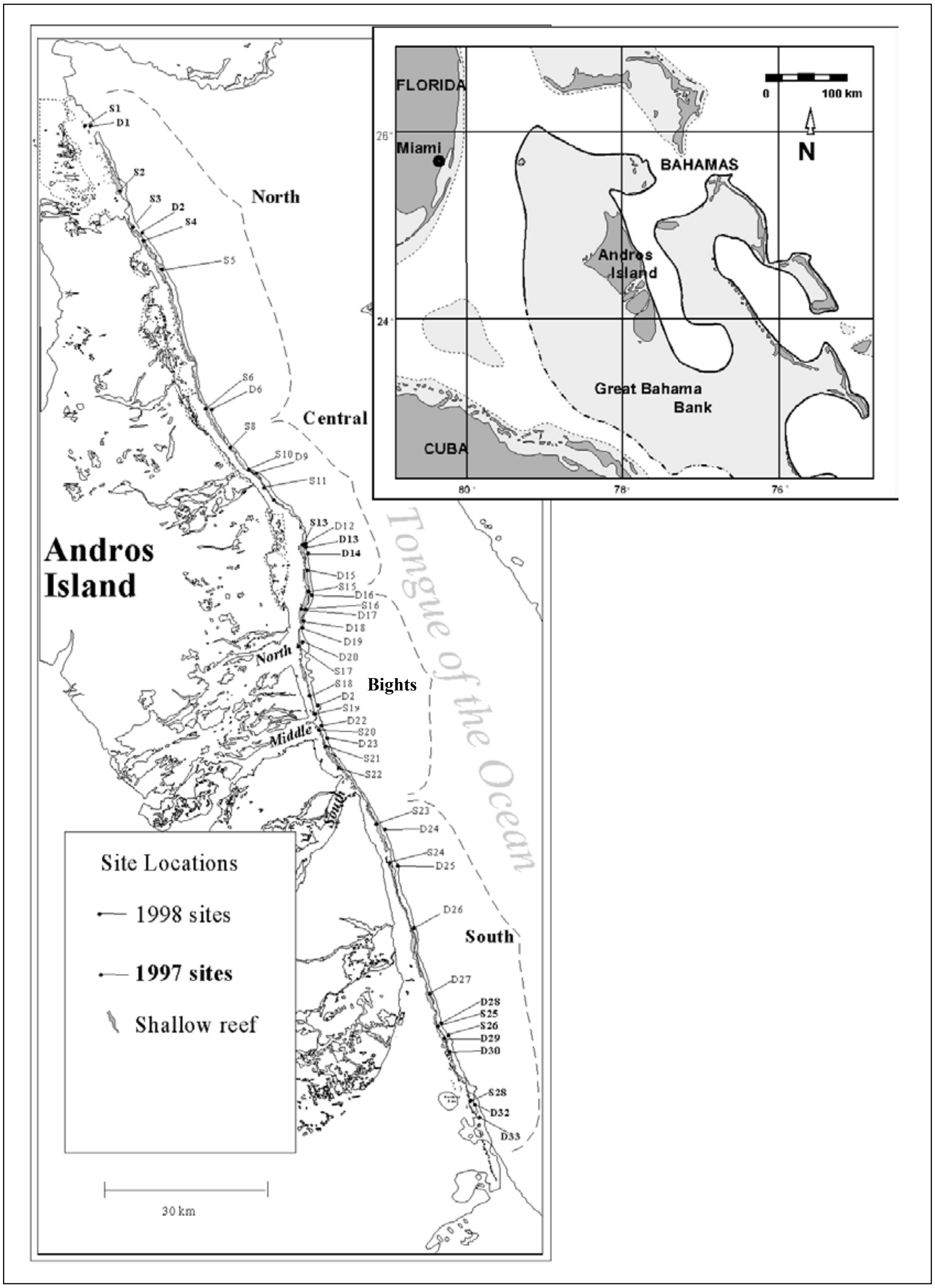

Figure 1. Location of Andros Island, the Bahamas (inset) and the 1997 and 1998 AGRRA survey sites in four areas (North, Central, Bights, South) Andros. See Tables 1A, 1B for site codes.

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ASSESSMENT OF THE ANDROS ISLAND REEF SYSTEM, BAHAMAS (PART 1: STONY CORALS AND ALGAE)

BY

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ABSTRACT

Spatially extensive shallow reef crests with high coral cover (particularly *Acropora*) and fore reefs with high topographic complexity were documented during the 1997–1998 rapid assessments of coral and algal indicators in the relatively remote Andros reef system. Apart from the ecological effects of the *Diadema antillarum* die-off, evidence of major disturbance events (hurricanes, bleaching) were not apparent in 1997, although chronic levels of disease and predation were higher than in other Western Atlantic reef areas. High macroalgal abundances in fore reefs are attributed to low grazing pressures whereas the high densities of herbivorous fishes limit macroalgae in reef-crest habitats. During 1998, warm sea surface temperatures triggered localized bleaching in reef crests and appear to have facilitated widespread outbreaks of disease with resulting high mortality of massive corals in many fore reefs.

INTRODUCTION

Recent declines in abundance and diversity of corals in the Western Atlantic are well documented in areas where local stressors such as overfishing, nutrification and sedimentation can be significant (see Ginsburg and Glynn, 1994). Less well known are the condition of coral reefs in more remote areas where anthropogenic influences are less important but where regional impacts caused by bleaching, diseases and hurricanes may be significant. To better understand the influences of regional versus local impacts, we examined the condition of a relatively remote area in the Bahamas, the Andros reef tract. Andros is separated both geographically and hydrographically from the greater Caribbean which may decrease the exchange of larvae and/or water-borne pathogens with other reefs of the region. Regional disturbances, such as the die-off of many acroporids from white-band disease (WBD) (Aronson and Precht, 1997, 2001) and detailed effects of the 1983 Caribbean-wide *Diadema* urchin die-off (Lessios et al., 1984), are poorly documented in Andros.

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The extent that anthropogenic impacts have affected the reefs off Andros is poorly quantified but is generally assumed to be minimal compared with many areas of the Caribbean. Andros has a very low population of about 8,155 (Bahamas Reef Environmental Education Foundation and MacAlister Elliot and Partners, 1998, unpublished report) with most of its populace concentrated in several small towns along the eastern coast of the island. Androsians rely on fishing, sponging and small-scale tourism for the majority of their income while additional employment comes from the Atlantic Underwater Test and Evaluation Centers (AUTEC), Androsia (a local batik factory), and small-scale farming. North Andros, used for timbering until 1975, now contains a small-scale agricultural industry (Sealey, 1990) but pollution and runoff are believed to be limited. The few small-scale resorts on Andros (<300 rooms total) cater towards tourism focused on guided bonefishing or diving the coral reefs.

Spatial trends in various indicators of the principal reef-building corals and algal populations that were surveyed during 1997 and 1998 using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) method are described in this paper. The condition of reef fish populations in Andros is presented in Kramer, Marks and Turnbull (this volume).

METHODS

Andros Island has the largest land area (6,000 km^2) of the Bahamas Archipelago and is located on the eastern margin of the western arm of Great Bahamas Bank where it abuts against the Tongue of the Ocean (Fig. 1). The extensive Andros reef tract parallels the eastern side of the island from Joulter Cays in the north to Saddleback Cays in the south (a total of 217 km). The reef is discontinuous in many places, particularly around the central and southern portion of Andros where several large channels (bights) cut across the entire island dividing it into three distinct landmasses. Smith (1948) and later Newell et al. (1951) both used the term "bank reef" to describe the Andros reef tract although it has also been described as a fringing reef, barrier reef, and fringing-barrier reef (which is probably the most accurate). The reef crest typically lies 1-2 km from the shoreline and is situated atop a Pleistocene ridge that is exposed in places in the form of small elongate offshore cays (e.g., Staniard Rock, Goat Cay, Long Rock, Long Bay Cays, Grassy Creek Cays). Fore reefs are best developed as high-relief features (e.g., pinnacles) composed of often dense aggregations of massive corals (primarily the *Montastraea annularis* species complex) and occur at intermediate depths between 7 m to 12 m, being most extensive in “low-to-intermediate” wave-energy environments. Well-developed reef crests and fore reefs often occur together in central and southern Andros. The outer reef slope contains a break at approximately 20 m followed by the shelf edge at 30 m that is marked by a near-vertical wall rich in sponges and other invertebrates.

For this study, the Andros reef tract was stratified into shallow crests (1-3 m deep) and intermediate-depth fore reefs (8-12 m deep), which were further subdivided into “well developed” and “poorly developed” categories for both depths using low altitude (200 m) oblique aerial photographs taken in July, 1997. Lagoonal patch reefs and deeper shelf-margin reefs were not investigated. Reconnaissance inspections or Manta tows were undertaken in each area to get an overview of reef type before haphazardly selecting representative well-developed sites to survey. In 1997, 26 sites (13 at 1-3 m depth, 13 at

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8-12 m) located primarily in the northern and southern sections of Andros Island were examined. In 1998, 28 (15 deep and 13 shallow) sites along 75 km of central Andros were surveyed (Fig. 1; Tables 1A, 1B). Four sites overlapped between the 1997 and 1998 surveys (S6-S7; D6-D7; D9-D10; D12-D13). All surveyors were trained in the AGRRA method and consistency exercises were conducted regularly to minimize differences among observers. For the two survey periods, a total of six persons participated in the benthic surveys with three surveyors collecting approximately 75% of all the data.

