monitoring datasets for Carriacou which might allow determination of change is difficult because earlier monitoring data is either not directly comparable (e.g., different indices) or not published. Comparisons can be made for a number of different indices between results from this survey and results from other surveys in other countries completed with identical methods and reported in the AGRRA database (Lang, 2003; Kramer, 2003). These comparisons allow placing Carriacou within a regional “context” for coral, algae, and fish community indices. Values for comparison were obtained from the AGRRA summary products website, released in August, 2005. Comparisons are made across all zones for the purpose of showing the gross trends and are mainly reflective of the fore-reef community types where most AGRRA surveys have taken place.

Based on this survey and in comparison to other similar surveys in the Caribbean region, the benthic communities around Carriacou appear to be in a fair condition. The average coral cover for all Carriacou sites was near 19.4% which is slightly lower than the average for all other Caribbean sites recorded in the AGRRA database (Figure 11). Live coral cover was slightly higher inside the SIOB-MPA than outside probably as a result of the recent damage caused by the passage of hurricanes Ivan and Emily which was higher on the eastern side of the island than the western side. Partial old coral mortality was very high for Carriacou reefs (>30%) largely because of the abundance of standing dead corals and broken corals from the passage of the hurricanes (Figure 12).

Wide-scale bleaching observed during the survey period on nearly all the reefs has also caused significant coral mortality. Re-surveys conducted at six of the sites in January, 2006 showed a 10% loss in coral cover for just these sites (from 22.6% to 20.1%) and a major increase in recent mortality (2.1% to 17.6%) (Table 7). Coral disease both during the survey (September, 2005) and in January, 2006 appear to remain low to moderate (<1%) (Table 7). This is somewhat surprising given that recent studies have been observing outbreaks of coral disease linked to bleaching events in the Caribbean (M. Brandt, personal communication). Recent observations in the U.S. Virgin Islands indicate that both white plague and black band outbreaks occurred 2-6 months after peak bleaching (Caroline Rogers, personal communication). Therefore, it is possible that the onset of coral diseases occurred after the January, 2006 assessment and that coral mortality is significantly greater than is portrayed in this report.

The amount of seaweed on Carriacou reefs is fairly low (average 45) compared to other Caribbean locations (average 145) (Figure 13). However, the macroalgal index was locally high at some of the fore-reef sites (>100) and indicates there may be some local factors causing patchiness. Large variations in sea urchin and parrotfish densities explain some of this but it is probably also a function of a variation in the physical environment around Carriacou (wave energy, currents, turbidity). There may also be some effect of localized point source nutrients contributing to the amount of macroalgae at some sites, but more detailed water quality assays are needed to verify this. Coral recruits were also fairly high in Carriacou (average ~7/m^2) compared to the Caribbean average (~2.5/m^2) but was dominated by brooding species rather than the reef building broadcasters (Figure 14). This would suggest that coral larval supply may be fairly high around Carriacou and that recovery from disturbance events may be comparatively rapid.

When total average biomass is calculated (based on abundance and size combined) Carriacou reefs score significantly lower than most other Caribbean countries and only half of the Caribbean average (Figure 15). The average density (~64/100m^2) was actually above the Caribbean average suggesting that small sizes of fishes are the main reason behind the low biomass observations. Very few fish larger than 20 cm were observed during the surveys, with the exception of Jacks, some Snappers, and only one Parrotfish greater than 30 cm. When average biomass for Carriacou reefs are broken down into groups and compared to other Caribbean countries within the database, values for herbivorous fish families (i.e. parrot and surgeon fish) compare poorly with other countries (Figure 16, 17). Grouper and Snapper biomass (not shown) also compare poorly to other Caribbean countries. Overfishing of large-bodied fishes is considered the prime reason for this pattern. Fisheries reports from Carriacou suggest that demersals targeted by fisherman are mainly snappers (*Lutjanidae sp*.) including L. buccanella, grouper types (*Serranidae sp*.), Red hind (*Epinephelus guttatus*), Coney or Butterfish (*Epinephelus fulvus*) Warsaw, Black and Tiger groupers; Parrot fishes (*Scaridae sp*.); Grunts (*Pomadasyidae sp*.), Queen Trigger fish (*Balistes vetula*), Doctor or Surgeon fishes (*Acanthuridae sp*.) (ICLARM, 1988). All of these species were observed but in only small-size classes. Although most fishing in Carriacou is artesinal, it is widespread and utilizes many different gear types (spear fishing, pot fishing, and gill nets. etc.). Furthermore, fishing takes place on nearly all the reefs leaving only few places for fish to grow large. Large-bodied parrotfish in particular are considered the most important grazers of seaweed on Caribbean reefs and are remarkably absent on Carriacou reefs.

The recovery of the reefs from the last years' hurricane and bleaching impacts will depend on maintaining or enhancing coral recruitment on the reefs and limiting the spread and build-up of macroalgae. The continued increase in Diadema densities around

Carriacou is an important factor in reducing macroalgal biomass as it is one of the primary consumers of seaweed (Edmunds and Carpenter, 2001). Large-bodied parrotfishes and surgeonfishes are also the primary consumers of fleshy macroalgae on coral reefs. However, herbivorous fish biomass on Carriacou reefs is quite low at present (~1000 g/m^2) as is overall fish biomass (~3100 g/m^2). The low fish biomass is attributed to the lack of large-bodied fishes (parrotfish, groupers, snappers) during the surveys (as opposed to low fish densities), and overfishing of the reefs is suspected as the principal cause (although the impact of the recent hurricanes may have also contributed). Reducing the harvesting of large-bodied fishes in Carriacou is necessary to bring the reefs back into a healthier state whereby they will be better able to cope with disturbance events such as hurricanes and coral bleaching. Although fish biomass inside SIOB-MPA was substantially higher than outside the park, it is still well below what might be considered a healthy state. Improved regulation of harvesting reef fishes within the SIOB-MPA should be a primary focus of the management plan now under development.

5. Summary and Recommendations

The coral reefs around Carriacou are in fair shape compared to other reef areas in the Caribbean. There has been a significant loss of live coral from hurricanes (Ivan and Emily) and the 2005 coral bleaching event. The reefs appear to have ample potential for recovery as indicated by other indicators such as the abundance of coral recruits and increasing densities of the black long-spined urchin, *Diadema antillarum*. Seaweed abundance, although presently low, is expected to increase in the next several years as it occupies the dead coral space recently lost coral bleaching and disease. This could significantly delay the recovery of the reefs by inhibiting new coral recruitment and increasing post-settlement mortality of small corals. At the moment, fish communities on Carriacou reefs are dangerously unhealthy with low overall biomass and a lack of large-bodied herbivores and carnivores. Efforts should be focused on improving the management of fishing practices around Carriacou to improve the state of the reef fish stocks and to reduce other stressors to the reefs during this period of recovery.

Particular recommendations for the SIOB marine protected area include:

1. Reduce harvests of large-bodied (>30 cm) fishes around well developed high relief reefs (as opposed to hardbottom areas). Particular focus should be reducing the take of large herbivorous parrot fishes within the SIOB-MPA (Sandy Island and the shelf slope break from Jackadan around to Mabouya). Consider slot limits, restricting fishing gear along with zoning as possible strategies to accomplish this.

2. Develop management plan for the Park with zoning that includes at least 30% "no take" areas. Consider user conflict areas within SIOB-MPA (e.g. where fishing activities interfere with recreational diving activities) as candidates for no-take areas.

3. Develop a public engagement strategy with Carriacou fishermen and increase their awareness of coral reefs and what healthy trophic balances look like- consider an exchange program to either Bonaire or St. Lucia.

4. Collaborate with the Fisheries Department to enhance existing fishing regulations against inappropriate fishing practices.

5. Remove garbage and lost fishing gear from coral reefs on a regular basis- conduct annual or biannual trash sweeps of reefs with volunteers.

6. Develop mooring buoy program for SIOB (installation and maintenance) within the SIOB MPA, targeting heavily visited coral reef areas (Sandy Island, Mabouya). Consider adding mooring buoys to other heavily used reefs outside of the SIOB MPA (e.g. White Island reef).

7. Develop an annual monitoring program for SIOB on 2-4 sites (shallow and deep) using fixed transects. Simple methods such as REEFCHECK are recommended. Indices to track include live coral cover, macroalgal index (amount and height of seaweed), coral recruitment, and reef fish density and size.

8. Repeat AGRRA surveys across multiple sites and reef types every five years to quantify how the condition of Carriacou reefs as a whole are changing and responding to climate change and other larger-scale threats.

9. Investigate implementation of small-scale experimental restoration projects such as relocating black sea urchins (adults and juveniles) from areas of high density (e.g. Cassada Bay) to areas of low density and where seaweed overgrowth may be inhibiting coral settlement (e.g. Point Cistern)

6. References:

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Appendix 1: Tables

Table 1: Surveyed Sites' Description

Site Code	Site Name	Region	Date Surveyed	Avg. Depth (m)	St. Dev.	Latitude(N)	Longitude (W)	MPA ?	Reef Category	Millenium L-3 Category
WPT1	Jackadan Island	W	9/20/2005	6.1	0.2	12.49415	-61.46627	No	Deep	Lagoon Terrace
WPT2	Sandy Island Deep	W	9/21/2005	7.3	0.8	12.48727	-61.48251	Yes	Deep	Fore-reef
WPT3	Sandy Island Shallow	W	9/21/2005	2.4	0.4	12.48475	-61.48052	Yes	Shallow	Intertidal Reef Flat
WPT4	Lighthouse	W	9/21/2005	6.8	0.7	12.48732	-61.47951	Yes	Deep	Fore-reef
WPT5	Sister Rocks	W	9/22/2005	15.5	1.5	12.47740	-61.50935	Yes	Deep	Undetermined Envelop
WPT6	Mabouya North	W	9/22/2005	10.7	2.9	12.48787	-61.49054	Yes	Deep	Undetermined Envelop
WPT7	Point Cistern	W	9/22/2005	5.9	0.7	12.47405	-61.49924	Yes	Deep	Undetermined Envelop
WPT8	Mabouya South	W	9/22/2005	9.6	1.1	12.48475	-61.49507	Yes	Deep	Lagoon Terrace
WPT9	White Island Shallow	SW	9/23/2005	2.5	0.9	12.43788	-61.47553	No	Shallow	Intertidal Reef Flat
WPT10	Saline Island Channel	SW	9/23/2005	7.9	1.1	12.43554	-61.47436	No	Deep	Intertidal Reef Flat
WPT11	Frigate Island	SW	9/23/2005	9.1	1	12.41777	-61.48318	No	Deep	Lagoon Terrace
WPT12	Cassada Bay	SW	9/23/2005	2.5	0.5	12.44446	-61.48554	No	Shallow	Reef Flat
WPT13	NE Pass	E	9/23/2005	11.2	0.5	12.49064	-61.41398	No	Deep	Outer Slope
WPT14	High North-Shallow	NE	9/24/2005	3.3	0.9	12.51953	-61.42577	No	Shallow	Intertidal Reef Flat
WPT15	Shoal	NE	9/24/2005	8.0	2.8	12.54491	-61.40434	No	Deep	Intertidal Reef Flat

Table 2: List of fish by family assessed with the AGRRA methodology

Table 2:

