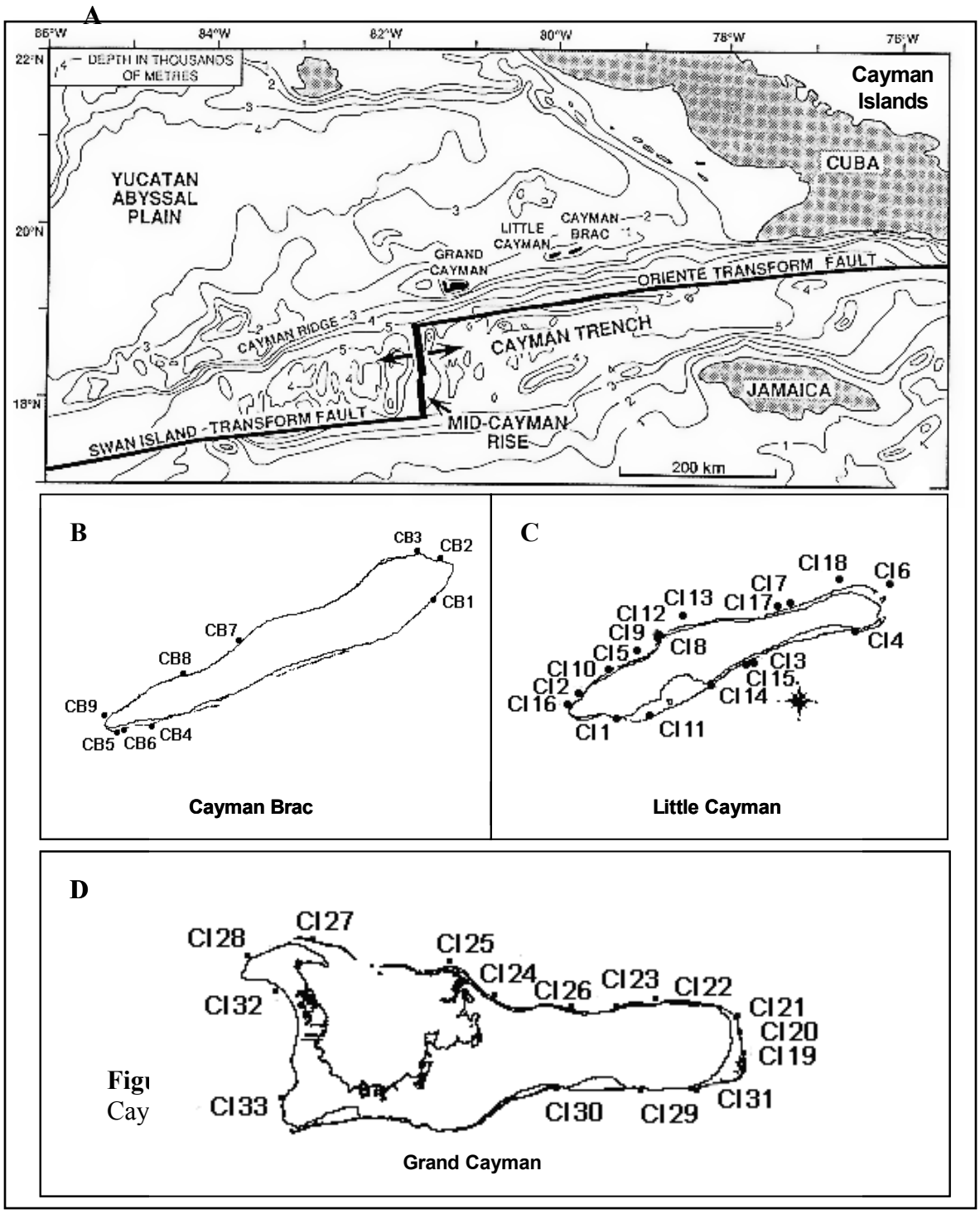

Figure 1. AGRRA survey sites in Grand Cayman and Little Cayman, Cayman Islands. See Table 1 for site codes.

STATUS OF CORAL REEFS OF LITTLE CAYMAN, GRAND CAYMAN AND CAYMAN BRAC, BRITISH WEST INDIES, IN 1999 AND 2000 (PART 1: STONY CORALS AND ALGAE)

BY

CARRIE MANFRINO,[1] BERNHARD RIEGL,[2] JEROME L. HALL,[3]
and ROBERT GRAIFMAN[4]

ABSTRACT

A benthic assessment of the isolated Cayman Islands was completed at 42 sites. Major changes in the reef community structure were documented by comparison with earlier studies. *Acropora palmata* and *A. cervicornis*, once abundant as shallow framework builders, were uncommon. Diseased stony corals were seen in >90% of the study sites, with the highest averages in Little Cayman, especially at Bloody Bay which is one of the most highly regulated marine parks in the Cayman Islands. The *Montastraea annularis* species complex accounted for two-thirds of the diseased corals which, along with other massive species, were affected largely by white-plague disease. Recent partial-colony mortality was particularly high in Grand Cayman. However, small- to intermediate-sized (<1.5 m diameter) colonies and recruits of reef framework builders (including the *M. annularis* complex) suggest a strong potential for population regeneration. Algal competition generally did not appear to be a problem for stony corals, and bleaching was insignificant, yet more prevalent, in the deeper (>10 m) sites.

INTRODUCTION

The Cayman Islands lie in the middle of the Caribbean Sea, about 240 km south of Cuba. They are comprised of three small (12–18 km long) low-lying, limestone islands with Little Cayman (LC) 125 km northeast of Grand Cayman (GC) and just 7.5 km to the southwest of Cayman Brac (CB). LC has a permanent resident population of about 130, and remains relatively undeveloped with four small dive

[1]Kean University, Department of Geology and Meteorology, 1000 Morris Ave. Union, NJ, 07083. Email: cmanfrin@kean.edu

[2]National Coral Reef Institute, Nova Southeastern University, 8000 N. Ocean Drive, Dania Beach, Florida, 33004.

[3]Institute of Nautical Archeology, Texas A & M University, College Station, TX, 77843.

[4]Marine Environmental Education and Research Institute, P.O. Box 1461, Princeton, NJ.
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lodges and one 40-room resort. There are 2,200 residents and three dive resorts on CB. In comparison, GC has a resident population of 36,000, and numerous large resort hotels, condominiums, and dive operators along the seven-mile beach area on the western side of the island. Georgetown Harbor is an important port for cruise ships.

The Cayman Islands are protected from open-ocean long-fetch Atlantic waves by the Antilles Island Arc, Hispaniola, and Cuba. Trade winds blow predominantly from the northeast but shift periodically to the east and southeast. The eastern side of GC receives the highest wind and wave energy, whereas the western sides of all three islands are least exposed. LC and CB are oriented northeast to southwest, so the southern sides tend to be more exposed to prevailing winds and waves. Polar fronts push winter storms south during the winter months, and winds around the islands shift to blow from the north, developing into Noreasters and Norwesters.

Two shallow-sloping submarine terraces occur around the islands with a few exceptions (e.g. Bloody Bay on LC is missing the lower terrace) (Rigby and Roberts, 1976; Blanchon et al., 1997). The upper terrace extends from the shoreline to a mid-shelf scarp at depths of 8–15 m and a lower terrace from the base of this scarp to the edge of the shelf at 15–20 m. Spectacular shelf-edge "walls" occur around all three islands. Fringing reefs and boulder ramparts are nearly continuous around LC and GC (except off the western side of GC) and occur along the south side (western third) of CB. In many locations, the boulder rampart (in 0.5–5 m water depth) was formerly a reef crest dominated by *Acropora palmata* on the upper terrace along the windward coasts (east, south, north of GC and LC, south of CB). High-relief (to 12 m) spur-and-groove or buttress reefs have developed at several sites at the edge of the upper terrace in the more exposed (eastern, northeastern, southeastern) sides of the islands. At "more protected" windward locations on the northern and southern coasts, low- to medium-relief (1–3 m) spurs and grooves are found at the edge of the upper terrace. In leeward locations (western side of GC; Bloody Bay on LC), where a reef crest is lacking, there are narrow, low-to-medium relief spurs and grooves or shelf-edge reefs with poorly developed spurs and grooves, although a few high-relief, elongated spurs occur along the upper terrace in Bloody Bay.

Episodes of coral bleaching were reported in the Cayman Islands in the late 1980's, 1995, and in 1998 when nearly 80% of the corals bleached on GC (LC and CB were not surveyed) (Timothy Austin, personal communication). The last major storms to impact the Caymans were Hurricanes Allen in 1980, Gilbert in 1988, and Mitch in 1998. Hurricanes Allen and Mitch reportedly had minimal impact underwater but Gilbert damaged the shallow reefs, particularly breaking small colonies of *Acropora palmata*, at many locations around GC (Blanchon and Jones, 1997; Timothy Austin, personal communication). The extent of the impacts by these storms remains largely undocumented on LC and CB; however, boulder ramparts on many of the beaches of all three islands and reef-crest zones that are largely biodetrital provide historic evidence of the continuous impact by major storms.

A Marine Conservation Law was passed in the Cayman Islands in 1979. Marine park areas (15 km^2), replenishment zone areas (15 km^2), an environmental zone (17 km^2) in the North Sound of GC, and animal sanctuaries/RAMSAR sites were designated in 1986 (Fig. 1A, B). Conservation regulations have not prevented

overfishing of conch and lobster, nor have they adequately protected grouper spawning grounds from fishing or turtle nesting sites from coastal development. Residents (for at least five years) can apply for licenses to use spearguns and seine nets and to capture turtles if they can prove these activities are a cultural necessity. A total of 500 speargun licenses have been issued in the Cayman Islands. Growth in the hotel industry has resulted in an influx of workers from other Caribbean countries and has resulted in increased use of fish traps (pots).

Recent amendments made to the Marine Conservation Legislation in the Cayman Islands include instituting a season for conch and limiting the catch to five per person (from 15) and 10 per boat (from 20). Grouper spawning sites are now protected, and a catch limit of 12 per boat and a minimum size of 12 inches have been set. Individuals normally resident in Cayman are permitted to line fish in these areas. Lobster catch limits have been reduced to three per person and six per boat per day, and the length of the closed season has been extended. Fish pots are now limited to a maximum of two per household, and they must now be licensed and tagged. Only Caymanians are granted fish pot licenses.