The total number of 10-m benthic transects deployed at each site ranged from 6 to 24 and video was recorded on some transects for archival purposes. In 1997, when a modified Version 1 of the AGRRA protocols was used, live stony coral cover was not quantified. Visual estimates of old mortality did not factor out open spaces between columns for lobate colonies such as *M. annularis* and recent mortality estimates included sides of colonies. Maximum (rather than average) macroalgal heights were recorded within quadrats. In addition, after estimating their abundance in the uppermost canopy layer of the algal quadrats, macroalgae were removed prior to estimating the abundance of underlying turf and crustose coralline algae. We substituted the newly adopted Version 2 of the AGRRA protocols for the 1998 surveys (see Appendix One, this volume), expanding the size and health assessments to all stony corals that were at least 10 cm in diameter for approximately half of the sites. Coral sizes were measured to the nearest 5 cm in both years. Identification of corals was based on Humann (1992).

Statistical analysis was performed with the Statistica (version 5.1) program. To permit comparisons between years, all stony corals <25 cm in diameter were excluded from these analyses and the *Montastraea annularis* species complex was treated as a single entity. To statistically characterize variance for the benthic indicators, only the first 10 transects were analyzed from each site. Size data were log(X+1)-transformed and percentage data were arcsine-transformed. Parameters were analyzed by students t-test and by 1-way and 2-way Analysis of Variance (ANOVA). For spatial analysis, the Andros sites were divided into four areas (North, Central, Bights, and South) (Fig. 1) and analyzed by ANOVA with sites hierarchically nested under areas as random factors.

RESULTS

Species Composition and Abundance of Stony Corals

A total of 3,221 stony corals were examined in 28 reef crests in Andros during the two years of field work. They were dominated by colonies of *Acropora palmata* and displayed varying degrees of development controlled, in part, by wave energy, reef aspect, and the presence of freshwater creeks. China Point (S10) was one of the few shallow sites that contained monotypic thickets of living *A. cervicornis*, although "standing dead" (colonies completely dead and still in growth position) thickets were encountered at several other sites. Live stony coral cover ranged from 20-54% (mean=36, sd=18) in 1998 in shallow reefs (Table 1A). A total of 16 "large" (≥25 cm) scleractinian and one hydrozoan species were recorded in the shallow crests (all reefs combined). *Acropora palmata* comprised a mean of 62% of all these large corals (Fig. 2A). The relative abundance of subdominant taxa on reef crests (e.g., *M. annularis*, *Millepora* *complanata*, *Porites astreoides*) was remarkably uniform across the reef areas (Fig. 3A). The most common size range for the colonies of *A. palmata* was 120-140 cm (mean diameter=137, sd=77) with the largest colonies exceeding 400 cm in diameter (Fig. 4A).

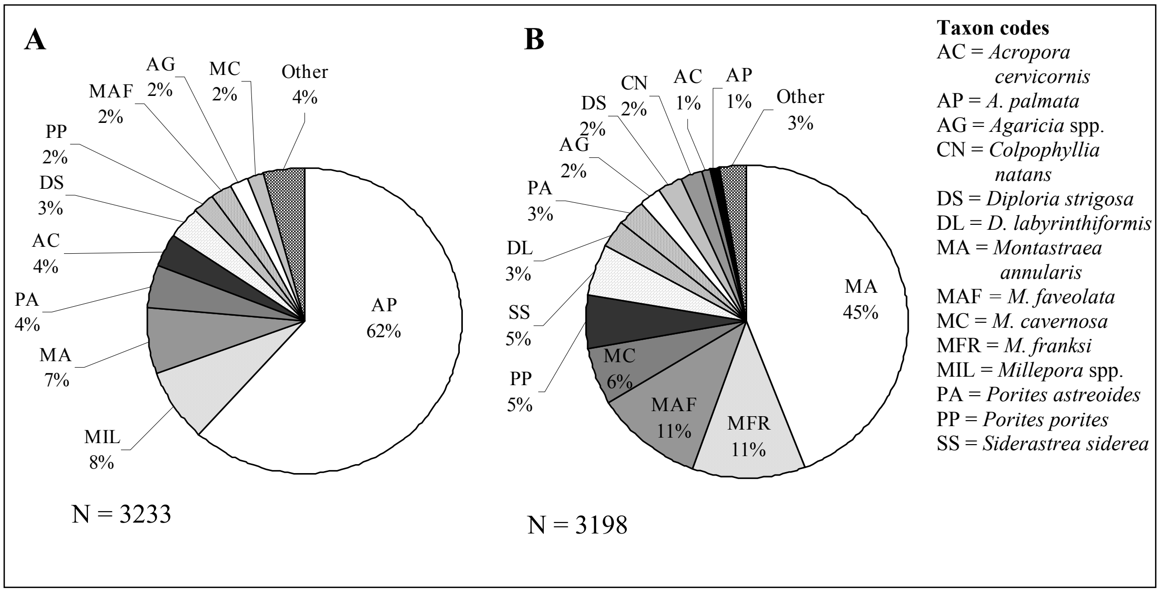

Figure 2. Species composition and mean relative abundance of all stony corals (≥25 cm diameter) on (**A**) reef crests and (**B**) fore reefs in Andros.

Its colony diameters were significantly smaller in the bights area (mean=118 cm for S18-S22) compared with the other areas along Andros (mean=152 cm) (ANOVA df=1, MS=37, F=18.2, p<0001) (Fig. 4A). Average colony diameters overall were largest in the northern area and smallest in the bights area (Table 2A).

In the 32 intermediate-depth fore reefs that were surveyed, a total of 3,156 large corals were assessed. Fore reefs were mainly dominated by assemblages of *M. annularis* (Fig. 2B) and they were best developed around protected channels, cays, and seaward of reef crests. Live stony coral cover in 1998 ranged from 6 to 45% (mean=22.6, sd=13.8) in the fore reefs (Table 1B). Several sites in the bights area (e.g., D18, D19) had low coral cover (<10%) and one site (D23) contained few corals greater than 25cm in diameter. A total of 18 species of large stony corals were counted within fore reef transects (all reefs combined), 67% of which were *M. annularis* complex *(M. annularis, M. faveolata, M. franksi)* (Fig. 2B). An exception to this pattern was the dominance of *S. siderea* rather than *M. annularis* at several sites in the bights area (Fig. 3B). Colonies of *M. annularis* were most common in the 40-50 cm size range (average=64, sd= 8), yet some individuals exceeded 250 cm in diameter (Fig 4B). Colony sizes were negatively correlated with water depth (r^2=0.03, p<0.0001) and significantly smaller in the reefs surveyed in 1998 (mean diameter=54 cm) than in 1997 (mean diameter=70 cm) (t-test, df=1443, t=10.1, p<0.0001). As in the reef crests, colonies were largest in the northern area and smallest in the bights (Table 2A).

The number of species of stony coral recruits (≤2 cm) was greater in fore reefs (26 species, all reefs combined) than in reef crests (16 species, all reefs combined). Small stony coral densities were also significantly higher in deeper (equivalent to 10.6 recruits/m^2) than in shallower sites (equivalent to 2.9 recruits/m^2) (t-test, t=12.7, df =544,