Common Name	Scientific Name	Common Name	Scientific Name
Angelfishes		***Groupers***	
Queen	*Holacanthus ciliaris*	Rock Hind*	*Epinephelus adscensionis*
Rock Beauty	*Holacanthus tricolor*	Graysby	*Epinephelus cruentatus*
Gray	*Pomacanthus arcuatus*	Coney*	*Epinephelus fulvus*
French	*Pomacanthus paru*	Red hind*	*Epinephelus guttatus*
Butterflyfishes		Nassau*	*Epinephelus striatus*
Longsnout	*Chaetodon aculeatus*	Black*	*Mycteroperca bonaci*
Foureye	*Chaetodon capistratus*	Yellowmouth*	*Mycteroperca interstitialis*
Spotfin	*Chaetodon ocellatus*	Tiger*	*Mycteroperca tigris*
Reef	*Chaetodon sedentarius*	Yellowfin*	*Mycteroperca venenosa*
Banded	*Chaetodon striatus*	***Snappers***	
Grunts		Mutton*	*Lutjanus analis*
Black Margate*	*Anisotremus surinamensis*	Schoolmaster*	*Lutjanus apodus*
Porkfish	*Anisotremus virginicus*	Cubera*	*Lutjanus cyanopterus*
White Margate*	*Haemulon album*	Gray*	*Lutjanus griseus*
Tomtate	*Haemulon aurolineatum*	Dog*	*Lutjanus jocu*
Caesar	*Haemulon carbonarium*	Mahogany*	*Lutjanus mahogoni*
Smallmouth	*Haemulon chrysargyreum*	Lane*	*Lutjanus synagris*
French*	*Haemulon flavolineatum*	Yellowtail*	*Ocyurus chrysurus*
Spanish	*Haemulon macrostomum*	***Surgeonfishes***	
Sailors choice	*Haemulon parra*	Ocean	*Acanthurus bahianus*
White	*Haemulon plumieri*	Doctorfish	*Acanthurus chirurgus*
Bluestriped	*Haemulon sciurus*	Blue Tang	*Acanthurus coeruleus*
Parrotfishes		***Leatherjacket***	
Midnight	*Scarus coelestinus*	Scrawled Filefish	*Aluterus scriptus*
Blue	*Scarus coeruleus*	Queen triggerfish	*Balistes vetula*
Striped	*Scarus croicensis*	Whitespotted filefish	*Cantherhines macroceros*
Rainbow	*Scarus guacamaia*	Orangespotted filefish	*Cantherhines pullus*
Princess	*Scarus taeniopterus*	Ocean triggerfish*	*Canthidermis sufflamen*
Queen	*Scarus vetula*	Black Durgon	*Melichthys niger*
Greenblotch	*Sparisoma atomarium*	Sargassum triggerfish	*Xanthichthys ringens*
Redband	*Sparisoma aurofrenatum*	***Other fishes***	
Redtail	*Sparisoma chrysopterum*	Spanish Hogfish	*Bodianus rufus*
Redfin	*Sparisoma rubripinne*	Bar Jack*	*Caranx ruber*
Stoplight	*Sparisoma viride*	Hogfish	*Lachnolaimus maximus*
		Yellowtail Damselfish	*Microspathodon chrysurus*
		Great Barracuda	*Sphyraena barracuda*

*Fishery importance of species is defined as "commercially significant" by FishBase

Table 3: Site Information

Site Code	Site Name	Reef Type	MPA ?	Total # of Colonies	Avg. Live Coral Cover (%)	St. Dev.	Avg. # of Coral Recruits/m2	St. Dev.	Avg. Rugosity (cm)	St. Dev.
WPT1	Jackadan Island	Deep	No	35	17.4	3.9	14.4	2.0	53.0	7.8
WPT2	Sandy Island Deep	Deep	Yes	42	17.9	2.0	4.3	4.0	50.0	13.0
WPT3	Sandy Island Shallow	Shallow	Yes	20	21.2	4.0	8.5	7.0	79.0	6.4
WPT4	Lighthouse	Deep	Yes	40	10.2	5.0	12.0	8.0	51.0	19.6
WPT5	Sister Rocks	Deep	Yes	82	25.9	9.0	12.0	6.0	60.0	16.5
WPT6	Mabouya-North	Deep	Yes	74	32.9	10.0	4.0	5.0	70.0	54.0
WPT7	Point Cistern	Deep	Yes	41	10.3	3.0	2.4	3.0	65.0	16.8
WPT8	Mayouba South	Deep	Yes	63	27.9	13.0	7.2	8.0	59.0	16.1
WPT9	White Island Shallow	Shallow	No	40	1.9	1.0	9.6	5.0	72.0	34.1
WPT10	Saline Island Channel	Deep	No	23	39.6	0.0	4.0	6.0	91.0	10.8
WPT11	Frigate Island	Deep	No	44	40.1	4.0	11.2	7.0	101.0	35.2
WPT12	Cassada Bay	Shallow	No	15	2.1	1.0	5.3	7.0	91.0	2.3
WPT13	NE Pass	Deep	No	16	6.2	6.0	1.6	2.0	49.0	19.1
WPT14	High North-Shallow	Shallow	No	6	3.6	3.0	3.2	5.0	104.0	31.1
WPT15	Shoal	Deep	No	16	26.2	0.0	4.8	7.0	94.0	8.5
Deep-all				476.0	23.1	5.1	7.1	5.3	67.5	19.8
Shallow-all				81.0	7.2	2.3	6.7	6.0	86.5	18.5
Inside MPA				362.0	20.9	6.6	7.2	5.9	62.0	20.3
Outside MPA				195.0	17.1	2.4	6.8	5.1	81.9	18.6
All Sites				557.0	18.9	4.3	7.0	5.5	72.6	19.4

Table 4: Coral Colony Information

Site Code	Avg. Old Partial Mortality (%)	St. Dev.	Avg. Recent Partial Mortality(%)	St. Dev	Colonies that were 100% Dead	St. Dev.	Avg. % Diseased	St. Dev.	Bleach Index (0-3)	St. Dev.
WPT1	38.0	17.0	0.3	0.4	17.3	19.5	0.0	0.0	0.5	0.5
WPT2	27.0	4.0	2.9	2.7	2.4	4.1	0.0	0.0	1.2	0.3
WPT3	38.0	1.0	1.3	1.7	5.6	9.6	0.0	0.0	0.7	0.7
WPT4	28.0	10.0	5.1	2.4	11.5	15.7	2.3	4.5	0.9	0.5
WPT5	17.0	6.0	1.1	0.6	0.0	0.0	1.2	2.4	1	0.3
WPT6	22.0	14.0	3.8	2.6	0.0	0.0	1.5	2.9	1.4	0.8
WPT7	38.0	17.0	5.4	4.9	1.5	2.9	7.2	5.4	1.2	0.5
WPT8	25.0	8.0	1.2	1.6	5.6	11.1	0.0	0.0	1.3	0.7
WPT9	71.0	15.0	2.0	1.8	35.1	15.5	3.3	5.8	0.2	0.3
WPT10	29.0	7.0	1.9	1.5	3.3	5.8	0.0	0.0	1.2	0.8
WPT11	29.0	5.0	2.6	1.3	0.0	0.0	0.0	0.0	1.5	0.6
WPT12	34.0	22.0	15.1	13.3	25.0	25.0	0.0	0.0	0.6	0.5
WPT13	14.0	8.0	1.5	2.6	0.0	0.0	0.0	0.0	0.6	0.4
WPT14	88.0	4.0	0.0	0.0	10.0	14.1	0.0	0.0	0.5	0.7
WPT15	20.0	0.0	4.0	0.6	5.6	7.9	0.0	0.0	1.9	0.3
Deep-all	26.1	8.7	2.7	1.9	4.3	6.1	1.1	1.4	1.2	0.5
Shallow-all	57.8	10.5	4.6	4.2	18.9	16.1	0.8	1.5	0.5	0.6
Inside MPA	27.9	8.6	3.0	2.4	3.8	6.2	1.7	2.2	1.1	0.5
Outside MPA	40.4	9.8	3.4	2.7	12.0	11.0	0.4	0.7	0.9	0.5
All Sites	34.5	9.2	3.2	2.5	8.2	8.7	1.0	1.4	1.0	0.5

Table 5A: Macro-algae Summary

Site Code	Avg. Live Coral Cover (%)	St. Dev.	Avg. Crustose Coralline(%)	St. Dev.	Avg. Fleshy (%)	St. Dev.	Avg. Calc. (%)	St. Dev.	Turf/ Bare (%)	St. Dev.	Sand (%)	St. Dev.	Other (%)	St. Dev.
WPT1	17.4	3.9	2.0	1.4	3.0	1.4	0.0	0.0	63.7	15.2	11.8	7.4	2.3	1.1
WPT2	17.9	2.0	3.0	2.6	20.3	6.8	0.0	0.0	49.1	8.0	6.0	7.9	3.7	1.5
WPT3	21.2	4.0	6.6	7.0	3.7	3.1	0.0	0.0	68.1	13.7	0.0	0.0	0.3	0.6
WPT4	10.2	5.0	3.2	4.0	35.5	6.7	0.0	0.0	49.1	12.3	0.6	1.3	1.5	1.2
WPT5	25.9	9.0	10.9	5.4	1.3	1.0	0.3	0.5	54.5	20.9	1.9	2.8	15.3	7.9
WPT6	32.9	10.0	2.4	1.7	24.1	8.3	0.0	0.0	36.8	12.4	0.0	0.0	3.9	2.8
WPT7	10.3	3.0	6.9	1.5	23.0	12.1	0.0	0.0	50.4	14.2	5.0	4.8	4.5	5.2
WPT8	27.9	13.0	4.8	2.5	28.8	13.1	0.0	0.0	30.7	6.9	6.1	5.6	1.8	1.7
WPT9	1.9	1.0	26.0	24.0	3.0	1.4	4.5	3.5	61.6	16.5	2.5	3.5	0.5	0.7
WPT10	39.6	0.0	5.1	0.8	0.8	1.0	2.5	0.7	34.7	4.9	1.0	1.4	16.4	2.3
WPT11	40.1	4.0	6.3	2.4	18.5	0.7	0.6	0.1	34.3	7.4	0.0	0.0	0.3	0.4
WPT12	2.1	1.0	17.3	6.7	0.9	1.2	1.8	1.0	77.8	5.5	0.0	0.0	0.2	0.3
WPT13	6.2	6.0	1.7	1.5	31.2	8.4	0.0	0.0	53.8	2.7	7.0	4.4	0.3	0.4
WPT14	3.6	3.0	8.5	7.8	5.3	6.7	13.0	4.2	56.2	3.7	10.0	7.1	3.5	2.1
WPT15	26.2	0.0	9.0	5.7	3.3	1.1	0.0	0.0	56.6	6.9	0.0	0.0	5.0	2.8
Deep	23.1	5.1	5.0	2.7	17.2	5.5	0.3	0.1	46.7	10.2	3.6	3.2	5.0	2.5
Shallow	7.2	2.3	14.6	11.4	3.2	3.1	4.8	2.2	65.9	9.9	3.1	2.7	1.1	0.9
MPA	20.9	6.6	5.4	3.5	19.5	7.3	0.0	0.1	48.4	12.6	2.8	3.2	4.4	3.0
No MPA	17.1	2.4	9.5	6.3	8.2	2.7	2.8	1.2	54.8	7.9	4.0	3.0	3.5	1.3
All	17.1	4.1	8.6	6.0	12.1	4.7	2.0	0.9	53.9	10.1	3.4	3.0	3.5	1.9

Table 5B: Macro-algae Summary

Site Code	Diadema (#/10m^2)	St. Dev.	Fleshy Macro Index	Calc. Macro Index	Recruits (#/m^2)	St. Dev.
WPT1	0.3	0.5	2.6	0.0	14.4	2.3
WPT2	0.0	0.0	60.3	0.0	4.3	3.7
WPT3	11.5	13.7	2.6	0.0	8.5	6.7
WPT4	0.0	0.0	89.9	0.0	12.0	7.6
WPT5	0.4	1.1	1.0	0.0	12.0	5.7
WPT6	0.0	0.0	60.9	0.0	4.0	4.8
WPT7	1.6	1.8	45.2	0.0	2.4	3.1
WPT8	0.0	0.0	91.3	0.0	7.2	8.4
WPT9	0.0	0.0	0.8	11.9	9.6	4.5
WPT10	0.3	0.5	0.5	4.5	4.0	5.7
WPT11	0.0	0.0	36.4	0.5	11.2	6.8
WPT12	20.8	22.8	1.3	1.3	5.3	6.7
WPT13	0.0	0.0	118.4	0.0	1.6	2.3
WPT14	6.0	6.2	1.6	42.9	3.2	4.5
WPT15	0.0	0.0	2.3	0.0	4.8	6.8
Deep	0.2	0.4	46.3	0.5	7.1	5.2
Shallow	9.6	10.7	1.6	14.0	6.7	5.6
MPA	1.9	2.4	50.2	0.0	7.2	5.7
No MPA	3.4	3.8	20.5	7.6	6.8	5.0
All	3.8	4.3	29.6	5.5	6.9	5.4