Beginning in the early 1980's, the Cayman Islands Department of Environment has installed 159 permanent moorings on GC, 56 on LC, and 54 on CB. Diving has historically been focused along the western and northwestern coasts of GC where some dive sites receive over 15,000 visitors per year. Most divers on LC visit only one location, Bloody Bay Marine Park, where there are 22 moorings over a 3 km distance. With increased human usage (fishing, coastal development, mangrove destruction, diving, etc.), concern about the survival of Cayman's coral reefs has been growing. The survey reported here was designed to rapidly assess the present status of these important resources with the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocols (Manfrino, et al., 2000) and to determine recent changes in reef community structure and condition in the various oceanographic settings by comparison with earlier accounts (as summarized by Rigby and Roberts, 1976; Roberts, 1994; Logan, 1994; Hunter, 1994). Evaluating the current distribution of *Acropora palmata* and *A. cervicornis* was a major concern because of the extensive distribution previously reported. Other objectives were to compare reefs off the more populous GC with those of its sister islands and to strategically survey sites both inside and outside of marine protected areas and those with both high diver pressure and low or no diver pressure. The Cayman Islands lie in the middle of the Caribbean Sea, far from most continental and many human influences, and thus should provide an important point of comparison for other AGRRA surveys throughout the region. A detailed report on the results of the fish assessments completed during this study can be found in Pattengill-Semmens and Semmens (this volume).

METHODS

A total of 11 scientists and graduate assistants conducted AGRRA benthos surveys on LC and GC in June 1999 and on CB in June 2000. As relatively little information existed for LC, its major reef types were initially characterized during a reconnaissance around the entire island using a standard manta-towing technique. We

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recorded locations where coral cover was high and where we could potentially survey typical reefs in the recommended water depths for the AGRRA protocol. Except for the southwest coast of GC, the representative sites that were studied on all sides of the islands were strategically located both inside and outside of marine parks and replenishment zones. At LC there was a higher concentration of sites in heavily dived areas (Bloody Bay, Jackson Point). Published maps and aerial photographic images made available from the Cayman Islands Department of Environment 1994 photo series and input from knowledgeable boat captains were essential aides in site selection. All scientists participated in two days of training to standardize measuring techniques and identification of species. Humann (1993) was our primary identification guide.

Following AGRRA protocol Version 2.2 guidelines (see Appendix One, this volume), two zones were examined: the shallow (1-5 m) *Acropora palmata* reef crest, and the generally well-developed framework reefs in depths of ~5-16 m on the upper terrace. *Acropora palmata* in the reef-crest zone was sparse, or completely dead, and although several sites were investigated, only one (CI11) was surveyed. Forty-one surveys were conducted on the upper terrace. The minimum size of surveyed stony corals was 10 cm and coral size was recorded to the nearest 10 cm. *Agaricia* was not identified to the species level. Damselfish in the vicinity of the surveyed corals were counted. All tiny corals (≤2 cm) were included in the counts of "recruits." Sediment was removed from crustose coralline algae before estimating their abundance in the quadrats. Algal abundances at CB were estimated using the AGRRA Version 3.1 protocols given in Appendix One, except they included turf algae.

For the purposes of analysis, the upper terrace sites were arbitrarily divided by depth into 18 "shallower" reefs that were located in ⩽10 m and 23 "deeper" reefs that were >10 m deep. Few geomorphological or habitat differences were associated with these depth divisions.

RESULTS

A total of 5,531 stony corals (all ≥10 cm in diameter) in 486 transects and 2,407 algal quadrats were assessed during surveys off LC (18 sites) and GC (15 sites) in June, 1999, and off CB (9 sites) in June, 2000 (Table 1). Average live stony coral cover varied between ~14% in CB and 23% in LC (Table 1).

Stony Coral Species

Thirty-three scleractinian and hydrocoral species with colonies of at least 10 cm diameter were encountered along the transect lines. However, roving surveys indicated a total of 37 species in the vicinity of the survey sites (including species characteristically not growing larger then 10 cm).

Reef crests. Acropora palmata, the once-dominant shallow reef-crest coral (Rigby and Roberts, 1976), was found only in rare patches just seaward of what is now a rubble rampart. Extensive groves of "standing dead" colonies (completely dead

but still in growth position) and "stumps" occurred in the windward reefs and off the north sides of GC and LC. Only one windward site on LC (CI11) was found with a zone of live *A. palmata* that was extensive enough to survey.

Upper terrace reefs. Stony corals (≥10 cm in diameter) off all three Cayman Islands were dominated by the *Montastraea annularis* species complex and *Agaricia* spp. (Fig. 2A). Inter-island comparisons indicate that *Montastraea annularis, M. faveolata* and *M. franksi* were numerically predominant in LC (>38%) and GC (~28%), but *Agaricia* was predominant in CB (Fig. 2B). The *Montastraea annularis* complex generally dominated the shallower reefs while *Agaricia* spp. were predominant in the deeper reefs (Fig. 3A, B).

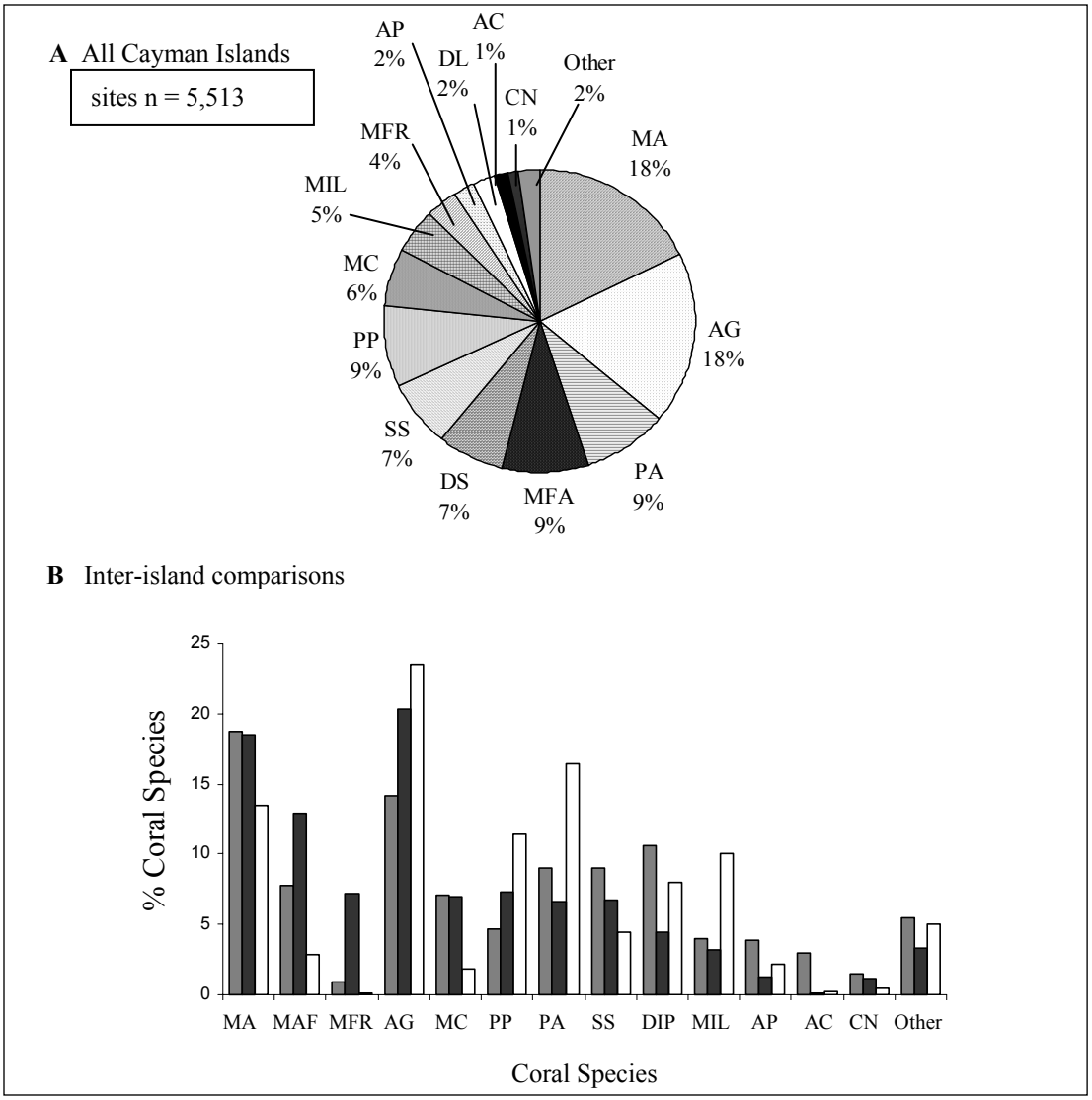

Figure 2. (**A**) Species composition and mean relative abundance of all stony corals (≥10 cm diameter) in all survey sites off the Cayman Islands. (**B**) Interisland comparison of 14 stony coral species. AC = *Acropora cervicornis,* AP = *A. palmata,* AG = *Agaricia agaricites,* CN = *Colpophyllia natans,* DIP = *Diploria* spp., DL = *D. labyrinthiformis*, DS = *D. strigosa,* MIL = *Millepora* spp., MA = *M. annularis,* MC=*M. cavernosa,* MAF= *M. faveolata,* MFR = *M. franksi,* PA = *Porites astreoides,* PP = *P. porites,* SS = *Siderastrea siderea.*