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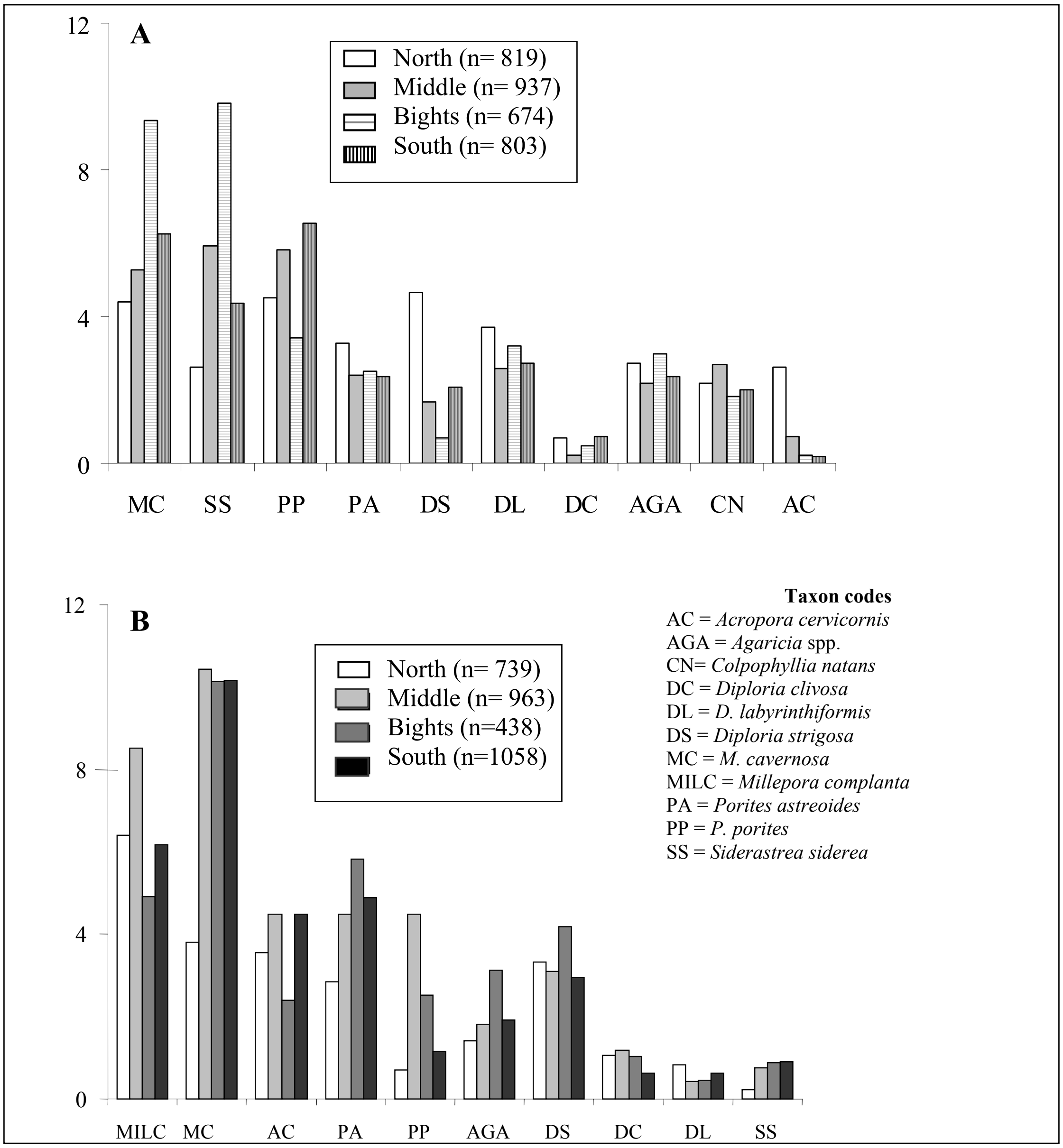

Figure 3. Relative species abundance of the 10 most abundant stony corals (≥25 cm diameter) on (**A**) reef crests (here excluding *Acropora palmata)*, (**B**) fore reefs (here excluding the *Montastraea annularis* complex) in four areas of Andros.

p<0.0001) but showed a high degree of variability among reefs (Tables 3A,3B). *Porites astreoides* was the most abundant recruit in reef crests (50%) and fore reefs (25%) despite low abundances of large adults (~4% in reef crests, 3% on fore reefs) (Fig. 5). *Acropora palmata* was the third most abundant (9%) recruit in shallow reefs with the *M. annularis* complex as the fourth most abundant (6%) in deep reefs.

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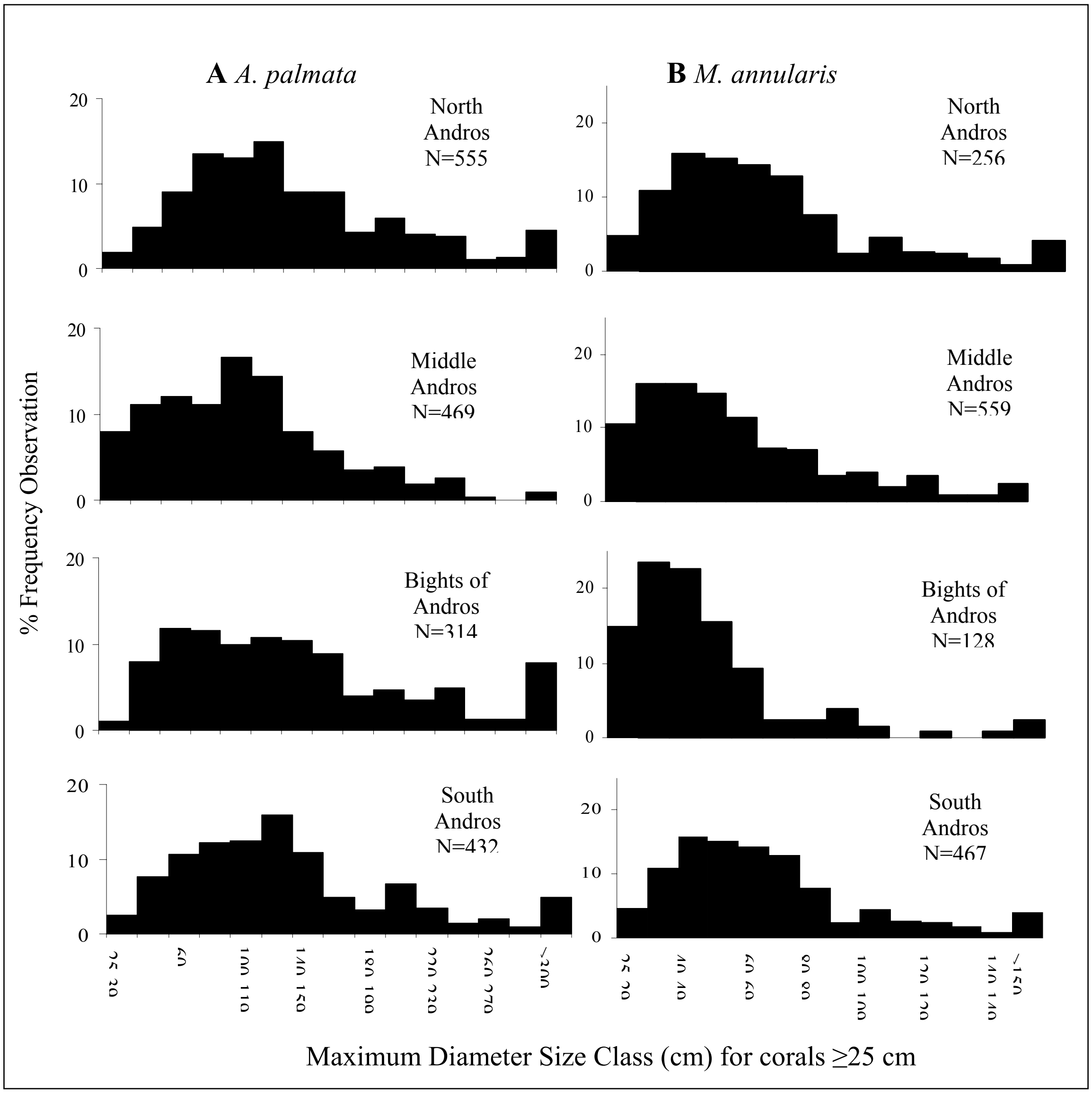

Figure 4. Size-frequency distribution of all colonies (≥5 cm diameter) of (**A**) *Acropora palmata* on reef crests and (**B**) *Montastraea annularis* on fore reefs in four areas off Andros.

Stony Coral Condition

Levels of old partial-colony mortality (hereafter old mortality) in large stony corals ranged from 12% (S5) to 52% (S25) (Table 2) and were higher in reef crests than fore reefs for both survey years (2-way ANOVA, df=581, MS=1787, F=12.5, p<0.0001). The frequency of 100% standing dead colonies was 10%. Reefs surveyed in 1997 had significantly higher old mortality (crests = 38%, fore reefs = 29%) than those surveyed in 1998 (crests = 29%, fore reefs = 22%) (2-way ANOVA, df=581, MS=5665, F=40.4, p<0.0001). Large differences in old mortality were apparent among species, with acroporids (n=1,764) accounting for the highest levels of old mortality (48% for *A.*

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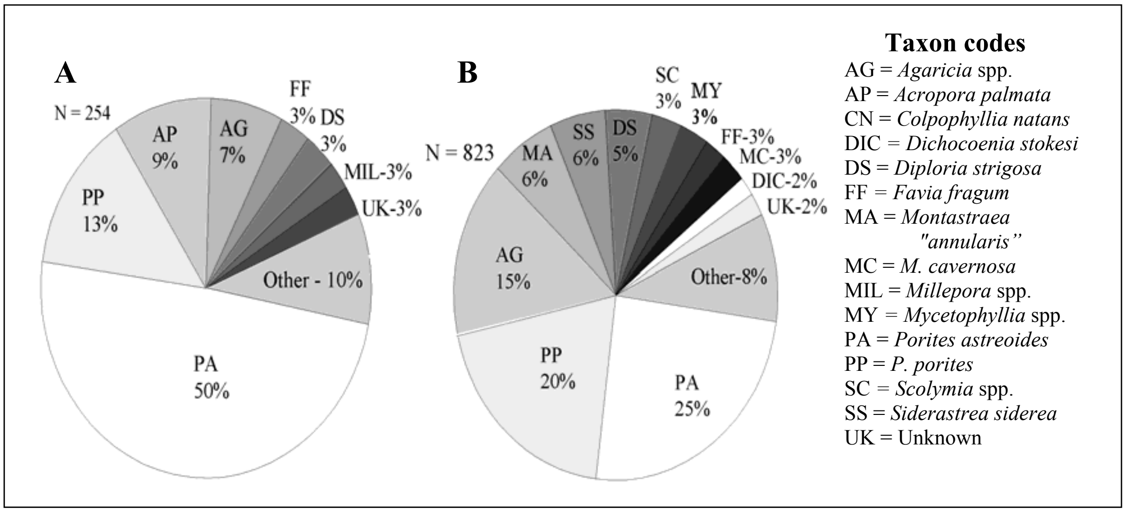

Figure 5. Species composition and mean relative abundance of stony coral recruits (≤2 cm diameter) in (**A**) reef crests and (**B**) fore reefs off Andros.