Table 6: Fish Summary

Site Code	Transect #	Reef Type	MPA?	Target Families #	Total # of Individuals	Avg. Biomass (g/100m2)	St.Dev.	Density (#/100m2)
WPT1	5	Deep	No	5	65	555.75	680.00	21.70
WPT2	10	Deep	Yes	11	215	1384.75	1338.70	35.80
WPT3	10	Shallow	Yes	11	424	3087.55	1871.40	70.70
WPT4	10	Deep	Yes	11	229	2111.58	3287.10	38.20
WPT5	8	Deep	Yes	11	326	5535.95	4292.87	67.90
WPT6	9	Deep	Yes	9	356	8060.56	9815.17	65.90
WPT7	9	Deep	Yes	10	256	2187.43	1106.99	47.40
WPT8	9	Deep	Yes	11	387	7758.08	7144.40	71.70
WPT9	9	Shallow	No	10	472	2557.35	3024.11	87.40
WPT10	8	Deep	No	9	272	2559.95	3372.87	56.70
WPT11	9	Deep	No	11	371	3973.93	3060.55	68.70
WPT12	9	Shallow	No	10	345	2190.00	1834.20	63.90
WPT13	8	Deep	No	7	266	624.56	529.11	55.40
WPT14	8	Shallow	No	6	486	1231.07	1915.08	101.30
WPT15	8	Deep	No	10	573	3140.44	4527.51	119.40
Deep-all				9.5	301.5	3444.8	3559.6	59.0
Shallow-all				9.3	431.8	2266.5	2161.2	80.8
Inside MPA				10.6	313.3	4303.7	4122.4	56.8
Outside MPA				8.5	356.3	2104.1	2367.9	71.8
All combined				9.5	336.2	3130.6	3186.7	64.8

Table 7: Coral Bleaching/ Disease Summary September 05 – January 06.

Site	Colonies (N)		Live Coral Cover (%)		Loss in Coral Cover (%)	Recent Partial Mortality (%)		Bleach Index		Diseased (%)	
	Sept. 05	Jan. 06	Sept. 05	Jan. 06		Sept. 05	Jan. 06	Sept. 05	Jan. 06	Sept. 05	Jan. 06
WPT1	35.00	33.00	17.35	17.00	0.35	0.30	13.30	0.50	0.36	0.00	0.00
WPT3	20.00	14.00	21.23	29.00	7.77	1.30	13.90	0.70	0.07	0.00	0.00
WPT4	40.00	31.00	10.20	16.00	5.80	5.10	19.70	0.90	0.42	2.10	3.30
WPT5	82.00	29.00	25.88	16.50	9.38	1.10	20.50	1.00	1.27	1.10	0.00
WPT6	74.00	18.00	32.93	19.00	13.93	3.80	17.50	1.40	0.39	1.40	0.00
WPT8	63.00	44.00	27.93	23.00	4.93	1.20	20.60	1.30	0.71	0.00	0.00
Average	52.33	28.17	22.59	20.08	2.50	2.13	17.58	0.97	0.54	0.77	0.55