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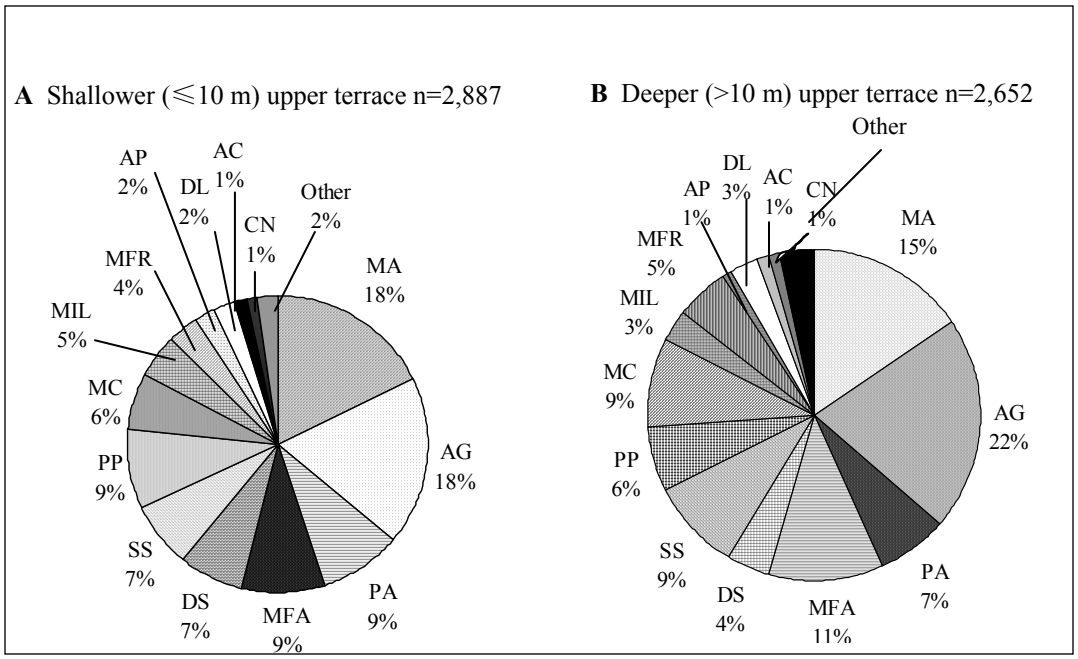

Figure 3. Species composition and mean relative abundance of all stony corals (≥10 cm diameter) in (**A**) shallower (≤10 m), (**B**) deeper (>10 m) upper terrace reefs off the Cayman Islands. See Figure 2 for species codes.

A. palmata was present in five of the six most exposed windward reefs off GC (CI19, CI20, CI21, CI29, CI 31) and in one protected windward reef along its northern coast (C124). It occurred in three of seven windward reefs off LC (CI3, CI11, CI15) and four of five windward reefs off CB (CB2, CB4, CB5, CB6). Live corals were generally less common than standing dead colonies. Although thickets of *Acropora cervicornis* were seen more commonly landward of the reef crests, at least a few small (<1 m diameter) colonies were present in the shallower parts of the spur-and-groove formations at most (10/15) reefs off GC. *A. cervicornis* was rare in LC and CB. Piles of broken branches and dead, intact thickets were found in spur-and-groove zones, on hardgrounds, and generally at locations where some live colonies occurred.

Stony Coral Size

The average diameter of the ≥10 cm stony corals (Table 2) was essentially identical off LC (~45 cm) and GC (~42 cm) but smaller off CB (~32 cm). Average coral height was somewhat greater off LC (nearly 30 cm), where *Montastraea faveolata* was numerically more abundant than off the other two islands (Table 2). The largest corals were *Montastraea faveolata* (with heights as great as 320 cm and diameters up to 400 cm), but there were also large (up to 390 cm tall) colonies of *Colpophyllia natans, Diploria clivosa, M. annularis,* and *Acropora palmata.* The diameters of live *A. palmata*, however, were all smaller (<1.5 m) than the standing dead colonies (1.5–2 m in diameter). Surveyed *M. annularis* occurred most frequently in the 21–60 cm diameter size range (Fig. 4A) and colonies that were more than 1 m in diameter were more common in LC and GC than in CB. Colonies of *Agaricia* spp.

were most abundant in the 21–30 cm class size, and rarely exceeded 70 cm in diameter (Fig. 4B). No correlation between coral size (height or diameter, all ≥10 cm in diameter) and water depth or level of exposure to prevailing winds was identified (Tables 2 and 3).

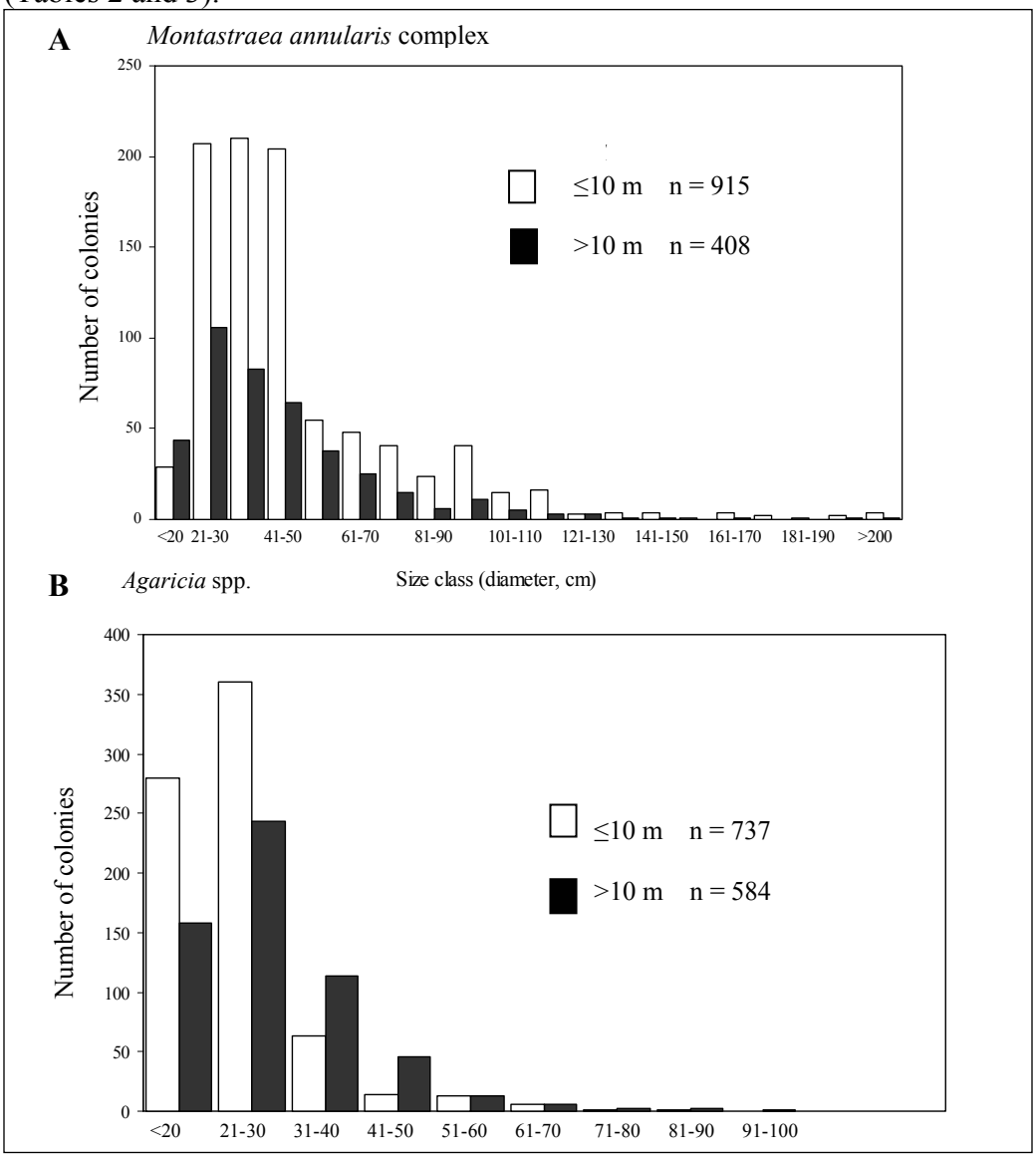

Figure 4. Size-frequency distribution of colonies (≥10 cm diameter) of (**A**) *Montastraea annularis, M. faveolata* and *M. franksi,* (**B**) *Agaricia* spp. in shallower (⩽10 m) and deeper (>10 m) upper terrace reefs off the Cayman Islands.

Stony Coral Diseases and Bleaching

Diseased stony corals were seen in over 90% (38/42) of the surveyed reefs (Table 2). Overall, the lowest incidence was at CB (mean = 2.3% diseased in 2000), while LC had the highest (mean = 5.5% diseased in 1999). Incidences of disease were

higher off the leeward sides of all three islands, affecting an average 6.5% of the leeward colonies versus 1.5 % of those off the windward coasts (Table 2). Heavily dived areas (CI 8,9,10, 22, 23, 27, 32, 33, CB 6,7) had high disease frequencies. For example, the mean percentages of diseased corals were more than double at two of the most popular dive sites (Cemetery Reef and Sunset House) on the western (leeward) side of GC than on its other coasts (Table 2). The highest percentage (mean >24%) of diseased corals was found at the Meadows site in Bloody Bay Marine Park off LC, and the average percentage of diseased colonies in Bloody Bay (10.5%) was nearly double that of the island as a whole.