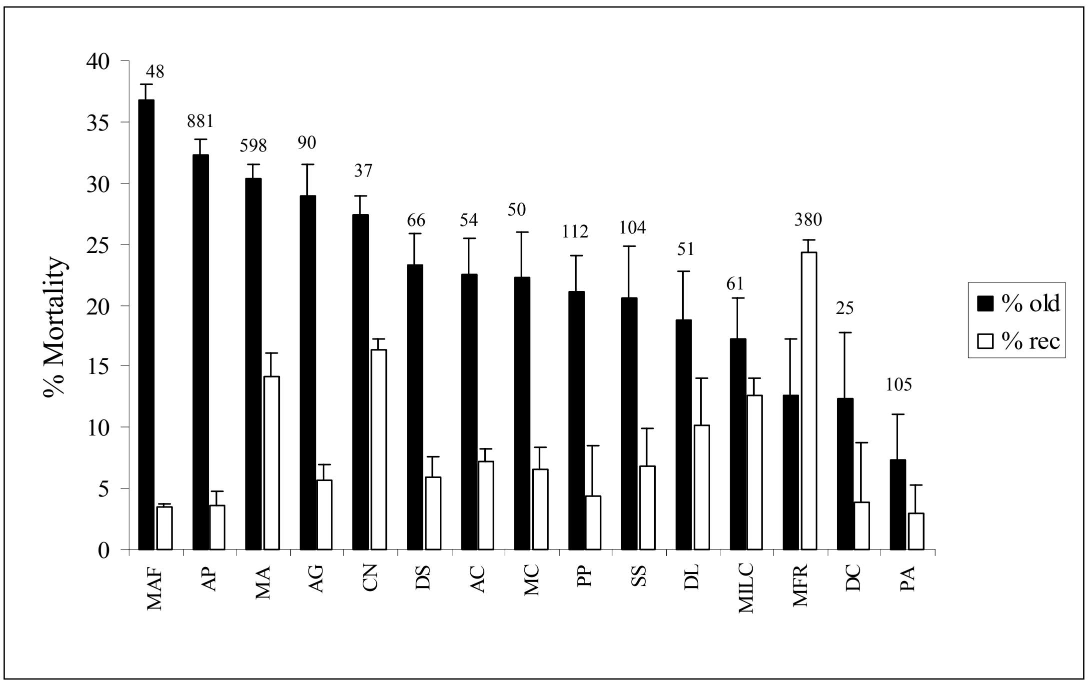

Figure 6. Percent old and recent (rec) partial colony mortality (mean ± standard error) in 1998 for the 15 most abundant ≥25 cm stony coral species; both survey depths combined, off Andros. Species codes same as in Figure 5 except MAF = *Montastraea faveolat*a, MA = *M. annularis,* MFR = *M. franks*i, AC = *Acropora cervicornis,* DL = *Diploria labyrinthiformis,* MILC = *Millepora complanata,* DC = *Diploria clivosa.*

cervicornis, 38% for *A. palmata*). These high values can be largely attributed to the presence of 100% standing dead colonies of *Acropora* which made up 1-24% (average 7%) of the assessed corals in shallow reef crests. Excluding 100% standing dead colonies, *Acropora* had an average old partial-mortality of 27%. Old mortality at fore reef sites ranged from 13% (D15) to 45% (D32) and the frequency of 100% standing

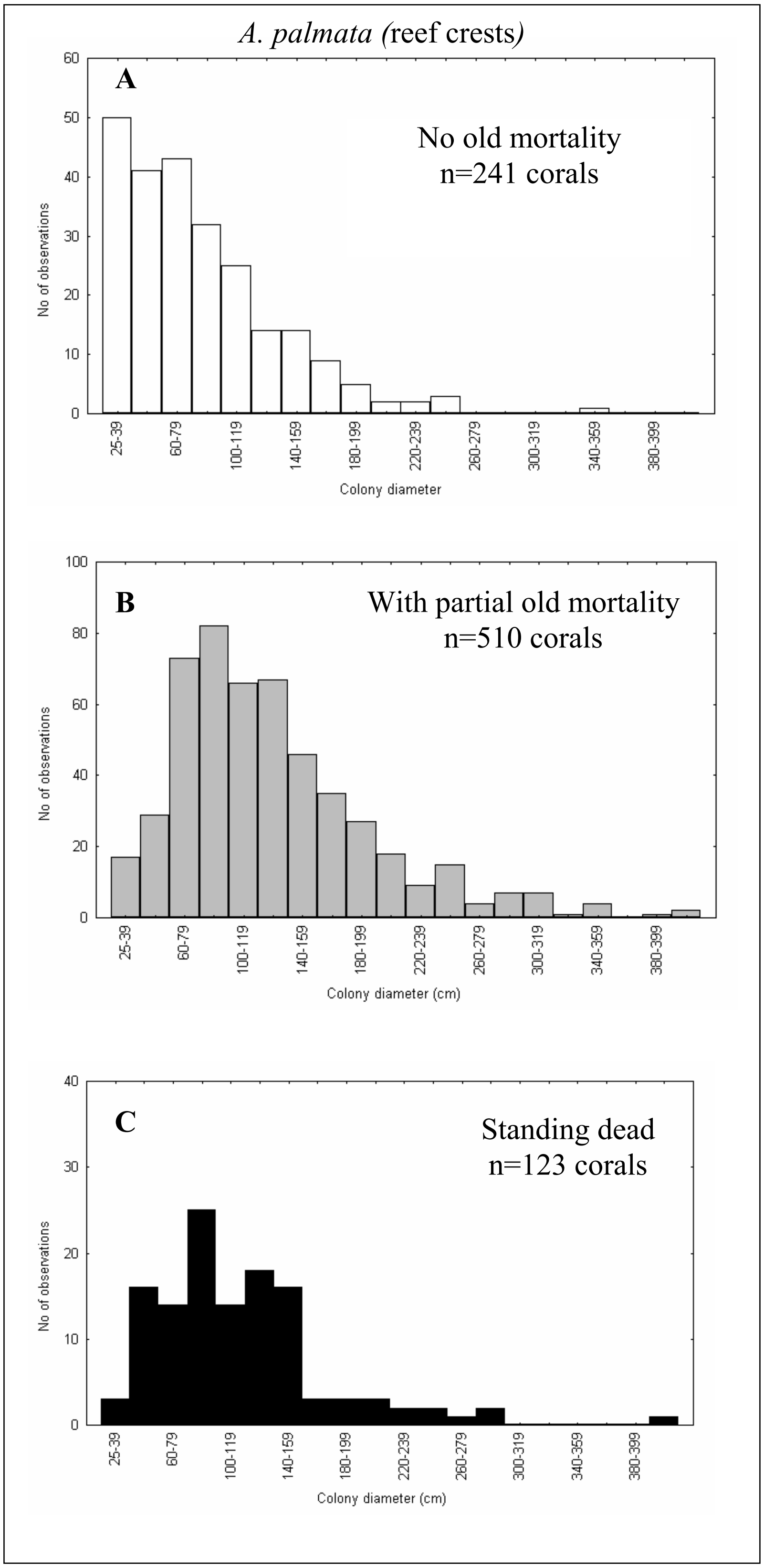

Figure 7A. Size frequency distribution of colony diameter for *Acropora palmat*a for 1998 with (**A**) no, (**B**) partial (1-99%) or (**C**) 100% (=standing dead) old colony mortality in reef-crest sites off Andros.