Appendix II: Figures

Figure 1: Benthic Cover

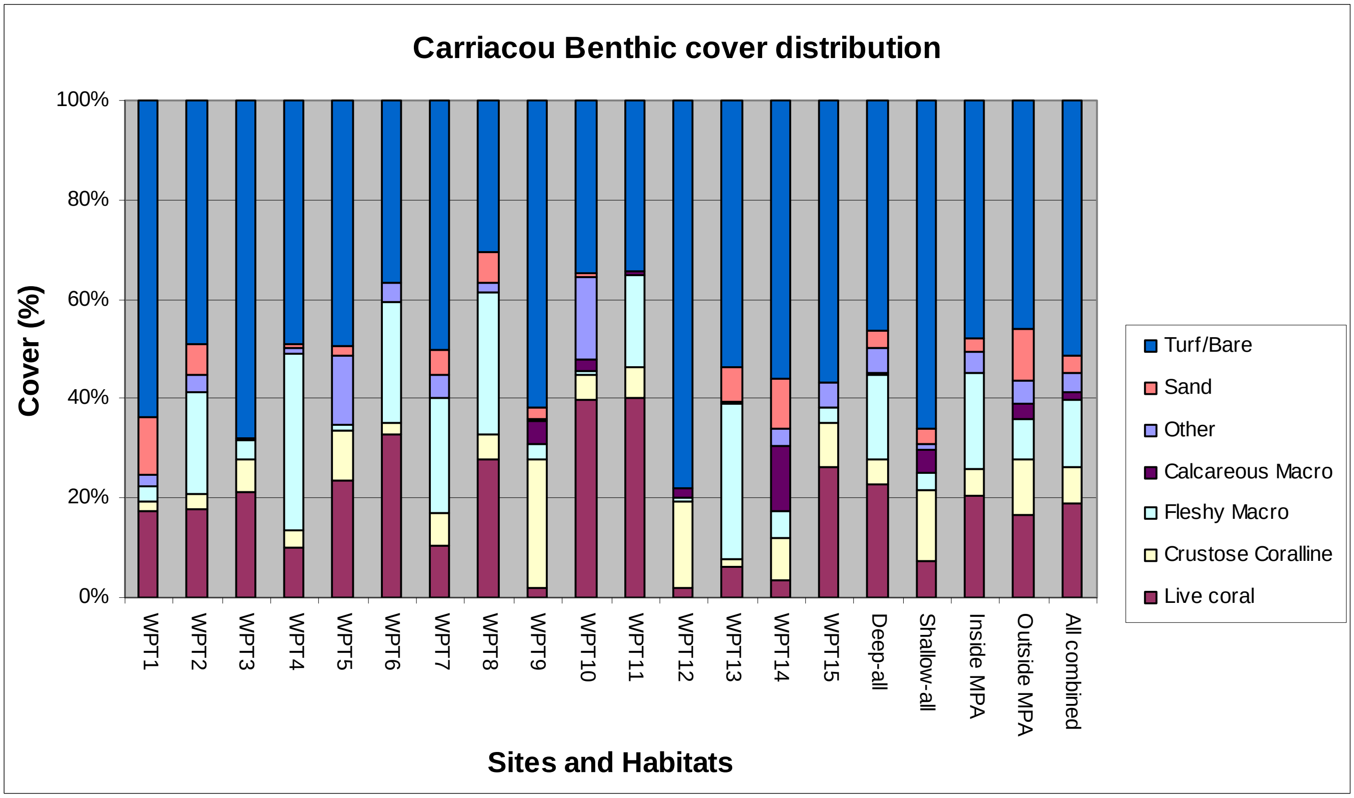


Figure 2: Coral Colony Partial Mortality

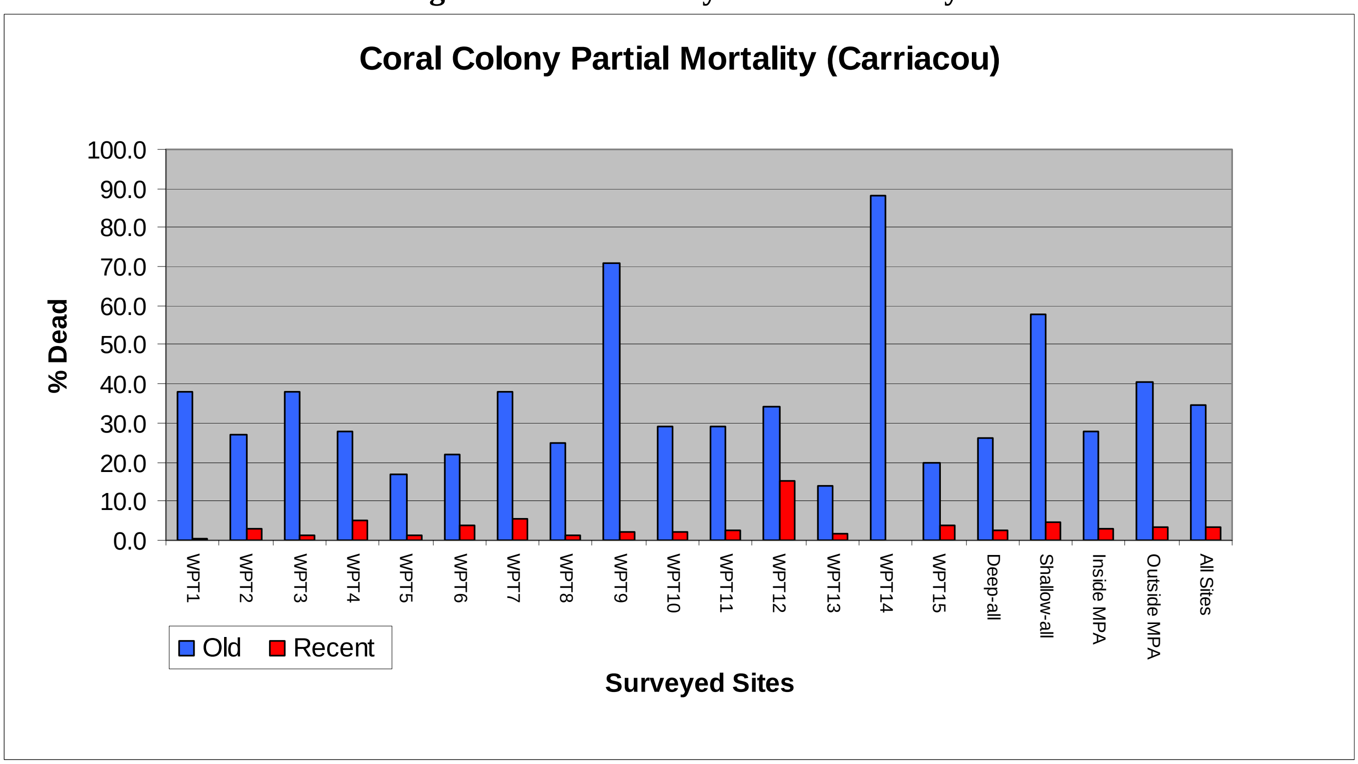


Figure 3: Coral Bleaching

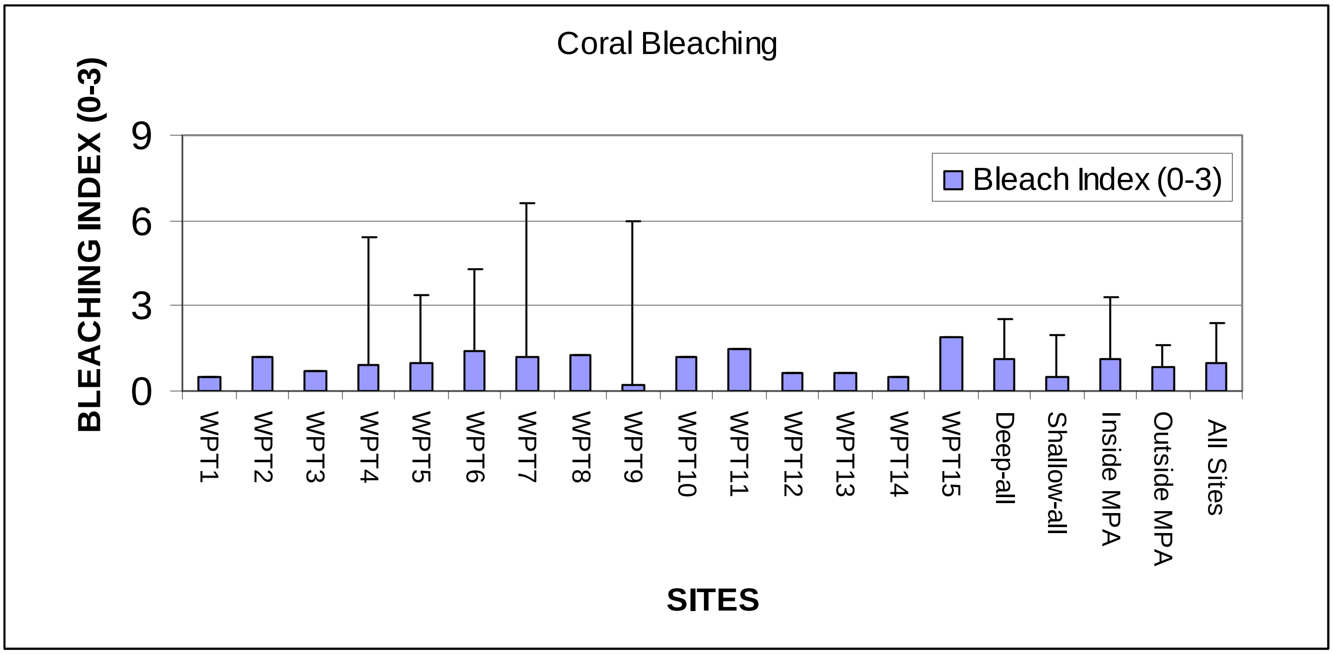


Figure 4: Coral Diseases

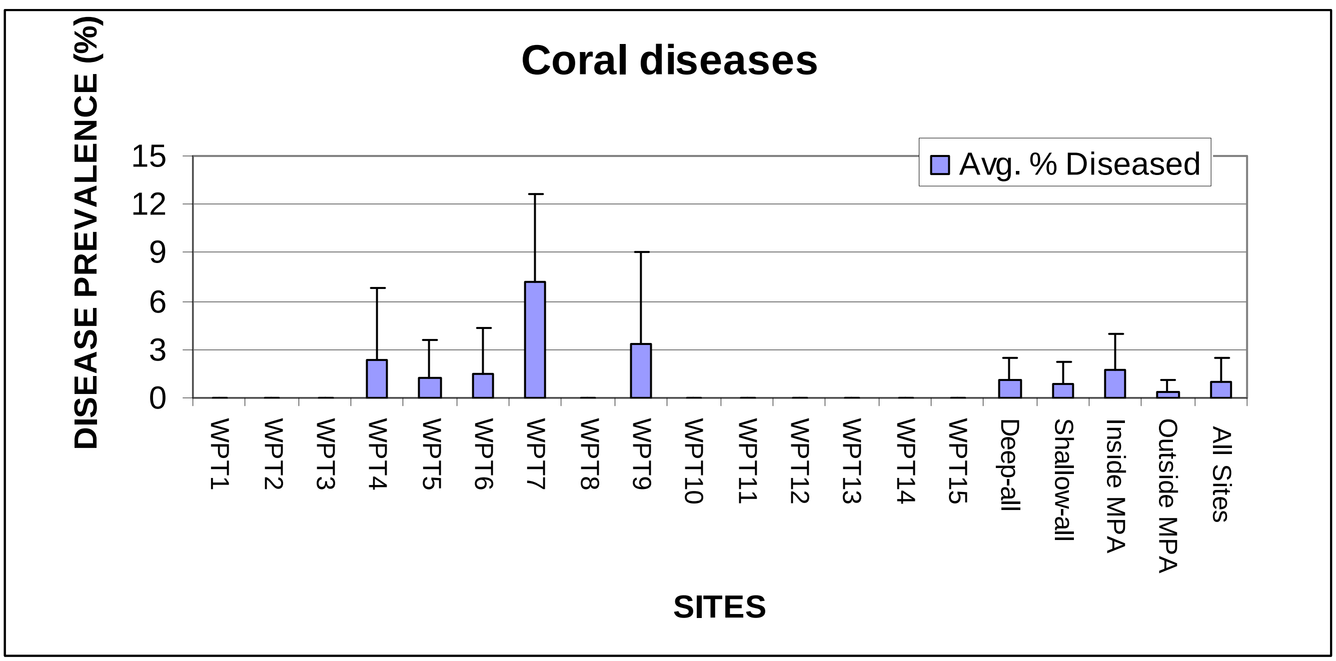


Figure 5: Macroalgal Indexes

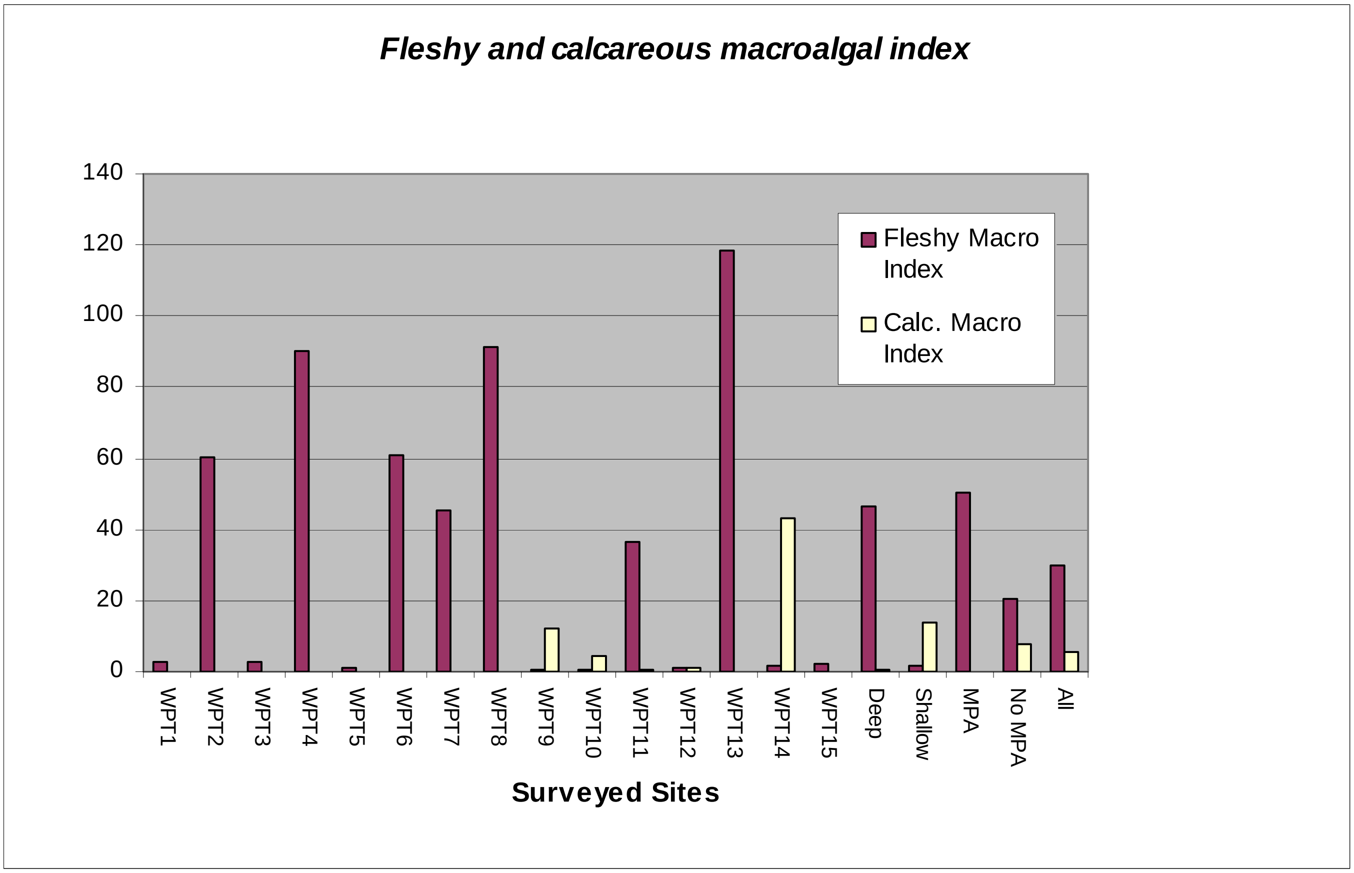