More than 85% of these diseases were white syndromes (sensu Peters, 1997), i.e., white plague (WP) (presumably Type I, as subsequent visits indicated the disease was moving slowly across the coral tissues), which affected most species of massive

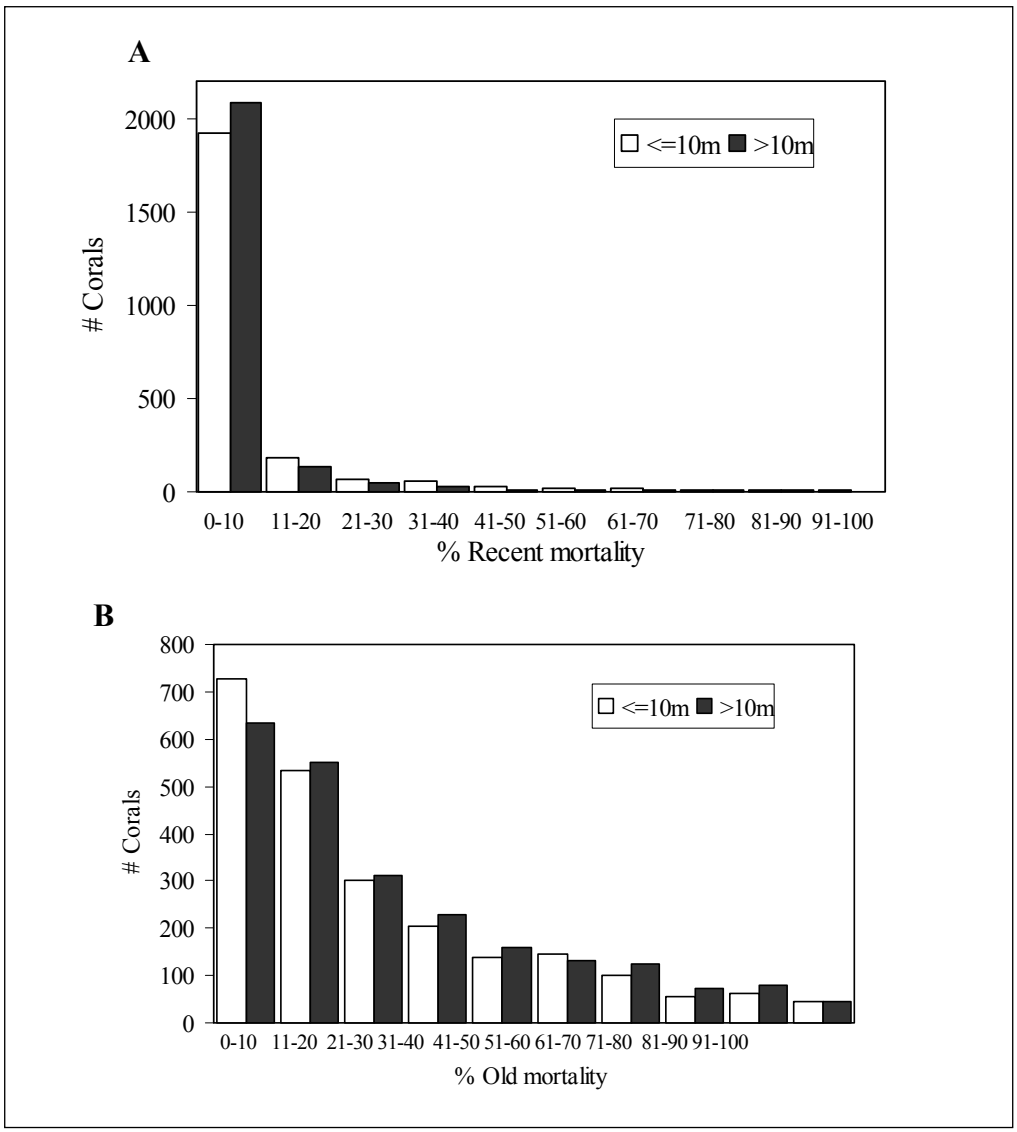

Figure 5. Frequency of (**A**) recent and (**B**) old partial colony mortality of stony corals (≥10 cm diameter), by depth (⩽10m and >10 m), in upper terrace reefs off the Cayman Islands.

corals except *Montastraea franksi*, and white-patch (white-pox) and white-band (WBD) diseases in *Acropora* (for descriptions of coral diseases see Peters, 1997). Black-band disease (BBD) and yellow-band (yellow-blotch) disease (YBD) only accounted, on average, for 11.4% and 3.4%, respectively, of the diseased corals off LC and GC, and neither were present in any of the transects or in random surveys off CB. No other diseases were noted in the study areas. Sixty-eight percent of the corals affected by disease were in the *Montastraea annularis* species complex, whereas only 3% were species of *Agaricia*. YBD was only found in *Montastraea annularis* and *M. franksi*; however, three colonies of *Porites astreoides* showed signs of a disease resembling YBD. BBD occurred preferentially in species of massive corals.

Regionally, the incidence of coral bleaching was low. The percent of stony corals that were bleached averaged higher off LC (2.4%) and GC (1.7%) in 1999 than off CB (0.3%) the following year. Bleached corals were twice as common in the deeper upper-terrace reefs off all three islands as in the shallower reefs. The non-algal-gardening yellowtail damselfish (*Microspathodon chrysurus*) was the most abundant damselfish in the immediate vicinity of the surveyed stony corals. In LC, 141 individuals/2,542corals (5.5%) were counted; corresponding values for GC were 84 fish/2,162 corals (3.9 %), and 19 fish/954 corals (1.99%) for CB.

Stony Coral Mortality

Recent partial-colony mortality (hereafter recent mortality) was in the 0-10% range for most stony corals (≥10cm diameter). Recent mortality in GC in 1999 (5.0%) was more than double that in LC (2.1%); corresponding values were even lower (1.3%) in CB in 2000 (Fig. 5A; Table 2). Overall, areas with the highest abundance of disease were also areas with high recent mortality. Old partial mortality (hereafter old mortality) averaged 21.3% of these colony surfaces, and there were no significant depth-related trends or differences between the islands and no differences related to exposure (Fig. 5B; Table 2). Apart from the Bloody Bay Marine Park area, “standing dead” corals were uncommon off LC, but they occurred at all but two of the 15 GC reefs and all but one of the nine CB reefs (Table 2).

Stony corals in about half of the GC (8/15) and LC (8/18) reefs but only a few (2/9) of those in CB had a total (= recent + old) partial mortality exceeding 25% of their colony surfaces. Corals in leeward settings generally had higher overall mortality percentages than those in more exposed windward orientations (Table 2). However, the only GC locations that had total mortality percentages of less than 20% were off the eastern end of the island. The highest percentages of recent (10.5%) and total (36%) mortality were recorded at Isabel’s Reef, a relatively new dive site off the northern GC coast.

High (>20%) to very high (>50%) percentages of recently dead colony surfaces in all three islands were most commonly found in *Montastraea annularis, Diploria strigosa* and *D. labyrinthiformis.* In the CB and LC reefs, *Agaricia* spp. had high percentages of recent mortality. Additional species with high-to-very high percentages of recent mortality off LC and GC included *M. faveolata* and *M. cavernosa*. In GC, *Acropora cervicornis, Colpophyllia natans* and *Siderastrea siderea* also commonly had high-to-very high percentages (10–60%) of recently dead

colony surfaces. On LC, recent mortality was also high (>20%) in *M. franksi* (which was less abundant on CB and GC) and in *Porites porites.*

Stony Coral Recruitment

Recruitment averaged 4.2 corals/m^2 (= .26 ± .65 recruits/.0625 m^2), was patchy in all reefs, and followed no trends related to exposure to higher or lower wave energy (Table 4). Recruitment was slightly higher in GC than in LC and CB. The most common recruits in the upper-terrace reefs were *Agaricia spp.* and *Porites astreoides* (Fig. 6A, B). Although there was little difference overall in the species composition of the recruits at these two depths*, Siderastrea siderea* was nearly twice as common in the deeper sites as in the shallow sites. Small colonies of *Montastraea annularis* were found at all depths; recruits of *M. faveolata* were also present in the deeper reefs.

Algal Relative Abundance

The relative abundance of turf algae was low, averaging 13.1% off CB to 22.4% off LC. The relative abundance of crustose coralline algae was highest in GC (mean = 53.5%) and lowest in CB (mean = 28%), whereas macroalgae showed the opposite pattern (30.5% versus 59%, respectively). Crustose coralline algal

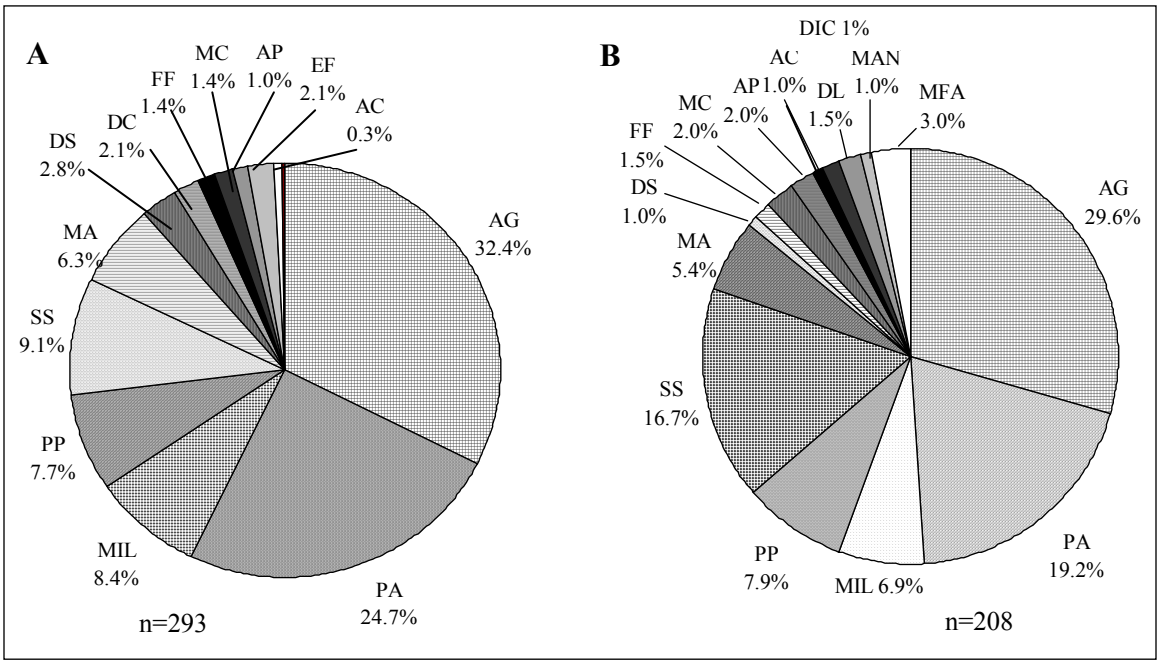

Figure 6. Species composition and mean relative abundance of all stony coral recruits (⩽2 cm diameter) in (**A**) shallower (⩽10 m) and (**B**) deeper (>10 m) upper terrace reefs off the Cayman Islands. AG = *Agaricia agaricites,* AC = *Acropora cervicornis,* AP = *A. palmata,* DIC = *Dichocoenia,* DC = *Diploria clivosa,* DL = *D. labyrinthiformis,* DS = *D. strigosa,* EF = *Eusmilia fastigiata,* FF = *Favia fragum,* MAN = *Manicina areolata*, MIL = *Millepora* spp., MA = *Montastraea annularis,* MC = *M. cavernosa,* MFA = *M. faveolata,* PA = *Porites astreoides,* PP = *P. porites,* SS = *Siderastrea siderea.*

abundance was slightly higher in the deeper sites off GC and LC, while macroalgal abundance was higher on average in the deeper sites off all three islands. Turf algae were less abundant at the deeper sites in GC and LC. Because of taller growth, the average macroalgal index (relative abundance of macroalgae x macroalgal height) was nearly three times larger in CB than in GC (Table 4), and was also regionally higher in the deeper reefs. The highest macroalgal index value was found in a fairly remote reef (CB3) in a leeward/protected windward location on the northeast side of CB. Macroalgae were less abundant and macroalgal index values were lower in the more exposed windward sides of all three islands, except in LC where the macroalgal indices were slightly lower off the leeward side. The windward side of GC, however, clearly had the least macroalgae and the lowest macroalgal indices (which brought down the overall average for GC as well) (Tables 3, 4). *Dictyota* spp., *Stypopodium zonale, Lobophora variegata,* and *Sargassum hystrix* were the most common macroalgae, especially on the southern sides of the islands. In some reefs, macroalgal encroachment and overgrowth, with resultant mortality of stony corals, was observed.