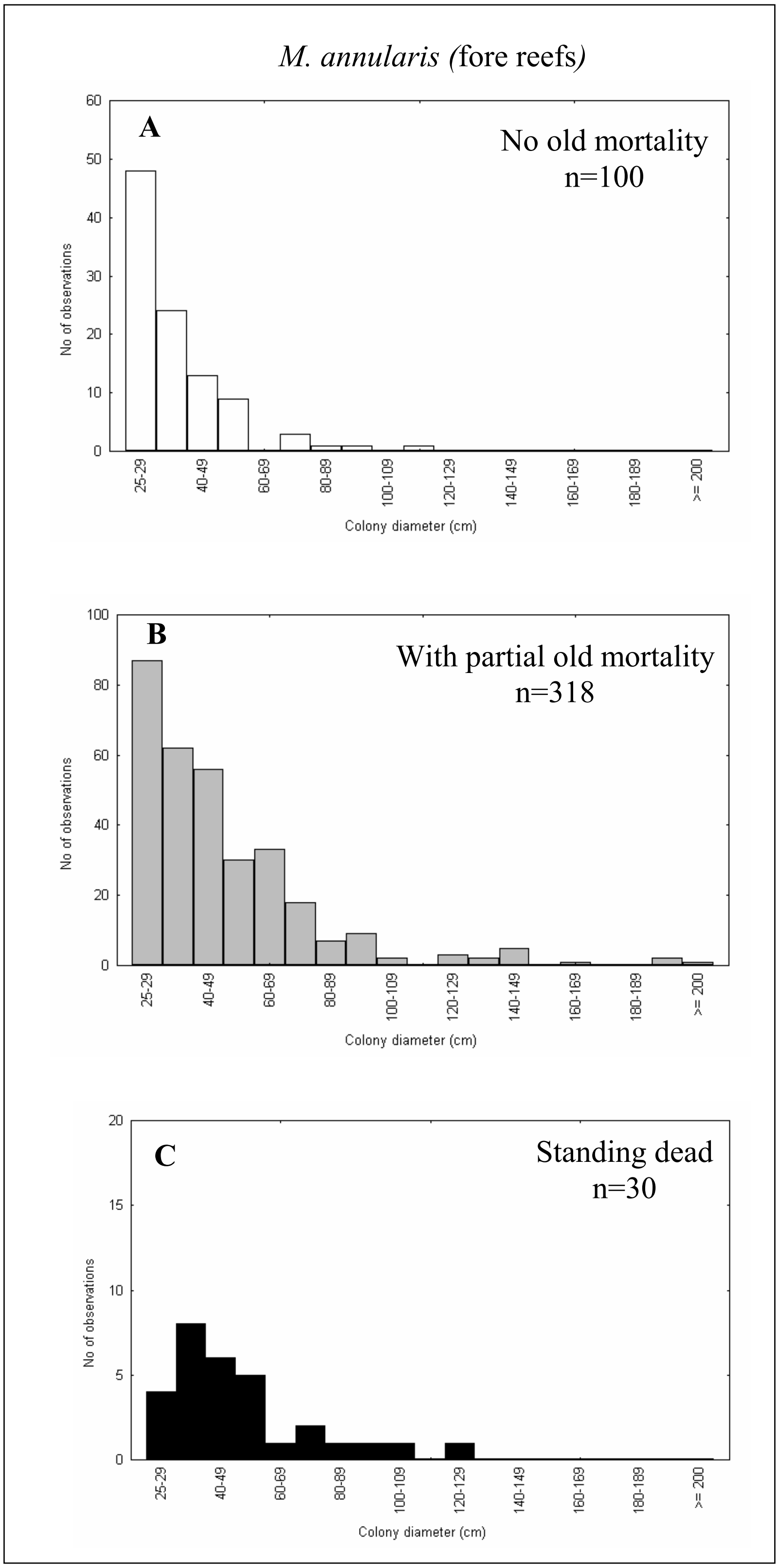

Figure 7B. Size frequency distribution of colony diameter for *Montastraea annularis* for 1998 with (**A**) no, (**B**) partial (1-99%) or (**C**) 100% (= standing dead) old colony mortality in fore-reef sites off Andros.

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dead colonies averaged 7% (Table 2B). *Montastraea faveolata* and *A. palmata* had the highest mean old mortality values (>30%) while *Porites astreoides* had the lowest (<10%) (Fig. 6 for 1998 data). In both *A. palmata* and *M. annularis*, old mortality values increased with colony size up to the mode of the population (120-140 cm-size classes for reef-crest colonies of *A. palmata*, 40-50 cm size classes for fore-reef colonies of *M. annularis*). Smaller corals tended to be either completely alive or completely dead (i.e., to have either no mortality or 100% mortality) whereas areas of old mortality were displayed on the surfaces of many of the larger colonies (Fig. 7A, B). Examination of three spatial scales (within reef, within areas, between areas) for each reef type showed that within-reef-variation explained approximately 80% of the variation in old mortality.

Recent partial-colony mortality (hereafter recent mortality) in the $\geq$25 cm stony corals ranged from 0.5-42.5% (Table 2) and was higher in fore reefs (mean 13%) than in reef crests (mean 6%) during both survey years (2-way ANOVA, df=580, MS=3403, F=34.6, p<0.0001). Recent mortality in the reef crests was lower during the 1998 surveys (average 4%) than in 1997 (average 7%) (t-test, df=270, t=5, p<0.0001) but was not significantly different between years in the fore reefs (1997 mean=11%, 1998 mean=13%) (t-test, df =310, t=0.4, p=0.7). Recent mortality showed no significant correlation with colony diameter in *A. palmata* and *M. annularis.* Very high levels of recent mortality (>20%) were recorded at several fore reefs in central and southern Andros during the 1998 survey (D10, D13, D24, D25). Significant differences in recent mortality also occurred between different coral species in 1998 (1-way ANOVA, df =40, MS=3787, F=7.7, p<0.001). Corals with the highest levels of recent mortality included *Montastraea franksi*, *Colpophyllia natans, M. annularis, and Diploria labyrinthiformis* (Fig. 6 for 1998 data).

Identifiable causes of recent stony coral mortality in reef crests included predation, diseases (Table 2A), physical damage associated with human-induced trash and boat groundings, and a bleaching event associated with warmer seawater temperatures observed in summer 1998 (see Kramer, this volume). Many colonies of *A. palmata* and *A. cervicornis* had elevated "chimneys" characteristic of repeated predation by the three-spot damselfish, *Stegastes planifrons*. Damselfish gardens were present on approximately 8% of all the surveyed stony corals and were significantly more common in reef crests than in fore reefs (t-test, df=584, t=3.76, p<0.0001). Evidence of predation by parrotfishes (particularly the stoplight parrotfish, *Sparisoma viride*) in the form of excavations or small bite marks was low. The corallivorous snail, *Coralliophila abbreviata,* was observed singularly and in small groups (three to five per group), mainly on colonies of *Acropora*. Small white (<25 cm^2) lesions were present on approximately 20% of all *A. palmata* surveyed (both years combined) and were attributed to either disease (patchy necrosis = white pox) or predation by *Coralliophila*. Although distinguishing recent mortality due to patchy necrosis from predation was often difficult, on average about 9% of the colonies of *A. palmata* were affected by diseases (all shallow sites combined). High (12-15% in S7, S9, S13, S15, S26) to alarmingly high (~25-30% in S11, S12, S28) incidences of disease were also observed. No large-scale bleaching was observed during 1997 (<2% of colonies overall affected); however, during August 1998, substantial bleaching (>10% of colonies affected) was observed in several shallow sites (e.g., S5, S21). Bleaching was very species-specific with *Millepora complanata*, *Agaricia tenuifolia*, *A. palmata*, and *A. cervicornis* being most affected. At one site (S24), where 80% of the colonies were discolored (mostly being completely bleached), entire "very recent" colony mortality was observed in several instances.

Recent mortality of stony corals in the fore reefs was mainly attributed to diseases (Table 2B) and, to a lesser degree, to overgrowth by macroalgae. No significant predation or bleaching was noted either year in deeper water (> 5m). In 1997, macroalgal overgrowth by *Microdictyon marinum* was observed to cause limited bleaching and mortality around the edges of colonies, particularly the lobate *M. annularis*. Stony coral diseases were widespread during 1997, but at moderate levels (4% of colonies infected). During 1998, significantly higher levels of disease were recorded (18% infected colonies) (1-way ANOVA, df =1, MS=1418, F=21.7, $p<0.001$), with the most common being black-band disease (BBD) and white plague (WP). During 1998, active BBD and WP infected mainly faviid corals which included in order of decreasing infection *M. franksi*, *M. annularis, M. faveolata, M. cavernosa, D. labyrinthiformis* and *C. natans*. Within reefs, BBD occurred in clumped distributions with simultaneously active infections in colonies that were either touching or closely adjacent. At larger spatial scales, diseases were more prevalent in fore reefs with higher colony densities than in less well-developed reefs with lower colony densities. This pattern may be due in part to the abundance of *M. franksi* and *M. annularis* which were more susceptible. The incidence of WP varied among reefs and it was observed most commonly in the central and southern areas in reefs containing a high density of large corals. Here, sites with <5colonies/10m often had a lower prevalence of disease. Both BBD and WP affected all stony coral size classes. Approximately 6% of all fore-reef stony corals surveyed in 1998 (primarily *M. annularis* and *M. franksi*) had suffered 100% recent mortality. The average colony diameter of the $\geq$25 cm corals with 100% recent mortality was 44 cm with most being in the 25-40 cm size class (although corals <25cm were not surveyed in all sites). During 1998, the percentage of recent partial-colony mortality was strongly correlated with the percentage of stony corals showing signs of disease ($r^2=0.63$, $p <0.001$).