Figure 6: *Diadema antillarum* Populations Distribution

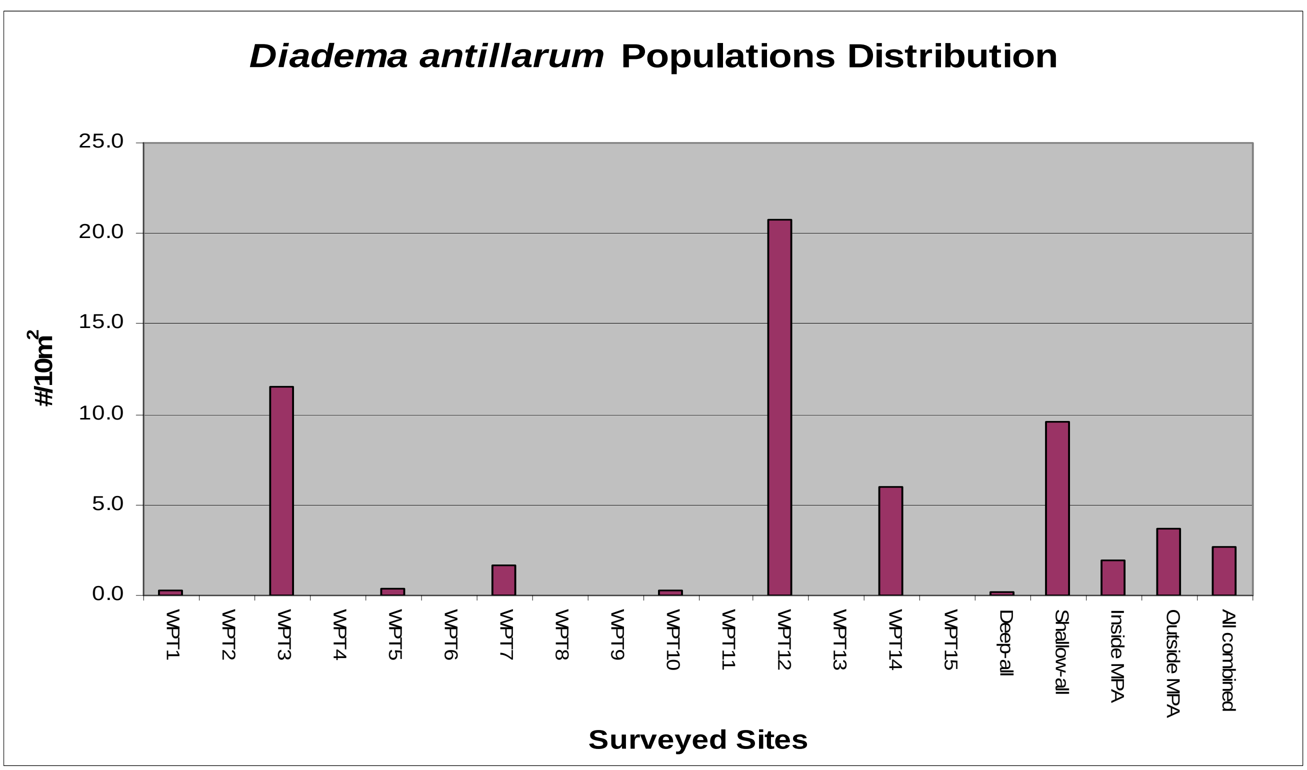


Figure 7: Coral Recruits

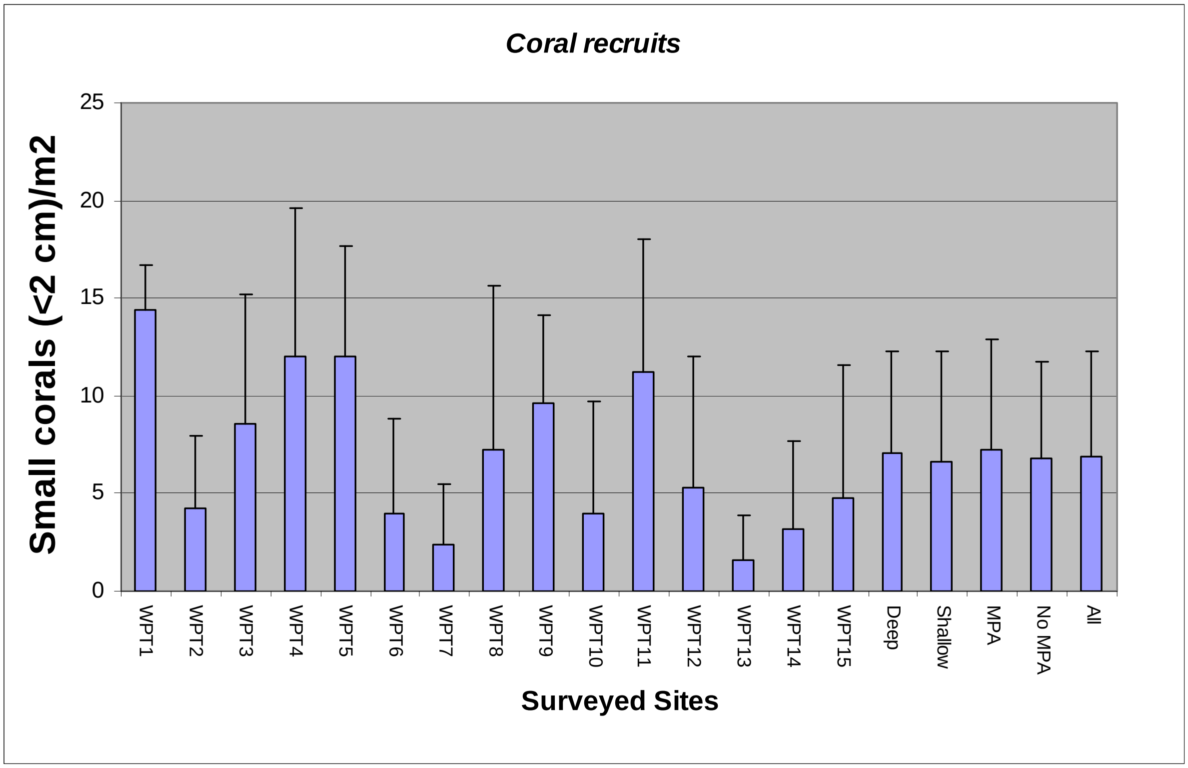


Figure 8: Fish Community Composition (Sites Combined)

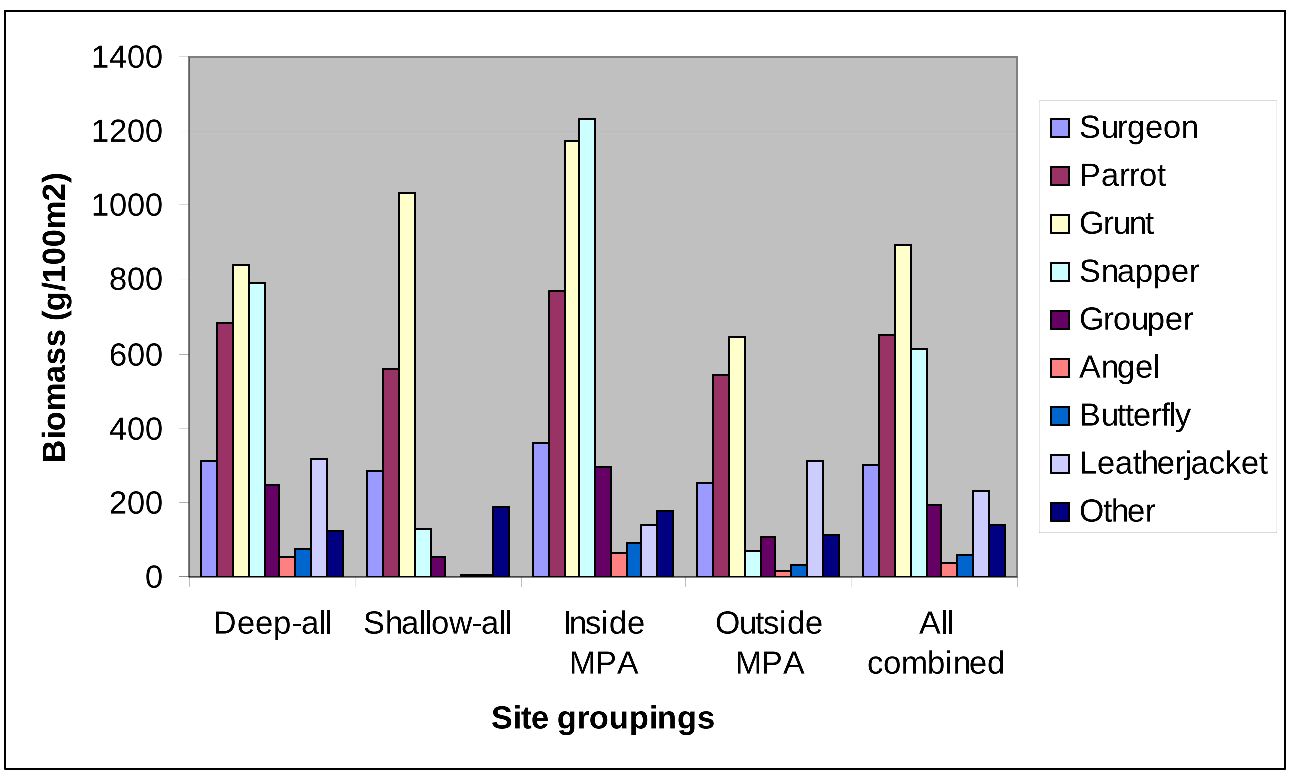


Figure 9: Fish Size Frequency Distribution

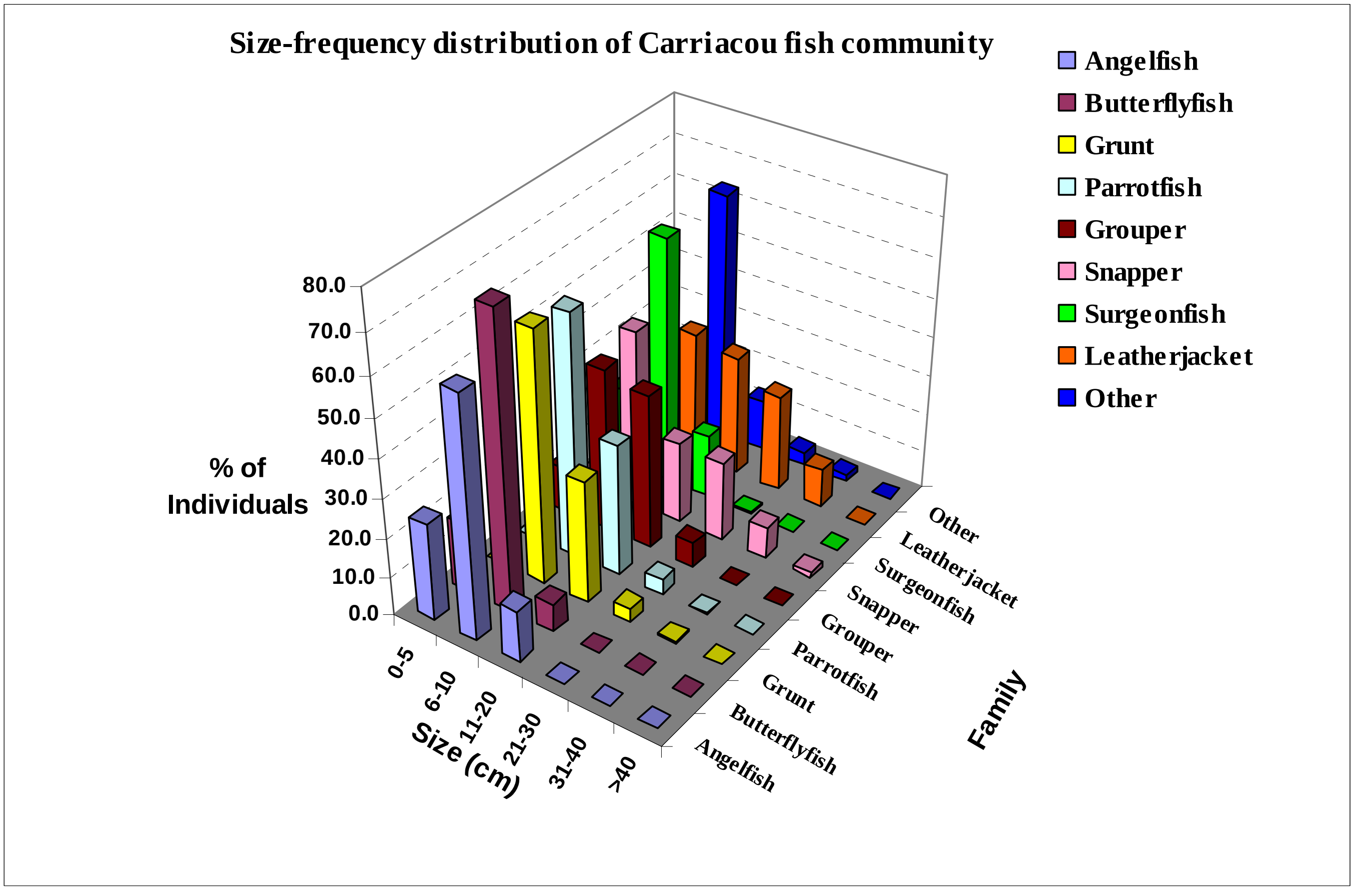
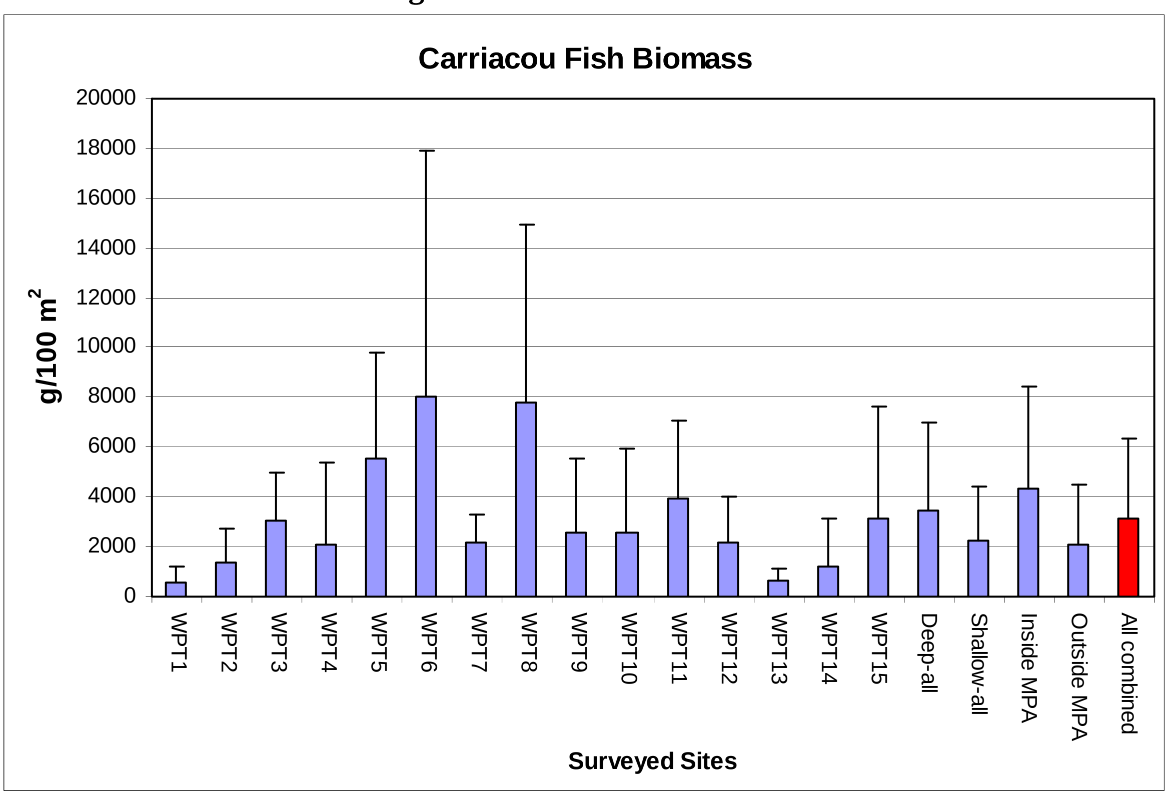