Diadema antillarum were only seen in transects at two reefs (one each shallower and deeper) on CB in 2000 and, even during roving dives, none were observed in the study areas off either GC or LC.

DISCUSSION

Comparisons with earlier studies of the coral communities in the Cayman Islands indicate that many changes have occurred over the past 30 years. The shallow *Acropora palmata* zone, as described for the 1970's and 1980's (Rigby and Roberts, 1976; Logan, 1994), no longer exists. In 1988, Hurricane Gilbert heavily impacted the north side of GC and destroyed much of the *A. palmata*-dominated fringing reef (Blanchon et al., 1997; T. Austin, personal communication). The predominance of standing dead colonies of *A. palmata* in many of the upper-terrace study sites on GC (CI 19, 20, 21, 24, 29, 31) is indicative of prior, major mass mortality, possibly from white-band disease or, in part, from one or more of the earlier mass bleaching events. Tossed, dead fragments that were being consolidated by *Millepora* and crustose coralline algae, and a few small (<1 m in diameter) intact colonies of *A. palmata*, were all that remained in the shallow fringing reef crests on the north side of GC, where we had found higher densities during previous surveys in 1997 (Manfrino, unpublished data). The colonies in this area, growing close to sea level, appear to be periodically smashed by the passage of major storms and were probably affected by Hurricane Mitch in 1998.

Off all three islands, and at all depths and habitats in which they occurred, colonies of *A. palmata* and of *A. cervicornis* were affected by WBD and white-patch disease. Earlier studies indicate that WBD severely impacted *A. cervicornis* on the GC fore reef in the 1980s (Woodley et al., 1997). Nevertheless, these coral species appear to us to have the potential for strong regeneration in the Cayman Islands.

Overall, since reefs with the highest abundance of disease were generally the reefs with high recent mortality, we presume that the latter was the result of diseases, particularly WP, WBB, and white patch. It is difficult to account for the observation

that LC had a higher percentage of diseased corals, but lower recent mortality values, than GC. One possible explanation is that outbreaks of disease in GC had occurred earlier that year, or in the year prior to our surveys, and was only at the time affecting the LC reefs. The higher occurrence of diseases in LC during June 1999 was possibly due to the higher percentage of *Montastraea faveolata* in the outer terrace reefs as WP had preferentially impacted the *Montastraea annularis* species complex. Surveys that continued on LC in 2000 and 2001 indicated outbreaks of disease activity with a trend of decreasing incidence of WP in 2001, then a major increase since January 2002 (further increasing in the 2002 summer months) that is causing a major mortality on the reefs around Little Cayman (Manfrino, unpublished data). The low occurrence of WP and low recent mortality (and the low live stony coral cover) on CB in the 2000 survey also supports a theory of waves of disease having previously swept through the CB reefs.

Differences between the islands, between the different depths, and between the different island settings were documented. The islands differed in several ways. In CB, stony corals were smaller, live stony coral cover and recent mortality were lowest, as were incidences of disease and bleaching, but there was a higher percentage of standing dead coral than had been found the previous year off the other two islands. In GC there was higher recent and total mortality, higher abundance of crustose coralline algae, slightly higher coral recruitment, and lower macroalgal abundance and macroalgal index values (especially low off the windward GC coast). In LC, stony coral size and cover were greatest and though standing dead coral was lowest, the incidences of bleaching and disease were highest (especially in the Bloody Bay Marine Park where recent mortality was also high). Fish abundance was also higher in LC than in GC (see Pattengill-Semmens and Semmens, this volume). Disease and recent and total mortality were high in popular dive sites off GC and LC, which also happen to be in leeward settings. In general, mean coral diameter and height were greater in the shallower depths off all three islands. Diseased stony corals were more common but bleaching was less abundant in the shallower depths. The relative abundance of macroalgae was higher in the deeper reefs.

No relationship between recruitment and level of exposure was found around any of the islands. Higher recruitment and coral regeneration off GC may occur because the higher abundance of crustose coralline algae in the windward reefs provides a more suitable surface for coral recruits.

The difference in the overall condition of reefs within protected and unprotected areas was unexpected; stony corals in dive sites at Bloody Bay Marine Park, the most highly regulated park in the Cayman Islands, were undergoing a major mortality event in 1999, and this area had amongst the highest disease counts of all three islands.

Although this survey did not include sites in any of the Cayman's shelf-edge reefs, a limited number of wall dives made at Bloody Bay during June, 1999 indicated that bleaching was no longer significant in the deeper reefs. However, high levels of macroalgal overgrowth (up to 100%) on some of the stony corals suggested that a wave of recent mortality may have occurred in the aftermath of the 1998 bleaching event.

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Table 1. Site information for AGRRA stony coral and algal surveys in the Cayman Islands.

Site	Site Code[1]	Reef Type[2]	Relative Exposure[3]	Level of Protection[4]	Latitude (° ' N)	Longitude (° ' W)	Survey date	Depth (m)	Benthic transects (#)	≥25 cm stony corals (#/10m)	% live stony coral cover (mean ± sd)
Little Cayman											
Meadows	CI8	Patch	Leeward	Park	19 41.510	80 04.130	Jun 10 99	6.0	16	14	37.0 ± 11.5
Berges Meredith	CI17	S&G	Leeward	Open	19 42.470	80 00.495	Jun 15 99	9.0	10	10	22.5 ± 4.5
Jigsaw Puzzle	CI2	High S&G	Leeward	Open	19 39.983	80 06.390	Jun 6 99	10.5	13	10	27.0 ± 9.5
Joy's Joy	CI10	Shelf edge	Leeward	Park	19 40.690	80 05.575	Jun 10 99	12.0	14	11	19.0 ± 6.5
Mixing Bowl-Three Fathom Wall	CI5	Shelf edge	Leeward	Park	19 41.096	80 04.700	Jun 8 99	12.5	15	13	29.0 ± 12.0
Nancy's Cup of Tea	CI9	Shelf edge	Leeward	Park	19 41.639	80 04.137	Jun 10 99	12.5	13	10.5	21.5 ± 14.0
Rock Bottom Wall	CI13	S&G	Leeward	Open	19 42.057	80 03.421	Jun 13 99	12.5	12	12	22.5 ± 10.5
Paul's Anchor	CI12	Shelf edge	Leeward	Park	19 41.661	80 04.181	Jun 13 99	13.0	12	11.5	17.0 ± 12.0
Lighthouse	CI16	S&G	Leeward	Open	19 39.702	80 06.728	Jun 15 99	14.0	10	10.5	25.5 ± 5.5
Penguin's Leap	CI7	Hardpan	Leeward	Open	19 42.551	80 00.487	Jun 9 99	16.0	16	11	16.5 ± 8.0
Wreck	CI18	Hardpan	Prot Windward	Outside Rep	19 42.996	79 58.921	Jun 15 99	11.0	10	10	15.0 ± 5.5
Main Channel- East Side	CI11	Fringing	Windward	Open	19 39.412	80 04.368	Jun 11 99	3.0	12	10	16.0 ± 5.5
Grundy's Gardens	CI1	S&G	Windward	Park	19 39.421	80 05.321	Jun 6 99	9.0	12	7.5	37.5 ± 11.5
Disneyland	CI3	S&G	Windward	Outside Rep	19 49.831	80 01.374	Jun 7 99	10.0	14	11	25.5± 6.5
Charles Bay	CI4	S&G	Windward	Open	19 41.628	79 58.459	Jun 7 99	11.0	17	8.5	17.5 ± 6.5
No Name	CI15	S&G	Windward	Outside Rep	19 40.628	80 01.562	Jun 14 99	11.0	12	11	26.5 ± 8.5
Black Tip Tunnels	CI6	S&G	Windward	Outside Rep	19 42.847	79 57.470	Jun 9 99	12.5	17	9.5	15.5 ± 7.5
Lucas's Ledge	CI14	S&G	Windward	Outside Rep	19 40.155	80 02.595	Jun 14 99	13.5	10	13.5	24.5 ± 6.0
All Little Cayman (mean ± standard deviation)								**11.0**	**13**	**10.8**	**23.1 ± 8.4**
Grand Cayman											
Cemetery Reef	CI32	Patch/S&G	Leeward	Park	19 21.917	81 23.726	Jun 22 99	9.0	13	11.5	17.5 ± 5.0
Sunset House	CI33	Patch/S&G	Leeward	Park	19 17.172	81 23.463	Jun 22 99	9.0	12	12	22.5 ± 12.0
Hepp's Mini Wall	CI28	Patch/S&G	Leeward	Park	19 23.126	81 24.992	Jun 20 99	11.5	12	14	22.0 ± 5.5
Delila's Delight	CI24	S&G	Prot Windward	Open	19 21.518	81 14.801	Jun 19 99	7.0	10	14.5	23.0 ± 13.0
Babylon	CI23	S&G	Prot Windward	Outside Rep	19 21.200	81 09.842	Jun 18 99	9.5	11	13.5	18.0 ± 3.5
Isabel's Reef	CI22	High S&G	Prot Windward	Open	19 21.460	81 08.145	Jun 18 99	10.5	11	12	24.5 ± 7.5
Bear's Paw	CI27	S&G	Prot Windward	Outside Rep	19 23.854	81 21.617	Jun 20 99	10.5	12	11.5	15.5 ± 3.5
Queen's Throne	CI25	Hardpan	Prot Windward	Outside Rep	19 22.818	81 17.493	Jun 19 99	12.0	12	11.5	14.5 ± 3.0

Table 1. continued.