Algal Communities and *Diadema antillarum*

Algal populations off Andros were distinctly different between the two reef habitats but were remarkably consistent within each depth zone. Reef crests (Table 3A) tended to be dominated by crustose coralline algae (mean relative abundance = 44%) and turf algae and contained relatively few macroalgae (mean relative abundance =15%). Dominant macroalgal species in the reef crests were *Dictyota divaricata, Stypopodium zonale* and *Turbinaria turbinata* with average canopy heights from 1-3 cm (mean = 1.8 cm) in 1998. In contrast, macroalgae (mean relative abundance = 47%) and crustose corallines (mean relative abundance = 35%) were codominants in fore reefs where turf algae were relatively scarce (Table 3B). The principal macroalgae observed in fore reefs were *Microdictyon marinum*, *Lobophora variegata*, *Dictyota pulchella, Dictyota divaricata*, *Sargassum hystrix*, and *Halimeda* spp. Macroalgal heights were significantly higher in fore reefs (averaging 3.3 cm in 1998) than in reef crests for both survey years (2-way ANOVA, MS=2.9, df =534, F=97, $p<0.0001$). When macroalgal abundance and height are considered together as a macroalgal index (Tables 3A, 3B), the index was four times greater in fore reefs (mean=204) than in reef crests (mean=46). *Diadema* was not recorded in any of the sites during 1997 although a few individuals were counted outside of transects at several sites. *Diadema* densities were slightly higher at examined sites in 1998, averaging 0.4 individuals/100m^2 in both habitats.

DISCUSSION

Shallow Reef Crests

The reef crests off Andros presently contain extensive areas of *Acropora palmata*, a large percentage of which have colonies that are partially or even fully alive on their upward facing surfaces. Densities of live and partially live (i.e., <100% total partial-colony mortality) colonies were high (~4 colonies/10m). Evidence of the WB epizootic reported to have decimated populations of *A. palmata* populations in other areas of the Caribbean (Aronson and Precht, 1997, 2001) was minimal. The low-to-moderate levels of old mortality, large colony sizes, and fairly even size-distributions that we observed all suggest modest levels of disturbance to *A. palmata* in the last several decades. Smaller colony sizes were recorded in several sites, particularly near the bights area (e.g., S16-S22) where tidal creeks and channels discharge water having highly variable temperatures and salinities from Great Bahama Bank that probably inhibits *Acropora* growth.

When *A. cervicornis* was present on shallow reefs, it usually occurred as thickets, particularly in the back reef, although most of these colonies were long dead. The distribution and abundance of historic *A. cervicornis* populations are not known for Andros although anecdotal reports suggest it may have been more common in shallow-patch and back-reef habitats.

Low-to-moderate values (1-5%) for recent partial-colony mortality observed in the majority of the reef crest surveys is thought to represent background (chronic) mortality caused by predation, disease, competition, and other biotic interactions. The higher levels of recent mortality recorded during 1997 (e.g., S9, S12-14) are mainly attributed to the way mortality was scored (by including colony sides) rather than to higher levels of disturbance relative to 1998. Levels of recent mortality recorded during 1998 at non-bleached sites (~3.5%) are comparable to levels recorded in other western Atlantic reef crests not experiencing acute disturbances (Kramer, this volume). Most colonies of *A. palmata* had recently dead tissues; however, the small size of most of these lesions suggests either that routine injuries are of limited areal extent and/or tissue regeneration occurs fairly quickly (Meesters et al., 1996). Alternatively, if lesions were caused by disease, tissue loss is slow but may accumulate while the colony remains infected.

National Oceanographic and Atmospheric Administration (NOAA) hotspot maps indicated a 1-2 degree increase in sea surface temperatures beginning in late May, 1998 and extending through August, 1998. Observations during 1998 suggest that bleaching and bleaching-induced mortality off Andros mainly impacted the shallow reefs. Spatially, the extent of bleaching impacts to shallow reefs was variable with reefs immediately south of South Bight being the most affected during the time of our survey. The high value for recent mortality (>15%) observed in one reef crest (S24) surveyed during August, 1998 is attributed to bleaching-induced mortality. Species that suffered mortality were mainly *Millepora complanata*, *Agaricia tenuifolia* and, to a lesser extent, *A. palmata*. Local reports from the Bahamas during 1998 suggest that region-wide bleaching reached a peak in late August/early September at least two weeks after our surveys ended (Wilkinson, 1998). Therefore, while our surveys indicated only localized impacts, the full effects of the 1998 bleaching event are difficult to ascertain since the immediate damage may have ensued for several weeks to months after our surveys and occurred beyond our survey area. However, the low relative abundance of macroalgae on reef crests, high abundance of living *A. palmata* colonies, and the presence of *A. palmata* recruits (mean=0.27/m^2) suggest that recovery from low-to-moderate levels of bleaching-induced mortality on reef crests is favored.

Fore Reefs

Patterns in coral abundance in the Andros fore reefs were evident at both small and large spatial scales. Well-developed fore reefs at intermediate depths (7-12 m) occurred mainly as dense patches of the *M. annularis* species complex often located off islands and along channels where either protection from large swells and/or underlying Pleistocene geomorphology favored reef growth. Grading away from these dense patches were stretches with lower relief, lower coral densities, and smaller coral sizes. Hence, the degree to which fore reefs had developed was largely determined by the abundance of the *M. annularis* complex. In poorly developed reefs, such as N. Mangrove (D23), the dominant coral was *S. siderea* (44%) while the *M. annularis* complex comprised only 17% of the large (≥25 cm in diameter) coral population. The size and abundance of the colonies of *Montastraea* in any particular site presumably reflect both the suitability of local conditions (Bak and Meesters, 1998) and rates of coral growth. That fore reefs located in shallower water (7-9 m) had larger colonies of the *M. annularis* complex than those located slightly deeper (10-12m) is probably explicable by the observation that growth rates for *Montastraea* can decrease sharply in this depth range (Hubbard and Scaturo, 1985) and even small absolute increases of water depth (2-3 m) may shift colonies to smaller sizes. The smaller colony sizes found overall in the 1998 surveys can be mainly attributed to the relatively poor environmental conditions in many of the reefs near the bights. In addition, survey depths were slightly shallower in 1997 compared with those in 1998 because the zone of maximum development in the northern and southern areas was shallower than in the central and bights areas.

That we found a strong relationship between levels of old mortality in *M. annularis* and colony size up to the mode of the population (40-50 cm) in Andros (Fig. 7) is similar to the relationship described by Bak and Meesters (1998) in the Netherlands Antilles. In addition, levels of old mortality were strongly influenced by the species composition of the stony corals present in any given reef. Therefore, differences in mean colony size and species composition can explain some of the between-reef variability in levels of old mortality and these factors should be taken into account when comparisons are made among sites, reefs, areas, subregions, and regions.

During 1998, a mass mortality event affected many massive corals in the Andros fore reefs. This widespread disturbance is thought to have begun in June approximately one month after abnormally warm sea surface temperatures enveloped the area (T. Turnbull, personal communication). Local observations of "white coral" were first reported in early July. One month later we found many massive colonies with either partial or complete recent tissue mortality and signs of disease (primarily WP and BBD) but surprisingly little evidence of bleaching (e.g. <5% colonies displayed discolored tissues). At severely impacted fore reefs, we estimated that up to 50% of the live stony coral cover had been recently lost. We believe severe outbreaks of one or more diseases must have occurred in late June/early July and moved through the entire area at a very rapid pace, perhaps in response to the increased seawater temperatures. [Increased temperatures can trigger or exacerbate the activity of microorganisms (bacteria, cyanobacteria, fungi, protozoans) and possibly viruses that are responsible for outbreaks of disease (e.g., Rutzler et al., 1983).] That the highest mortalities off Andros were observed at depths of 6-12 m in reefs with high coral densities and complex geomorphological structure suggests that diseases might be expected to spread most rapidly under conditions in which colonies (particularly monogeneric coral assemblages) have direct or close contact with one another. The unusually luxuriant growth of the *M. annularis* species complex that is typical of the Andros fore reefs may have made these communities very prone to outbreaks of disease. Recovery from this massive disturbance will take many years, possibly decades.

Acropora cernivornis was rarely seen in the deeper sites. Examination of sediments from several fore reefs, however, revealed only small amounts of *A. cervicornis* rubble indicating that it may never have been as common on Andros as in many other areas of the western Atlantic (e.g., Jamaica, Belize, Bonaire).

Algae and *Diadema*

Historic populations of *Diadema* in the Bahamas, particularly at shallow depths, were very high according to descriptions by Storr (1964) and Newell and Rigby (1951). The low abundances observed in Andros (both shallow and deep sites) during our surveys reinforces local anecdotal accounts that the1983-84 die-off of *Diadema antillarum* in the western Atlantic (Lessios et al., 1984) also decimated populations on Andros. At present, scarids (parrotfish), acanthurids (surgeonfish), and some pomacentrids (damselfish) are the principal herbivores in Andros' reefs (Kramer, Marks and Turnbull, this volume). As documented in other studies (Hay, 1984; Morrison, 1988), these herbivores are disproportionately distributed across the Andros shelf with higher numbers principally associated with well-developed shallow reef-crest habitats.