Figure 10: Total Fish Biomass



Country Comparisons:

Figure 11: Live Coral Cover

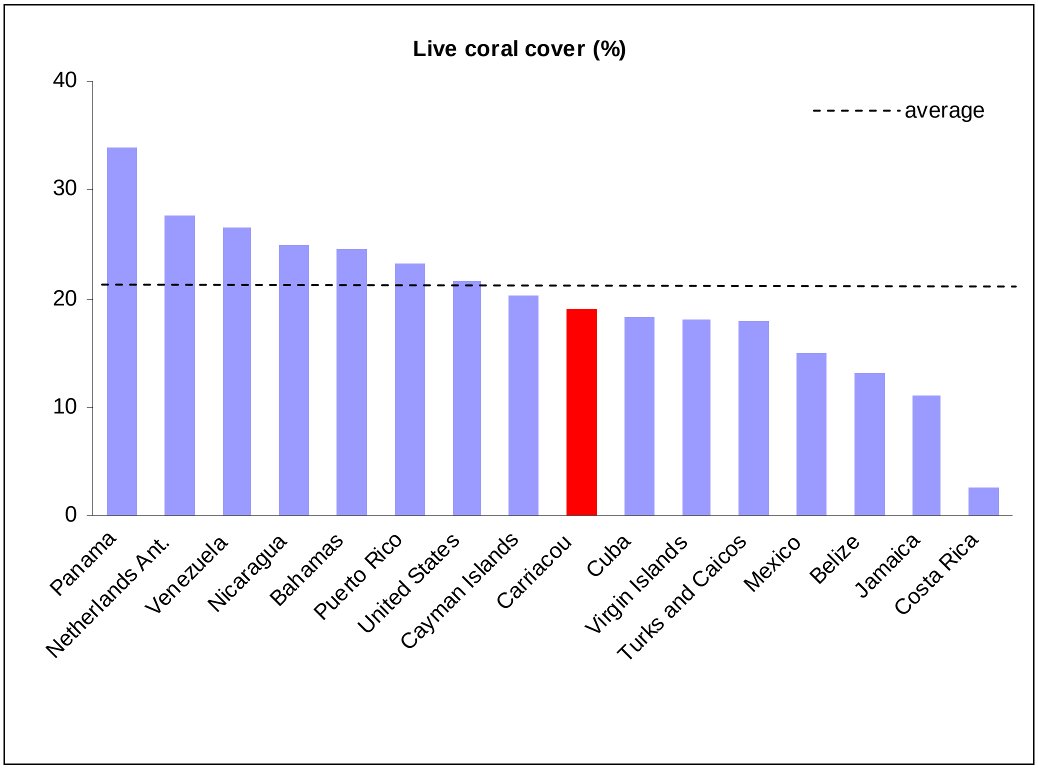


Figure 12: Coral Mortality

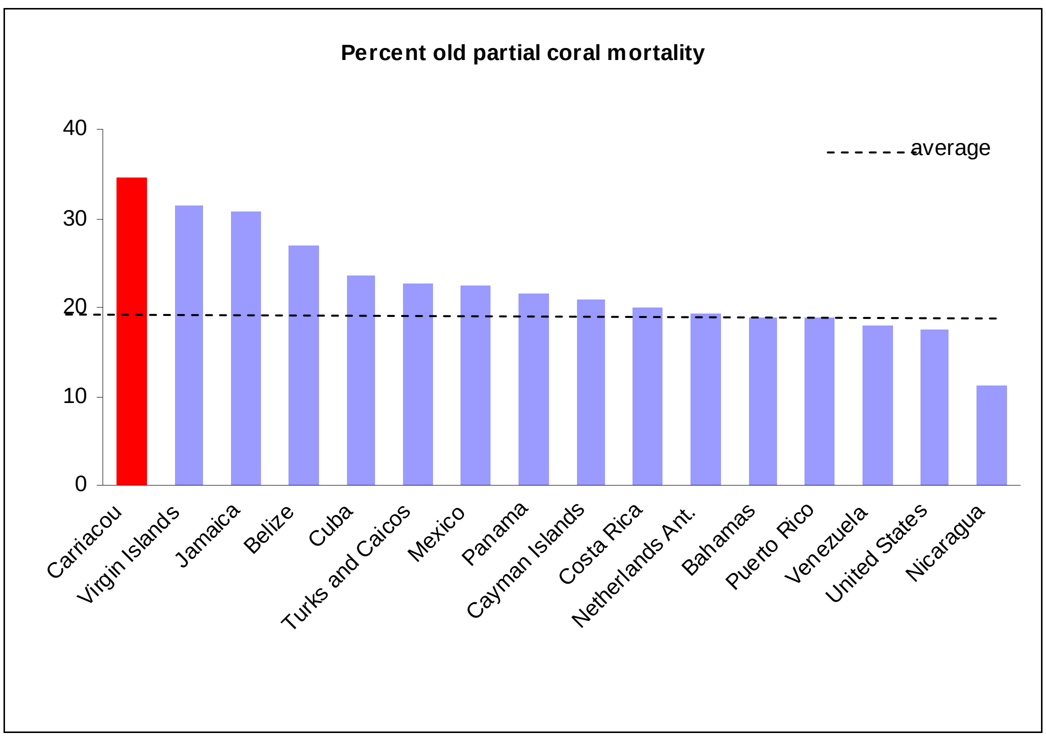


Figure 13: Fleshy Macroalgal Index

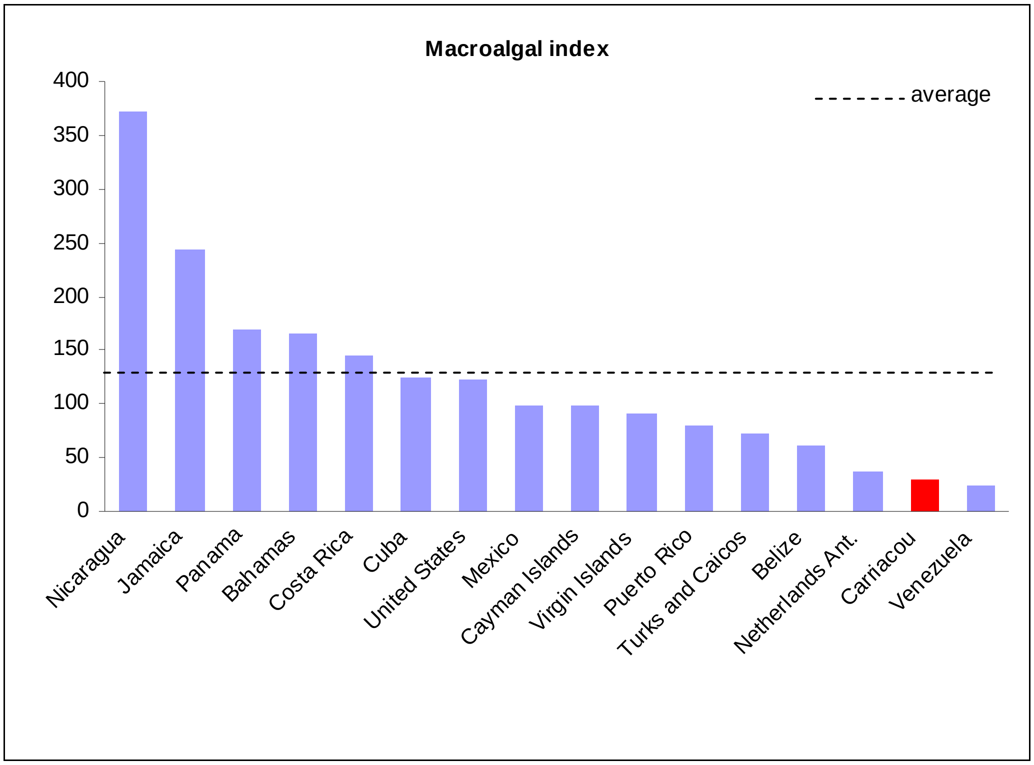


Figure 14: Small Corals (< 2 cm)