Site name	Site Code[1]	Reef Type[2]	Relative Exposure[3]	Level of Protection[4]	Latitude (° ' N)	Longitude (° ' W)	Survey date	Depth (m)	Benthic transects (#)	≥25 cm stony corals (#/10m)	% live stony coral cover (mean ± sd)
Casey's Reef	CI26	S&G	Prot Windward	Outside Rep	19 21.202	81 11.746	Jun 19 99	14.0	12	10	12.5 ± 4.0
East End Reef	CI19	High S&G	Windward	Open	19 19.058	81 04.484	Jun 17 99	6.5	12	12	23.0 ± 9.5
Playing Field	CI31	High S&G	Windward	Open	19 17.565	81 06.318	Jun 21 99	7.5	12	12	17.5 ± 4.5
Kaho's Reef	CI20	High S&G	Windward	Open	19 20.002	81 04.596	Jun 17 99	9.0	11	12	18.0 ± 4.5
Kelly's Caverns	CI29	High S&G	Windward	Outside Rep	19 17.476	81 08.772	Jun 21 99	9.0	12	13.7	22.0 ± 6.5
Snapper Hole	CI21	High S&G	Windward	Open	19 20.634	81 04.676	Jun 18 99	20.0	12	13	24.0 ± 10.5
Breakers	CI30	S&G	Windward	Open	19 17.507	81 12.069	Jun 21 99	12.5	10	12.5	22.5 ± 4.5
All Grand Cayman (mean ± standard deviation)								**10.5**	**11.5**	**12.4**	**19.8 ± 6.5**
Cayman Brac											
Greenhouse Reef	CB7	High Patch/S&G	Leeward	Open	19 43.215	79 49.700	Jun 25 00	7.0	7	24	16.0 ± 4.5
Patch Reef	CB8	Patch	Leeward	Park	19 41.935	79 52.539	Jun 25 00	8.0	7	15	11.5 ± 4.0
End of Island	CB9	Low S&G	Leeward	Open	19 41.271	79 53.645	Jun 25 00	9.5	10	8	9.0 ± 2.5
Bert Brothers	CB3	S&G	Lee/Prot Wind	Open	19 45.491	79 44.457	Jun 22 00	16.5	8	12	14.0 ± 4.0
Pillars of Hercules	CB2	Fallen Blocks/S&G	Windward	Open	19 45.261	79 43.824	Jun 22 00	4.0	9	11	21.5 ± 5.5
Sargent Major Reef	CB6	S&G	Windward	Park	19 40.844	79 52.969	Jun 23 00	8.0	9	12	16.0 ± 7.5
Lighthouse Reef	CB5	S&G	Windward	Park	19 40.792	79 53.249	Jun 23 00	9.5	8	13	14.5 ± 5.5
Peter's Anchor	CB1	Fallen Blocks	Windward	Open	19 44.831	79 43.416	Jun 22 00	10.5	10	9	10.5 ± 4.5
Pillar Coral Reef	CB4	S&G	Windward	Park	19 40.933	79 52.187	Jun 23 00	10.5	9	12.5	16.0 ± 7.0
All Cayman Brac (mean ± standard deviation)								**9.5**	**8.5**	**12.8**	**14.3 ± 5.0**
All Cayman Islands (mean ± standard error)								**10.5**	**11.5**	**11.7**	**19.7 ± 6.9**

[1]CI = LC (for sites 1-18) or GC (for sites 19-33) in Pattengill-Semmens and Semmens (this volume).
[2]S & G = spur and groove
[3]Prot. = protected; Lee = leeward; Wind. = windward
[4]Rep = Replenishment Zone

Table 2. Size and condition (mean ± standard deviation) of all stony corals (≥10 cm diameter), by site in the Cayman Islands.

Site name	Site code	Relative exposure	Depth (m)	Stony corals			Partial-colony mortality (%)			Stony corals (%)		
				(#)	Diameter (cm)	Height (cm)	Recent	Old	Total	Standing dead	Bleached	Diseased
Little Cayman												
Meadows	CI8	Lee	6.0	221	66.0 ± 45.5	43.0 ± 35.5	7.0 ± 16.5	23.0 ± 23.5	30.0 ± 26.5	0.5	0	24.5
Berges Meredith	CI17	Lee	9.0	102	52.0 ± 30.0	32.0 ± 25.5	2.0 ± 4.0	22.5 ± 23.0	24.0 ± 24.5	0	1.0	9.0
Jigsaw Puzzle	CI2	Lee	10.5	128	43.0 ± 23.5	31.0 ± 21.5	1.0 ± 7.0	20.0 ± 20.5	20.5 ± 21.5	1.0	0	1.5
Joy's Joy	CI10	Lee	12.0	157	35.0 ± 23.0	23.5 ± 17.5	5.0 ± 14.0	19.0 ± 22.5	24.0 ± 25.0	0	2.5	12.5
Mixing Bowl-Three Fathom Wall	CI5	Lee	12.5	196	40.5 ± 20.5	29.5 ± 21.0	0.5 ± 2.5	23.0 ± 23.5	23.5 ± 23.5	0	1.0	0.5
Nancy's Cup of Tea	CI9	Lee	12.5	138	43.0 ± 31.5	28.0 ± 23.0	2.5 ± 7.5	30.0 ± 27.0	32.0 ± 28.0	1.5	3.5	12.5
Rock Bottom Wall	CI13	Lee	12.5	142	41.5 ± 28.5	23.5 ± 18.0	1.0 ± 4.5	26.5 ± 26.0	27.5 ± 26.5	0	7.0	3.0
Paul's Anchor	CI12	Lee	13.0	139	34.5 ± 18.0	23.5 ± 16.5	2.0 ± 5.0	24.5 ± 25.0	26.5 ± 27.0	0	1.5	5.0
Lighthouse	CI16	Lee	14.0	106	46.0 ± 26.0	25.5 ± 22.0	1.5 ± 8.5	15.5 ± 18.5	17.0± 20.5	0	5.5	3.0
Penguin's Leap	CI7	Lee	16.0	174	35.5 ± 18.5	26.5 ± 16.0	1.5 ± 4.5	33.5 ± 28.0	35.0 ± 29.0	0	3.5	3.0
Wreck	CI18	Prot Wind	11.0	99	42.5 ± 19.5	26.5 ± 16.0	6.5 ± 20.5	20.5 ± 21.5	27.0 ± 25.5	1.0	3.0	8.0
Main Channel- East Side	CI11	Wind	3.0	122	38.0 ± 35.0	17.0 ± 20.0	0.5 ± 3.0	14.0 ± 23.5	14.5 ± 24.0	0	0	4.0
Grundy's Gardens	CI1	Wind	9.5	90	80.0 ± 71.5	59.0 ± 66.5	1.0 ± 4.5	23.5 ± 22.5	24.0 ± 22.5	0	1.0	0
Disneyland	CI3	Wind	10.0	152	48.0 ± 39.5	32.0 ± 26.0	1.0 ± 6.5	20.5 ± 26.5	27.5 ± 26.5	0	2.5	0.5
Charles Bay	CI4	Wind	11.0	146	40.0 ± 35.0	27.5 ± 34.0	0.5 ± 3.0	17.0 ± 24.0	17.5 ± 23.5	0	2.0	0.5
No Name	CI15	Wind	11.0	130	54.0 ± 49.0	30.5 ± 31.5	2.0 ± 6.0	17.5 ± 21.5	19.5 ± 24.5	0	2.5	3.0
Black Tip Tunnels	CI6	Wind	12.5	162	36.5 ± 29.0	25.0 ± 24.5	1.0 ± 6.5	25.5 ± 28.0	26.5 ± 28.5	0.5	5.0	2.0
Lucas's Ledge	CI14	Wind	13.5	135	42.5 ± 30.5	27.0 ± 22.0	1.5 ± 6.5	15.0 ± 20.50	16.5 ± 21.5	0	2.0	6.0
All Little Cayman (mean ± standard deviation)			**11.0**	**141.1**	**45.4 ± 31.4**	**29.5 ± 25.4**	**2.1 ± 7.2**	**21.7 ± 23.6**	**24.1 ± 25.0**	**0.2**	**2.4**	**5.5**
Grand Cayman												
Cemetery Reef	CI32	Lee	9.0	151	45.5 ± 29.0	28.0 ± 29.5	9.0 ± 18.5	27.5 ± 26.5	36.5 ± 32.5	2.0	0	10.5
Sunset House	CI33	Lee	9.0	144	49.0 ± 31.0	30.5 ± 28.0	7.5 ± 16.5	22.5 ± 23.5	30.0 ± 27.5	0	0	11.0
Hepp's Mini Wall	CI28	Lee	11.5	170	37.5 ± 26.5	23. ± 21.00	3.5 ± 11.5	19.0 ± 22.5	22.5 ± 25.5	0	2.0	2.0
Delila's Delight	CI24	Prot Wind	7.0	143	44.5 ± 33.5	25.5 ± 24.5	5.5 ± 16.5	24.0 ± 27.5	29.5 ± 30.5	3.0	3.5	3.5
Babylon	CI23	Prot Wind	9.5	151	43.5 ± 24.5	22.0 ± 15.0	6.5 ± 16.0	28.0 ± 28.5	35.0 ± 31.0	0.5	0.5	5.5
Isabel's Reef	CI22	Prot Wind	10.5	132	47.5 ± 25.5	24.5 ± 15.5	10.5 ± 22.5	26.0 ± 26.5	36.0 ± 31.5	2.5	4.0	7.0
Bear's Paw	CI27	Prot Wind	10.5	136	43.0 ± 28.5	22.0 ± 23.0	6.5 ± 16.5	26.0 ± 27.0	32.5 ± 33.0	6.0	3.0	7.5
Queen's Throne	CI25	Prot Wind.	12.0	137	36.5 ± 18.0	20.5 ± 14.0	5.0 ± 14.5	23.0 ± 25.5	28.0 ± 29.5	1.5	2.0	0.5

Table 2. continued.