Macroalgal indices for the 1998 sites displayed a strong inverse relationship with herbivore biomass (Kramer, Marks and Turnbull, this volume). The relationship is unusually well pronounced, and may also reflect that our surveys took place when, due to seasonal blooms of *Microdictyon marinum,* the macroalgal index reaches a seasonal peak in the late summer (T. Turnbull, personal communication). Within individual habitat types (e.g., reef crest or fore reef), the herbivore-algae relationship was only weakly significant indicating other synergistic factors, such as wave energy and sedimentation, may also influence algal abundance patterns. However, the overall algal-herbivore relationship between depths suggests a strong top-down control on the distribution of macroalgae on Andros. Herbivorous fishes may have compensated for the loss of *Diadema* as an herbivore in reef crests but not in fore-reef sites. High macroalgal canopy heights and lack of grazed surfaces reflect a general lack of herbivory at greater (>6 m)

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depths. The impact of excessive algae to fore reef corals is potentially severe, but not well characterized, off Andros. *Microdictyon,* which attaches to the sides of *Montastraea annularis* columns, was observed to grow over the edges of its live tissues and other small corals causing bleaching and, in some cases, mortality. Following the 1998 mass mortality of many massive stony corals, macroalgal abundances are expected to have further increased on fore reefs given the increased availability of substratum space. Macroalgal abundances will likely remain high in Andros fore reefs until levels of grazing by either *Diadema* or herbivorous fishes increase.

Even given the high relative abundance of macroalgae, mean densities of coral recruits in the Andros fore reefs were fairly high (equivalent to 10.6/m^2) compared with other areas of the wider Caribbean (Bak and Engel, 1979), suggesting that small corals may be able to survive despite overtopping by macroalgae. In addition, average recruit density for the shallow sites (equivalent to 3 juveniles/m^2) was higher than at similar reef types in the Florida Reef Tract (maximum ~2.5 juveniles of <4cm diameter/m^2) (Chiappone and Sullivan, 1996). Juvenile species richness was also higher in the shallow reefs off Andros (16 species) than in shallow reefs off the Florida Keys (~11 species) (Chiappone and Sullivan, 1996). The presence and relatively high abundance of recruits of *A. palmata* in reef crests and of the *M. annularis* complex in fore reefs is surprising given that recruits of these species are generally absent or present in very low numbers in settlement studies (e.g., Bak and Engel, 1979; Hughes and Jackson, 1985; Rylaarsdam, 1983). High recruit abundance for these corals on Andros may be attributed to the high densities of adult colonies. The survivorship of the recruits we surveyed was not examined but may play an important role in the stability of these populations. Additional surveys focused on understanding the recruitment and survivorship of *A. palmata* and the *M. annularis* species complex on Andros are warranted.

Despite their relatively remote location, our results indicate that the reefs off Andros Island have been affected by some (e.g., loss of *Diadema antillarum*), but not many, of the regional disturbances documented in other parts of the Caribbean. Impacts of the regional WBD epizootic on *Acropora* and of the massive bleaching events prior to 1998 appear to have been lower off Andros, based on the dense thickets of live *A. palmata* and the large size of many stony corals at the time of our survey. However, a high abundance of macroalgae and the presence of coral diseases in these reefs are suspected in years prior to 1997. In 1998, the massive disease outbreak in fore-reef habitats, particularly in the central and bights areas, resulted in catastrophic tissue loss for many large corals (particularly the *M. annularis* complex). Bleaching in shallow reef crests during 1998 also caused acute localized loss of live stony corals often resulting in complete colony mortality for the most severely impacted reefs in southern Andros (personal observations). The longer-term trajectory with regard to the recovery of these reefs will depend on the frequency of future disturbance events, the status of their *Diadema* populations, and the recruitment of new, and survivorship of existing, stony corals.

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Table 1A. Reef crest site information for AGRRA stony coral and algal surveys off Andros Island, Bahamas (*1997 sites are italicized*).

Reef crest Site Name	Site Code	Latitude (N° ′)	Longitude (W° ′)	Survey Date	Depth (m)	Transects (#)	≥25 cm Stony Corals (#/10m)[2]	% Live Stony Coral Cover (mean ± sd)[2]
N. Joulters	*S1*	*25.31322*	*78.03433*	*Aug 15 97*	*2.5*	*13*	*13.5*	---
Golding	*S2*	*25.22392*	*78.08557*	*Aug 18 97*	*1.5*	*12*	*12.0*	---
Morgan	*S3*	*25.1601*	*78.0029*	*Aug 17 97*	*1.5*	*14*	*10.5*	---
Coconut Point	*S4*	*25.12885*	*77.98303*	*Aug 17 97*	*1.5*	*13*	*11.0*	---
Mahore	S5	25.06367	77.93783	Aug 21 98	1.0	10	9.5	43.0 ± 14.5
S. Staniard 2	S7	24.84493	77.86098	Aug 20 98	0.5	7	9.0	41.0 ± 22.5
S. Staniard 1	*S6*	*24.84217*	*77.8586*	*Oct 19 97*	*3.5*	*9*	*9.0*	---
North Andros-all[1]						**78**	**10.6**	**42**
N. Love Hill	S8	24.77435	77.80772	Aug 18 98	1.0	9	9.5	41.5 ± 14.0
S. Love Hill	*S9*	*24.84425*	*77.8563*	*Aug 5 97*	*1.5*	*17*	*7.0*	---
China Point	S10	24.75133	77.80767	Aug 18 98	1.0	13	9.0	54.0 ± 31.0
Red Rock	S11	24.72917	77.77017	Aug 7 98	1.0	17	6.5	37.0 ± 15.5
S. Autec	*S12*	*24.69953*	*77.74343*	*Aug 6 97*	*1.5*	*11*	*6.5*	---
S. Long Rock	*S13*	*24.63067*	*77.691*	*Aug 9 97*	*2.5*	*15*	*9.0*	---
Mid Long Rock	*S14*	*24.6259*	*77.69318*	*Aug 8 97*	*1.5*	*24*	*8.0*	---
Sugar Rock	S15	24.5448	77.68372	Aug 10 98	2.0	8	7.0	20.0 ± 11.0
Central Andros-all[1]						**114**	**7.8**	**38**
Autec2-South	S16	24.484	77.699	Aug 11 98	1.0	10	7.0	24.0 ± 11.5
N. Bight	S17	24.4395	77.69807	Aug 12 98	2.0	11	9.0	33.5 ± 9.0
Big Wood	S18	24.36703	77.68235	Aug 13 98	1.5	12	9.0	36.0 ± 11.0
Autec 3	S19	24.34315	77.67068	Aug 12 98	1.0	11	10.0	39.5 ± 15.5
Middle Bight	S20	24.3069	77.65638	Aug 13 98	1.5	11	9.5	35.5 ± 10.5
Mangrove C.	S21	24.29167	77.6462	Aug 13 98	1.5	15	8.5	25.0 ± 10.5
Mangrove S	S22	24.25315	77.62917	Aug 13 98	1.0	13	10.0	30.0 ± 13.5
Bights-all[1]						**83**	**9.0**	**28.5**
Congo Town	S23	24.3013	77.64788	Aug 15 98	1.0	15	9.0	30.5 ± 14.5
Long Bay Cay	S24	24.09793	77.53703	Aug 16 98	1.0	12	10.5	35.5 ± 11.5
North Rock	*S25*	*23.79092*	*77.42637*	*Aug 14 97*	*2.0*	*15*	*9.5*	---
North Grassy	*S26*	*23.77822*	*77.41902*	*Aug 13 97*	*2.0*	*15*	*9.0*	---
Delta	*S27*	*23.70967*	*77.38237*	*Aug 13 97*	*2.0*	*13*	*9.5*	---
Pigeon	*S28*	*23.6965*	*77.377*	*Aug 11 97*	*1.5*	*14*	*8.5*	---
South Andros-all[1]						**84**	**9.3**	**33.0**

[1]Transects (#) = sum; all other columns = means
[2]Based on analysis of the first 10 transects/site.

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Table 1B. Fore reef site information for AGRRA stony coral and algal surveys off Andros Island, Bahamas (*1997 sites are italicized*).