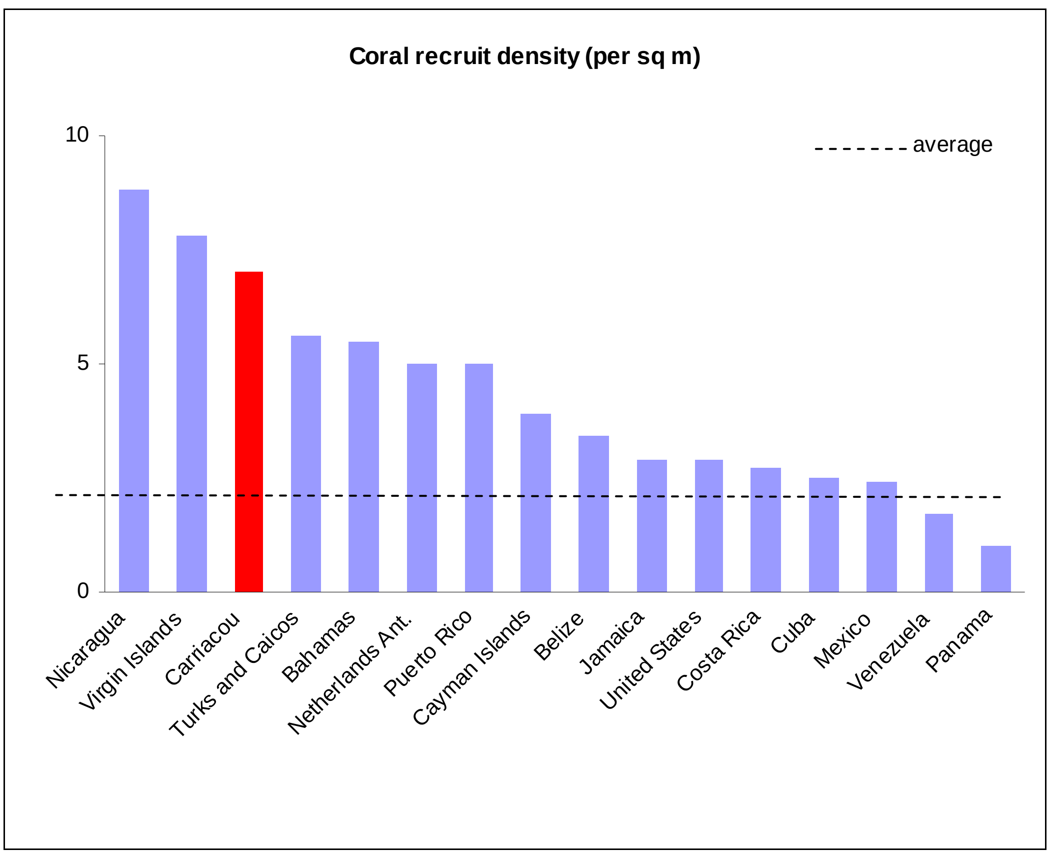


Figure 15: Fish biomass

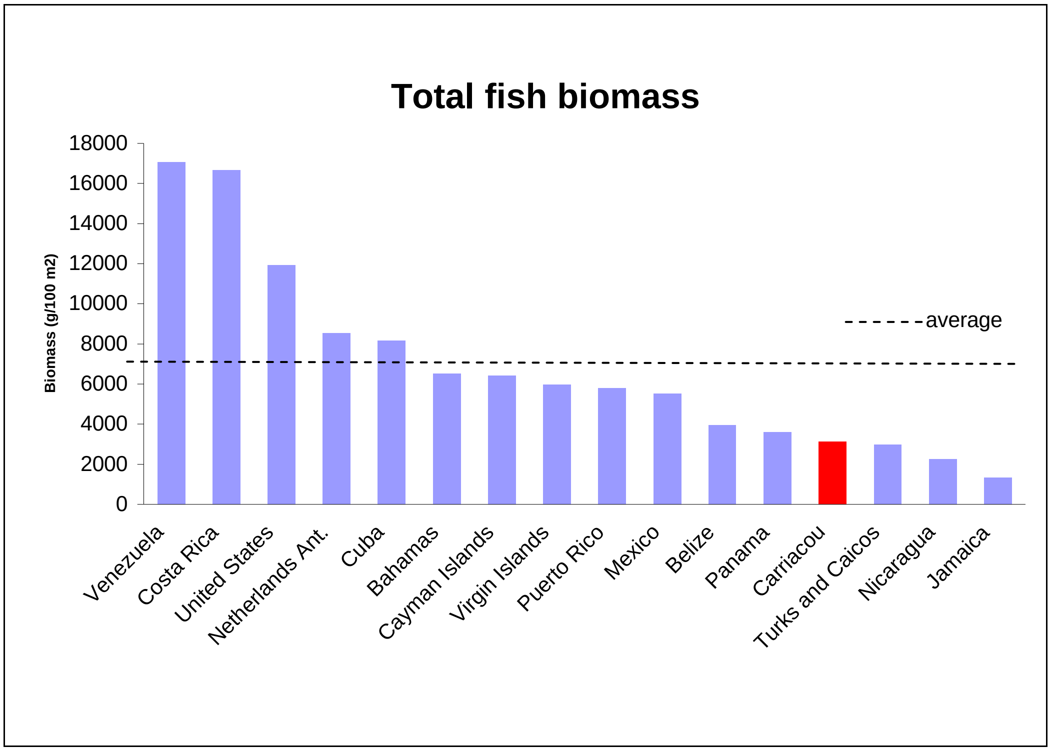


Figure 16: Surgeonfish Biomass

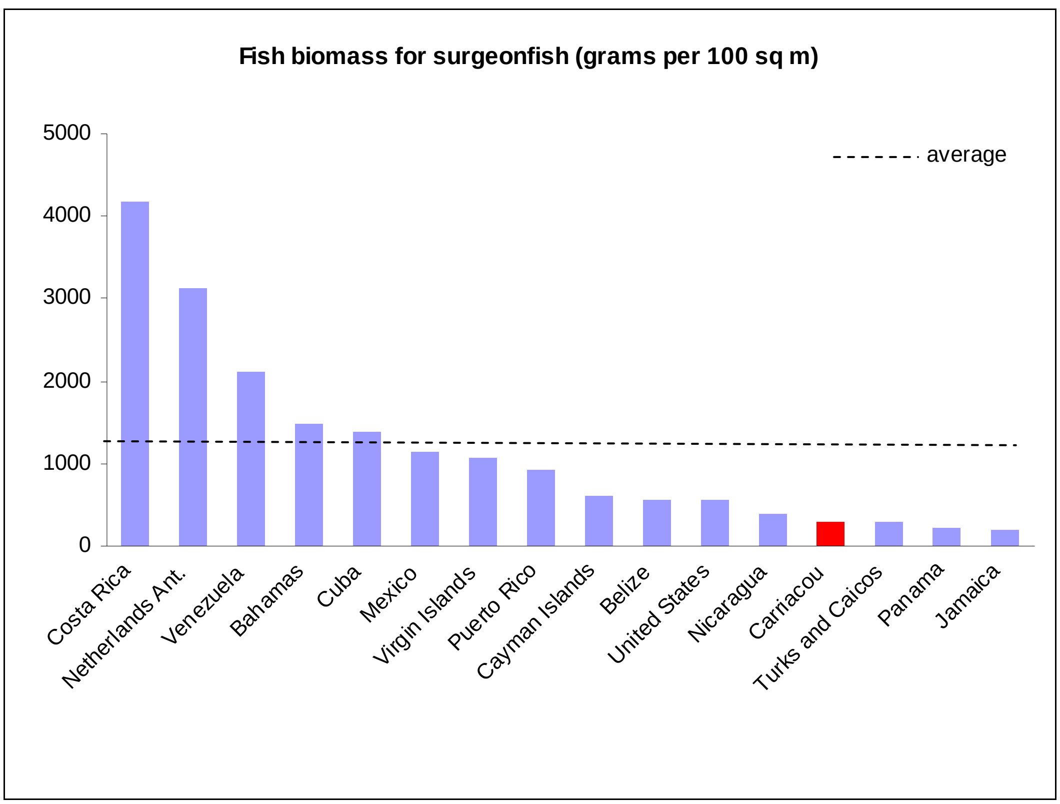
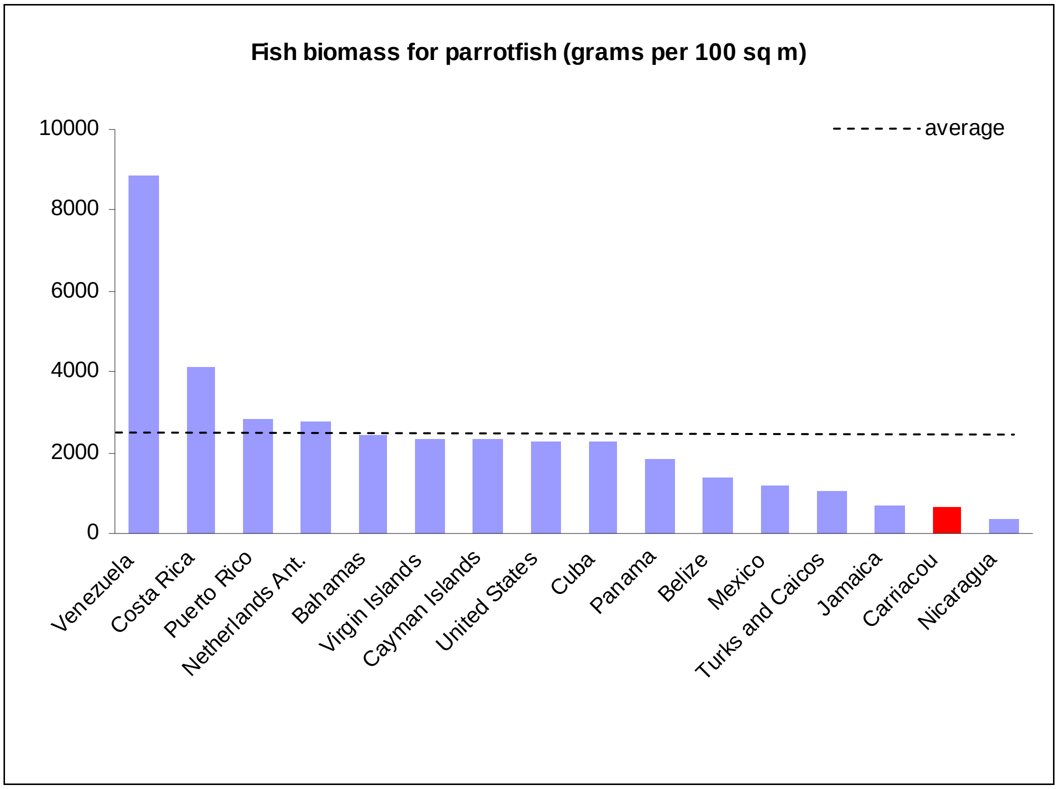
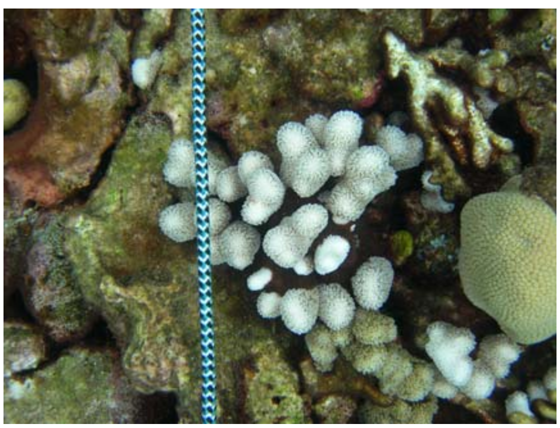
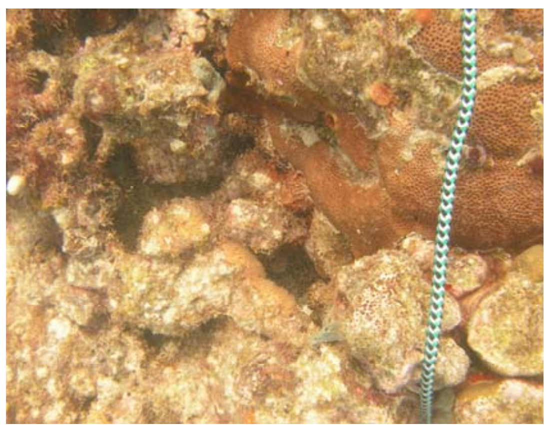