Site name	Site code	Relative exposure	Depth (m)	Stony corals			Partial-colony mortality (%)			Stony corals (%)		
				(#)	Diameter (cm)	Height (cm)	Recent	Old	Total	Standing dead	Bleached	Diseased
Casey's Reef	CI26	Prot Wind	14.0	122	34.5 ± 13.5	17.5 ± 11.5	3.5 ± 13.5	20.5 ± 23.5	24.0 ± 26.5	1.5	5.0	1.0
East End Reef	CI19	Wind	7.0	145	36.0 ± 30.5	18.5 ± 24.5	1.5 ± 9.0	16.5 ± 21.5	18.0 ± 23.0	2.0	0	4.0
Playing Field	CI31	Wind	7.5	144	43.0 ± 37.0	23.5 ± 23.0	2.5 ± 7.5	19.0 ± 24.5	21.5 ± 27.0	0.5	0	1.5
Kaho's Reef	CI20	Wind	9.0	131	33.0 ± 21.0	17.0 ± 13.5	2.0 ± 9.5	15.5 ± 21.5	17.5 ± 23.0	1.5	1.5	3.0
Kelly's Caverns	CI29	Wind	9.0	164	45.5 ± 38.0	27.0 ± 25.5	3.5 ± 13.5	20.0 ± 24.5	23.5 ± 26.5	2.5	2.0	0.0
Snapper Hole	CI21	Wind	10.0	155	47.5 ± 33.5	25.0 ± 20.5	2.0 ± 6.5	18.5 ± 28.5	20.5 ± 29.5	4.5	1.5	2.0
Breakers	CI30	Wind	12.5	127	44.0 ± 30.0	21.0 ± 19.5	6.0 ± 21.0	24.0 ± 25.0	30.0 ± 29.5	1.5	1.0	1.0
All Grand Cayman (mean ± standard deviation)			**10.0**	**143.5**	**41.8 ± 28.0**	**23.0 ± 20.6**	**5.0 ± 14.1**	**22.0 ± 25.1**	**27.0 ± 28.5**	**2.0**	**1.7**	**4.0**
Cayman Brac												
Greenhouse Reef	CB7	Lee	7.0	168	31.5 ± 21.0	25.0 ± 16.0	2.5 ± 8.0	29.5 ± 32.0	34.0 ± 32.0	6.0	0	4.0
Patch Reef	CB8	Lee	8.0	106	28.5 ± 32.0	24.0 ± 28.0	1.0 ± 2.5	31.5 ± 29.0	32.5 ± 29.0	3.0	0	6.5
End of Island	CB9	Lee	9.5	79	25.0 ± 14.0	17.0 ± 13.5	0.2 ± 1.5	19.5 ± 26.0	19.5 ± 26.0	2.5	1.5	2.5
Bert Brothers	CB3	Lee/ Prot Wind	16.5	94	27.0 ± 18.5	21.0 ± 13.0	2.5 ± 6.5	18.0 ± 23.5	20.5 ± 25.0	1.0	0	4.5
Pillars of Hercules	CB2	Wind	4.0	97	38.5 ± 32.0	20.5 ± 14.5	0.1 ± 1.0	10.0 ± 14.5	10.0 ± 14.5	0	0	0
Sergeant Major Reef	CB6	Wind	8.0	107	34.5 ± 35.0	24.0 ± 24.5	0.2 ± 1.0	18.5 ± 29.5	18.5 ± 30.0	6.5	0	1.0
Lighthouse Reef	CB5	Wind	9.5	103	38.5 ± 34.5	29.5 ± 26.5	1.5 ± 5.0	14.5 ± 25.0	16.0 ± 26.0	4.0	0	1.0
Peter's Anchor	CB1	Wind	10.5	89	29.0 ± 23.0	14.5 ± 11.5	2.5 ± 11.5	10.5 ± 17.0	13.0 ± 20.5	1.0	1.0	0
Pillar Coral Reef	CB4	Wind	10.5	112	37.0 ± 32.5	29.5 ± 25.0	2.0 ± 4.5	22.5 ± 30.5	24.0 ± 31.5	4.5	0	1.0
All Cayman Brac (mean ± standard deviation)			**9.0**	**106.1**	**32.3 ± 27.0**	**22.7 ± 19.2**	**1.3 ± 4.6**	**19.3 ± 25.3**	**20.9 ± 26.**	**3.2**	**0.3**	**2.3**
All Cayman (mean ± standard error)			**10.5**	**134.4**	**41.4 ± 29.5**	**25.7 ± 22.5**	**3.0 ± 9.0**	**21.2 ± 24.5**	**24.3 ± 26.5**	**1.5**	**1.7**	**4.2**

Table 3. Comparison of benthos data (mean ± standard deviation, where appropriate) in leeward, windward and protected windward settings and at all shallower (≤10m) and all deeper (>10m) sites, in Little Cayman, Grand Cayman and Cayman Brac.

Parameter	Setting[2]					Depth	
Island[1]	Leeward	Windward	Leeward + Protected Windward	Protected Windward	Protected windward + Windward	Shallower	Deeper
Diameter, stony corals (cm)							
LC	43.5 ± 26.5	48.5 ± 40.0	43.5	42.5	47.5	61.5 ± 46.5	41.0 ± 26.5
GC	44.0 ± 29.0	41.5 ± 31.5	42.5	41.5	41.5	42.5 ± 30.5	34.5 ± 13.5
CB	28.0 ± 21.5	35.5± 31.5				33.0 ± 28.0	31.0 ± 24.5
Height, stony corals (cm)							
LC	28.5 ± 21.5	31.5 ± 32.0	28.5	26.5	30.5	41.5 ± 38.5	26.5 ± 22.0
GC	27.0 ± 26.0	22.0 ± 21.0	24.0	22.0	22.0	24.0 ± 23.0	17.5 ± 11.5
CB	21.5 ± 17.5	23.5 ± 20.5				23.5 ± 20.5	21.5 ± 16.5
Diseased stony corals (%)							
LC	7.5	2.5	7.5	8.0	3.0	8.5	4.5
GC	8.0	2.0	5.5	4.0	3.0	5.0	1.0
CB	4.5	0.5				2.5	1.5
Bleached stony corals (%)							
LC	2.5	2.0	2.5	3.0	2.5	1.0	3.0
GC	0.5	1.0	2.0	3.0	2.0	1.0	5.0
CB	0.5	0.2				0.2	0.5
Recruitment, stony corals (#/.0625m^2)							
LC	0.2 ± 0.6	0.2 ± 0.6	0.3	0.5	0.3	0.3 ± 0.8	0.2 ± 0.5
GC	0.3 ± 0.6	0.3 ± 0.5	0.3	0.3	0.3	0.3 ± 0.6	0.3 ± 0.6
CB	0.2 ± 0.3	0.2 ± 0.3				0.2 ± 0.3	0.2 ± 0.4
Recent partial mortality, stony corals (%)							
LC	2.5 ± 7.5	1.0 ± 5.0	3.0	6.5	1.5	2.5 ± 8.0	2.0 ± 7.5
GC	6.5 ± 15.5	3.0 ± 11.	6.5	6.0	4.5	5.0 ± 13.5	3.5 ± 13.5
CB	1.5 ± 4.5	1.0 ± 4.5				1.0 ± 3.0	2.0 ± 7.5
Old partial mortality, stony corals (%)							
LC	23.5 ± 23.5	19.0 ± 24.0	21.5	23.5	19.0	22.5 ± 24.0	22.0 ± 23.5
GC	23.0 ± 24.0	19.0 ± 24.0	24.0	24.5	21.5	21.5 ± 24.5	20.5 ± 23.5
CB	24.5 ± 27.5	15.0 ± 23.5				20.5 ± 26.0	17.0 ± 23.5
Standing dead, stony corals (%)							
LC	0.5	0.1	0.3	1.0	0.2	0.1	0.3
GC	0.5	2.0	2.0	2.5	2.5	1.5	1.5
CB	3.0	3.0				3.5	2.0
Relative abundance, crustose coralline algae (%)							
LC	39.0 ± 22.0	35.5 ± 22.5	39.0	40.0	36.0	34.5 ± 25.0	39.0 ± 21.0
GC	36.5 ± 20.5	63.5 ± 20.5	46.5	51.5	57.5	51.0 ± 21.0	55.5 ± 19.5
CB	30.5 ± 22.0	26.5 ± 25.0				31.5 ± 24.0	21.5 ± 22.0
Relative abundance, macroalgae (%)							
LC	42.0 ± 21.0	36.5 ± 21.0	42.0	44.0	37.5	29.0 ± 20.0	44.0 ± 21.5
GC	39.5 ± 26.0	15.5 ± 19.0	39.0	39.0	27.0	27.5 ± 22.0	32.0 ± 20.5
CB	62.0 ± 22.0	56.0 ± 26.0				55.5 ± 24.5	65.5 ± 24.0
Macroalgal Index							
LC	83.9	93.1	82.2	65.1	89.6	73.6	90.7
GC	55.2	19.8	54.8	54.7	37.2	53.1	23.1
CB	175.0	92.7				100.3	197.3
Relative abundance, turf algae (%)							
LC	19.5 ± 19.5	27.5 ± 22.5	19.0	16.0	26.5	36.5	17.0 ± 18.5
GC	24.0 ± 25.0	21.0 ± 19.0	14.5	9.5	15.5	21.5 ± 21.5	12.0 ± 16.0
CB	7.5 ± 11.5	17.5 ± 19.0				13.0 ± 16.0	13.0 ± 15.5

[1]LC = Little Cayman; GC = Grand Cayman; CB = Cayman Brac

[2]None of the sites at CB are considered protected leeward with the possible exception of the Bert Brothers location which is a marginal protected leeward location. Only one site on LCwould be considered protected windward (Wreck).