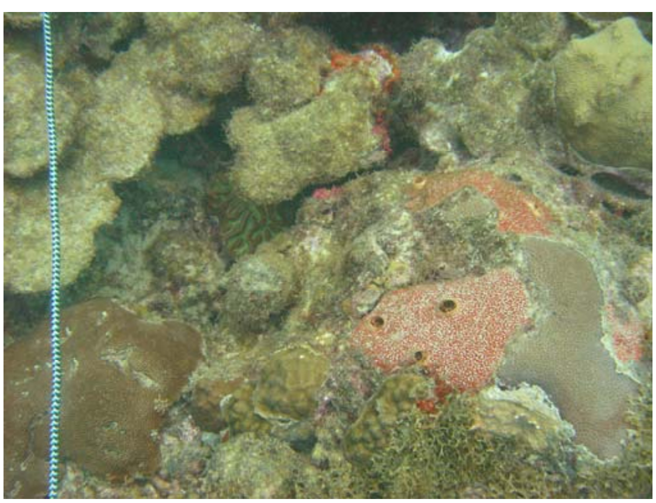
Figure 17: Parrotfish biomass

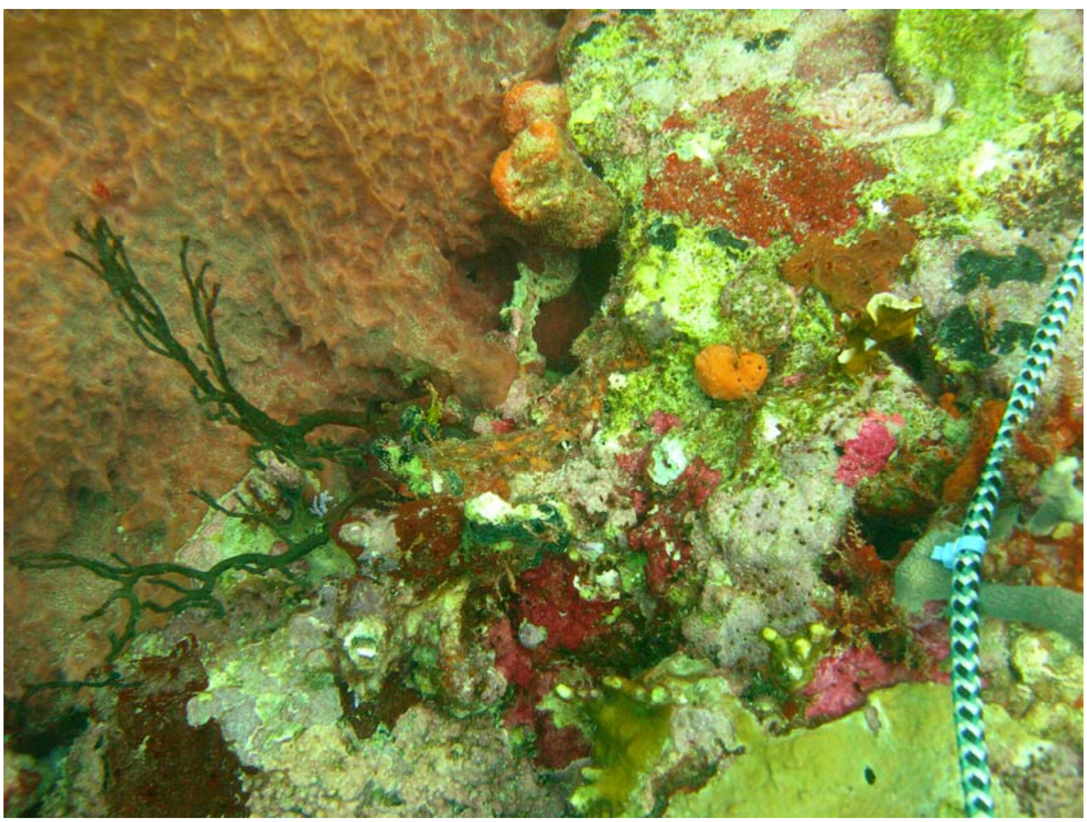


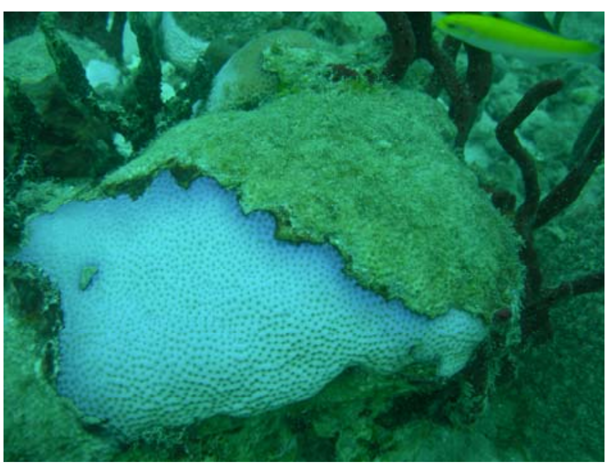
Appendix III: Carriacou Reef Photos- September, 2005

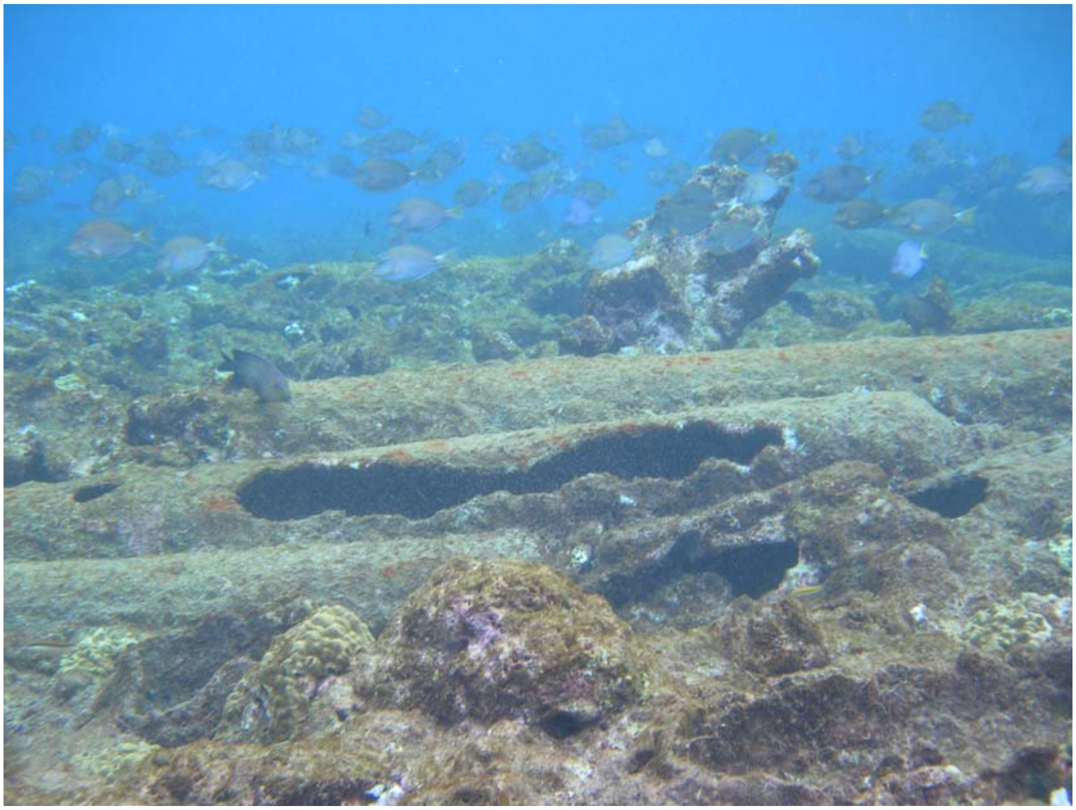












Appendix IV: AGRRA Carriacou training course

The participants for the survey (and training) included: Phil Kramer and James Byrne from TNC, Jerry Mitchell and Paul Phillip from the Grenada Fisheries, Clare Morral from St. George's University, Kenroy Noel—the local fisherman, Cuthbert Snagg—the local water taxi operator, and Werner "Max" Nagel—the local dive operator.

As a part of the coral reef assessment, the AGRRA Training session was held in Carriacou, Grenada from September 18-22, sponsored by the Carriacou Environmental Committee and The Nature Conservancy. Five Grenadians participated in the training and were instructed in the use of the AGRRA version 4.0 protocol by Dr. Philip Kramer and James Byrne. The objective for the training was to build capacity among Grenadian resource managers, reef stakeholders, and scientists to empower them in their ability to monitor and manage the Sandy Island Marine Protected Area.

Qualifications of participants:

*Certified and experienced scuba diver in good health. Some evidence that applicants were indeed experienced i.e. a dive log, statement of experience, or a letter from a dive master was required.

*Some experience in identifying corals and/or fishes was desirable, but not required. Training materials were sent in advance in order to help the participants in learning the Latin names of corals or fishes. Knowledge of a few common reef corals or fishes by their descriptive names was helpful.

*Serious interest in coral reefs and their protection.

The theory behind the assessment of condition in coral and algae communities was taught by Philip Kramer. Participants heard ½ day of lectures on different components of the benthic methodology. Specific modules included: coral identification, coral condition, size measurements, algae identification, and coral recruit identification. Participants then spent two days learning the benthic field methodology on snorkel and dive tanks. Fixed transects were set on the bottom and each participant would assess the transect and fill out a data sheet. The transect was then video-recorded or photographed and results between observers were compared. Discussions of individual corals or quadrats allowed significant improvement in observer consistency. For the remaining survey period, participants would set and evaluate one transect each which was then checked for consistency by Dr. Kramer.

James Byrne taught and trained the participants on coral reef fish identification and fish surveys. Components included: reef fish identification (AGRRA target list), size measurements, and roving diver fish identification. Field training consisted of timed swimming over transects, checking size estimates with the use of wooden fish models of different sizes, swimming over transects together and comparing results, and conducting rover diver observations. Fishermen participants also learned scientific names and common names of most reef species.

At the end of the training session, a ceremony was held by the Carriacou Environmental Committee (CEC) to provide certificates of accomplishment to all participants. Participants came away equipped to organize and execute both—assessment and monitoring of reef community condition, and make the initial analyses of the results. Participants also learned how to enter data into the preformatted AGRRA excel spreadsheets.

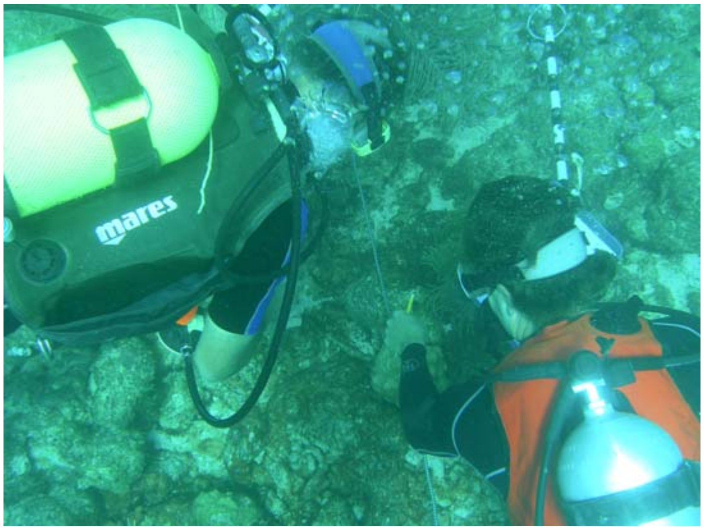
Workshop Outline

Day 1: Carriacou reef survey objectives, coral condition module, coral identification quiz, identification of colony boundaries, algae identification, fish identification. Preparation of field equipment (All participants).

Day 2: Check out dives for all participants. Identification of corals, algae and fishes. Estimate of sizes of fish and partial mortality of corals. Depending on the background and interests of the participants, they were assigned to either the benthos or fish groups.

Days 3-6: Consistency field training- applying the AGRRA methods for corals, fishes and algae and entering field data (2 dives/day; 2 snorkels/day).

Training photographs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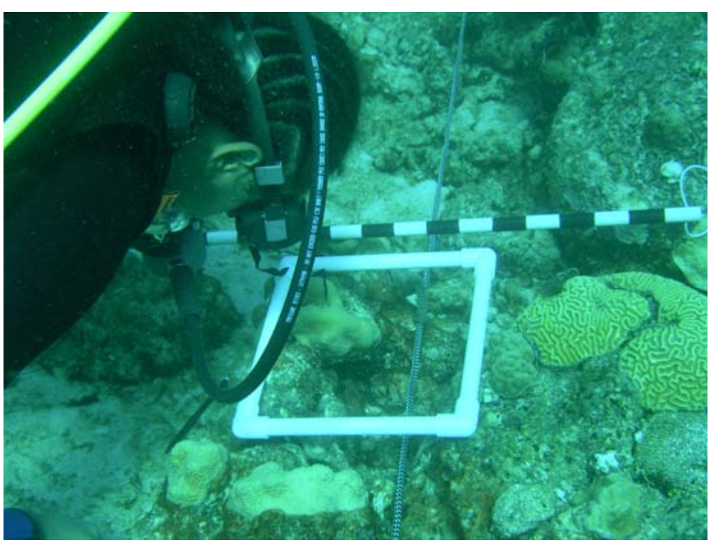

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The Grenada Dove

Carriacou Environmental Committee