Pp. 204-225 in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496.

Table 4. Algal characteristics, density of stony coral recruits and *Diadema antillarum* (mean ± standard deviation), by site in the Cayman Islands.

Site Name	Site Code	Relative Exposure[1]	Depth (m)	Quadrats (#)	Relative Abundance (%)			Macroalgal		Recruits (#/.0625m^2)	*Diadema* (#/100m^2)
					Macroalgae	Turf algae	Crustose coralline algae	Height (cm)	Index[2]		
Little Cayman											
Meadows	CI8	Lee	6	75	23.0 ± 23.0	41.5 ± 29.5	35.5 ± 29.0	2 ± 1	36	0.4 ± 1.2	0
Berges Meredith	CI17	Lee	9	50	47.5 ± 24.0	16.0 ± 19.5	37.0 ± 23.0	2 ± 1	95	0.3 ± 0.7	0
Jigsaw Puzzle	CI2	Lee	10.5	67	28.0 ± 20.5	29.0 ± 21.0	43.5 ± 22.0	2 ± 1	62	0.4 ± 1.1	0
Joy's Joy	CI10	Lee	12	70	41.0 ± 20.5	15.0 ± 16.0	44.0 ± 24.5	2 ± 1	76	0.2 ± 0.4	0
Mixing Bowl-Three Fathom Wall	CI5	Lee	12.5	67	36.5 ± 17.5	21.0 ± 21.0	42.5 ± 19.0	3 ± 2	98	0.3 ± 0.5	0
Nancy's Cup of Tea	CI9	Lee	12.5	60	50.5 ± 20.5	13.0 ± 14.5	36.5 ± 19.5	2 ± 1	83	0.1 ± 0.3	0
Rock Bottom Wall	CI13	Lee	12.5	60	45.5 ± 20.0	13.0 ± 16.5	41.5 ± 22.0	2 ± 1	94	0.3 ± 0.5	0
Paul's Anchor	CI12	Lee	13	60	41.5 ± 19.0	16.5 ± 19.5	42.0 ± 20.0	2 ± 1	80	0.2 ± 0.4	0
Lighthouse	CI16	Lee	14	50	58.5 ± 22.0	13.5 ± 17.5	28.5 ± 17.5	2 ± 1	102	0.1 ± 0.5	0
Penguin's Leap	CI7	Lee	16	79	47.0 ± 20.5	14.5 ± 17.5	38.5 ± 23.5	2 ± 2	116	0.1 ± 0.4	0
Wreck	CI18	Prot Wind	11	50	44.0 ± 21.	16.0 ± 18.5	40.0 ± 18.5	1 ± 1	65	0.5 ± 0.7	0
Main Channel- East Side	CI11	Wind	3	59	8.0 ± 12.0	59.0 ± 30.5	32.5 ± 31.0	1 ± 1	8	0.4 ± 0.7	0
Grundy's Gardens	CI1	Wind	9	60	38.0 ± 24.0	36.5 ± 24.5	25.5 ± 20.0	3 ± 2	112	0.1 ± 0.4	0
Disneyland	CI3	Wind	10	75	29.0 ± 17.0	30.0 ± 21.0	41.0 ± 22.0	3 ± 1	76	0.4 ± 0.8	0
Charles Bay	CI4	Wind	11	89	39.0 ± 24.5	24.0 ± 21.5	37.0 ± 20.0	3 ± 3	115	0.2 ± 0.5	0
No Name	CI15	Wind	11	60	49.0 ± 24.0	14.5 ± 21.0	37.0 ± 21.5	2 ± 1	120	0.1 ± 0.3	0
Black Tip Tunnels	CI6	Wind	12.5	85	46.0 ± 23.5	18.5 ± 20.0	35.5 ± 22.0	2 ± 1	115	0.2 ± 0.5	0
Lucas's Ledge	CI14	Wind	13.5	60	48.0 ± 22.0	11.0 ± 18.0	40.5 ± 22.5	2 ± 1	108	0.3 ± 0.9	0
All Little Cayman (mean ± standard error)			**11**	**65.3**	**40.0 ± 21.0**	**22.5 ± 20.5**	**37.5 ± 22.0**	**2 ± 1**	**87**	**0.2 ± 0.6**	**0.0**
Grand Cayman											
Cemetery Reef	CI32	Lee	9	65	47.0 ± 30.5	34.0 ± 30.0	19.0 ± 20.0	2 ± 1	91	0.2 ± 0.4	0
Sunset House	CI33	Lee	9.0	59	39.0 ± 24.5	27.5 ± 26.5	34.0 ± 19.5	1 ± 1	43	0.1 ± 0.3	0
Hepp's Mini Wall	CI28	Lee	11.5	65	32.0 ± 23.0	11.0 ± 18.0	56.5 ± 21.0	1 ± 1	32	0.5 ± 0.9	0
Delila's Delight	CI24	Prot Wind	7	50	25.5 ± 21.5	24.5 ± 25.0	50.0 ± 22.0	2 ± 1	52	0.6 ± 1.5	0
Babylon	CI23	Prot Wind	9.5	54	46.0 ± 28.5	11.0 ± 18.5	43.0 ± 21.0	2 ± 1	91	0.2 ± 0.5	0
Isabel's Reef	CI22	Prot Wind.	10.5	44	42.0 ± 20.0	7.0 ± 17.0	51.0 ± 19.5	2 ± 1	69	0.3 ± 0.6	0
Bear's Paw	CI27	Prot Wind	10.5	60	39.0 ± 24.0	8.5 ± 16.0	52.0 ± 21.0	1 ± 1	46	0.2 ± 0.5	0
Queen's Throne	CI25	Prot Wind	12	59	41.0 ± 17.5	4.0 ± 12.5	55.0 ± 17.0	1 ± 1	39	0.3 ± 0.4	0

Table 4. continued.

Site Name	Site Code	Relative Exposure[1]	Depth (m)	Quadrats (#)	Relative Abundance (%)			Macroalgal		Recruits (#/.0625m^2)	*Diadema* (#/100m^2)
					Macroalgae	Turf algae	Crustose coralline algae	Height (cm)	Index[2]		
Casey's Reef	CI26	Prot Wind	14	60	39.5 ± 20.5	2.4 ± 5.5	58.0 ± 21.5	1 ± 1	39	0.3 ± 0.5	0
East End Reef	CI19	Wind	6.5	60	16.0 ± 20.5	14.0 ± 17.5	70.0 ± 22.0	1± 1	20	0.3 ± 0.6	0
Playing Field	CI31	Wind	7.5	60	8.5 ± 14.0	26.5 ± 20.5	65.0 ± 20.0	1 ± 1	5	0.2 ± 0.4	0
Kaho's Reef	CI20	Wind	9.	56	28.5 ± 25.5	10.5 ± 15.5	61.0 ± 21.5	2 ± 1	47	0.4 ± 0.7	0
Kelly's Caverns	CI29	Wind	9.	60	9.0 ± 13.0	23.5 ± 18.0	67.5 ± 19.5	1 ± 1	7	0.4 ± 0.5	0
Snapper Hole	CI21	Wind	20	60	18.5 ± 22.5	24.0 ± 20.5	57.5 ± 17.5	1 ± 1	26	0.2 ± 0.5	0
Breakers	CI30	Wind	12.5	50	13.5 ± 17.5	27.0 ± 22.5	59.5 ± 20.5	1 ± 1	13	0.2 ± 0.5	0
All Grand Cayman (mean ± standard error)			**10.5**	**57.5**	**30.5 ± 21.5**	**17.0 ± 19.0**	**53.5 ± 20.5**	**1 ± 1**	**42**	**0.3 ± 0.6**	**0.0**
Cayman Brac											
Greenhouse Reef	CB7	Lee	7	35	64.0 ± 24.0	15.5 ± 20.0	20.5 ± 19.0	2 ± 1	147	0.	0
Patch Reef	CB8	Lee	8	35	75.0 ± 14.0	4.0 ± 6.0	21 ± 14.5	2 ± 1	165	0.2 ± 0.4	0
End of Island	CB9	Lee	9.5	45	34.5 ± 27.0	5.3 ± 8.5	60.5 ± 31.5	1 ± 1	21	0.2 ± 0.0	0
Bert Brothers	CB3	Lee	16.5	40	75.0 ± 22.0	5.0 ± 10.5	20.0 ± 22.5	5 ± 5	368	0.3 ± 0.7	0
Pillars of Hercules	CB2	Wind	4	45	38.0 ± 28.0	29.5 ± 28.0	33.0 ± 28.5	2 ± 1	61	0.1 ± 0.0	9
Sargent Major Reef	CB6	Wind	8	45	54.5 ± 30.0	8.0 ± 14.0	37.5 ± 31.5	1 ± 1	71	0.4 ± 0.5	0
Lighthouse Reef	CB5	Wind	9.5	40	67 ± 24.0	16.0 ± 19.0	16.5 ± 20.0	1 ± 3	94	0.2 ± 0.6	0
Peter's Anchor	CB1	Wind	10.5	45	51.5 ± 25.5	24.0 ± 20.0	24.5 ± 23.5	3 ± 1	134	0.2 ± 0.5	1
Pillar Coral Reef	CB4	Wind	10.5	40	69.5 ± 24.0	10.5 ± 15.5	20.0 ± 20.5	2 ± 1	104	0.2 ± 0.0	0
All Cayman Brac (mean ± standard error)			**9.5**	**41.1**	**59.0 ± 24.5**	**13.0 ± 15.5**	**28.0 ± 23.5**	**2 ± 2**	**129**	**0.2 ± 0.3**	**1.1**
All Cayman (mean ± standard error)			**10.5**	**56.9**	**41.0 ± 22.0**	**18.0 ± 17.5**	**41.5 ± 21.5**	**2 ± 1**	**81**	**0.2 ± 0.5**	**0.2**

Lee = leeward; Wind = windward; Prot Wind = protected windward; Prot Lee = protected leeward