Deep Fore Reef Site Name	Site Code	Latitude (N° ′)	Longitude (W° ′)	Survey Date	Depth (m)	Transects (#)	≥25 cm Stony Corals (#/10m)[2]	% Live Stony Coral Cover (mean ± sd)[2]
N. Joulters	*D1*	*25.3132*	*78.0856*	*Aug 16 97*	*6.5*	*12*	*16.0*	---
Nichols	*D2*	*25.1438*	*72.9875*	*Aug 17 97*	*9.5*	*13*	*13.0*	---
Conch	*D3*	*25.1026*	*77.9639*	*Oct 17 97*	*5.5*	*9*	*8.5*	---
Bucket	*D4*	*24.8793*	*77.8784*	*Oct 20 97*	*10.0*	*6*	*11.0*	---
N.Staniard	*D5*	*24.8775*	*77.8791*	*Oct 18 97*	*7.5*	*13*	*6.5*	---
S. Staniard 2	D7	24.50630	77.56437	Aug 20 98	9.0	9	11.0	37.0 ± 13.0
S.Staniard 1	*D6*	*24.8438*	*77.9406*	*Oct 19 97*	*8.0*	*6*	*14.5*	---
North Andros-all[1]						**68**	**11.5**	**37.0**
S. Love Hill	*D8*	*24.7678*	*77.7987*	*Aug 6 97*	*8.5*	*16*	*9.0*	---
Coffee	*D9*	*24.7452*	*77.7786*	*Aug 7 97*	*11.0*	*15*	*7.5*	---
West Klein	D10	24.7450	77.7847	Aug 7 98	10.5	10	9.0	24.5 ± 8.0
S. Autec	*D11*	*24.7015*	*77.7402*	*Aug 7 97*	*13.0*	*8*	*9.5*	---
S. Long Rock	*D12*	*24.6307*	*77.6910*	*Aug 9 97*	*8.0*	*12*	*11.5*	---
Long Rock	D13	24.6260	77.6910	Aug 8 98	8.7	10	11.0	22.5 ± 8.0
Mid Long Rock	*D14*	*24.37547*	*77.41587*	*Aug 9 97*	*9.5*	*11*	*10.0*	---
Green Cay	D15	24.5958	77.6933	Aug 9 98	11.0	14	3.0	11.0 ± 4.0
Sugar Rock	D16	24.5402	77.6821	Aug 10 98	11.5	13	6.5	18.0 ± 7.0
Central Andros- all[1]						**109**	**8.5**	**19**
Bristol Galley	D17	24.5263	77.6892	Aug 10 98	11.5	12	7.0	17.0 ± 5.0
Autec 2	D18	24.5064	77.6970	Aug 11 98	12.5	15	3.5	9.0 ± 3.0
Autec 2-South	D19	24.4833	77.6965	Aug 11 98	10.5	12	7.5	15.0 ± 5.0
N. Bight	D20	24.4393	77.6962	Aug 12 98	9.5	11	11.5	31.0 ± 12.5
Autec 3	D21	24.3432	77.6707	Aug 14 98	10.5	10	9.0	25.5 ± 10.5
Middle Bight	D22	24.3097	77.6530	Aug 14 98	9.0	10	11.0	28.0 ± 8.0
Mangrove N.	D23	24.3011	77.6478	Aug 14 98	9.5	23	2.0	5.5 ± 3.0
Bights-all[1]						**93**	**7.4**	**18.5**
Congo Town	D24	24.3012	77.6479	Aug 15 98	10.5	10	12.0	21.0 ± 15.5
Long Bay Cay	D25	24.0997	77.5334	Aug 16 98	10.5	10	11.0	19.0 ± 9.0
Oasis	D26	23.9476	77.3867	Aug 16 98	6.0	10	12.5	45.5 ± 21.0
High Point Cay	D27	23.4200	77.4600	Aug 17 98	9.0	9	13.5	35.0 ±7 .5
North Rock	*D28*	*23.7965*	*77.4222*	*Aug 13 97*	*7.5*	*11*	*11.5*	---
North Grassy	*D29*	*23.7803*	*77.4168*	*Aug 13 97*	*9.5*	*9*	*10.0*	---
South Grassy	*D30*	*23.7285*	*77.3974*	*Aug 12 97*	*7.5*	*10*	*12.5*	---
Delta	*D31*	*23.7097*	*77.3810*	*Aug 13 97*	*8.5*	*12*	*7.5*	---
Pigeon	*D32*	*23.6945*	*77.3742*	*Aug 11 97*	*9.0*	*12*	*8.0*	---
Saddleback	*D33*	*23.6767*	*77.3703*	*Aug 11 97*	*8.5*	*10*	*12.5*	---
South Andros-all[1]						**103**	**11.2**	**30.0**

[1]Transects (#) = sum; all other columns = means
[2]Based on analysis of the first 10 transects/site.

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Table 2A. Size and condition (mean ± standard deviation) of all stony corals (≥25 cm diameter) in first 10 transects/site, by reef-crest sites off Andros (*1997 sites are italicized*).

Reef Crest	Site	Year	Stony Corals		Partial-Colony Mortality (%)			Stony Corals (%)		
Site Name	Code		(#)	Diameter (cm)	Recent[2]	Old	Total	Standing dead	Bleached	Diseased
N. Joulters	*S1*	*1997*	*177*	*114.5 ± 5.5*	*6.5 ± 0.5*	*21.5 ± 2.0*	*28.0 ±2.0*	*3.5*	*1.5*	*8*
Golding	*S2*	*1997*	*144*	*117.5 ± 6.0*	*5.5 ± 0.5*	*33.0 ± 3.0*	*38.5 ±3.0*	*10.5*	*2*	*5*
Morgan	*S3*	*1997*	*144*	*114.5 ± 7.0*	*7.0 ± 1.5*	*21.5 ± 2.0*	*28.0 ±2.5*	*5.4*	*2*	*7*
Coconut Point	*S4*	*1997*	*138*	*134.0 ± 6.0*	*6.5 ± 1.0*	*37.0 ± 3.5*	*42.0 ±3.0*	*20.5*	*0*	*3*
Mahore	S5	1998	94	123.0 ± 9.5	2.0 ± 0.5	12.0 ± 2.0	13.5 ±2.0	1	14	6.5
S. Staniard 2	S7	1998	64	135.5 ± 12.5	0.5 ± <0.5	24.0 ± 4.0	24.5 ±4.0	8	0	15
S. Staniard 1	*S6*	*1997*	*80*	*191.0 ± 12.5*	*4.5 ± 1.0*	*43.5 ± 4.5*	*47.0 ±4.5*	*24.5*	*11*	*0*
North Andros-all[1]			**841**	**133 ± 27**	**4.5 ± 2.5**	**27.5 ± 11.0**	**31.5 ± 11.5**	**10.5 ± 8.8**	**4.5 ± 5.7**	**6.5 ± 4.7**
N. Love Hill	S8	1998	85	101.5 ± 10.0	3.5 ± 1.5	24.0 ± 2.5	27.0 ± 3.0	0	3.5	1
S. Love Hill	*S9*	*1997*	*116*	*116.0 ± 6.5*	*11.0 ± 1.5*	*38.0 ± 3.0*	*47.5 ± 3.0*	*8.5*	*6*	*12*
China Point	S10	1998	109	105.5 ± 8.0	2.5 ± 0.5	25.0 ± 3.0	27.0 ± 3.0	3.5	10	4.5
Red Rock	S11	1998	108	97.0 ± 5.5	2.5 ± 0.5	32.0 ± 2.5	35.0 ± 3.0	1	7.5	25
S. Autec	*S12*	*1997*	*71*	*128.5 ± 9.0*	*9.5 ± 1.5*	*41.5 ± 4.5*	*50.0 ± 4.0*	*14*	*1.5*	*25.5*
S. Long Rock	*S13*	*1997*	*130*	*126.0 ± 9.0*	*8.5 ± 1.0*	*37.5 ± 2.5*	*45.5 ± 3.0*	*8.5*	*1*	*14*
Mid Long Rock	*S14*	*1997*	*195*	*108.0 ± 4.5*	*8.5 ± 0.5*	*36.5 ± 2.0*	*44.0 ± 2.5*	*7.*	*3.5*	*9.5*
Sugar Rock	S15	1998	57	117.5 ± 9.0	4.0 ± 1.0	27.5 ± 4.5	31.5 ± 4.0	9.	0	14
Central Andros all[1]			**871**	**112.5 ± 11.5**	**6.0 ± 3.5**	**33.0 ± 6.5**	**38.5 ± 9.5**	**6.5 ± 4.6**	**4.1 ± 3.5**	**13.2 ± 8.7**
Autec 2-South	S16	1998	69	96.0 ± 6.5	1.0 ± 0.5	39.0 ± 4.5	39.5 ± 4.5	16	4.5	10
N. Bight	S17	1998	99	117.5 ± 6.0	2.0 ± 0.5	31.5 ± 3.5	33.0 ± 3.5	13	1	8
Big Wood	S18	1998	109	89.0 ± 5.5	4.5 ± 0.5	23.0 ± 3.0	27.0 ± 3.0	9	7.5	2
Autec 3	S19	1998	110	85.0 ± 5.0	3.5 ± 0.5	25.0 ± 3.0	28.5 ± 3.0	7.5	8	3.5
Middle Bight	S20	1998	103	88.0 ± 6.0	5.0 ± 1.0	35.0 ± 3.5	39.5 ± 3.5	12.5	5	1
Mangrove C.	S21	1998	124	84.0 ± 5.0	3.5 ± 1.0	38.5 ± 3.5	41.0 ± 3.5	17.5	13.5	4
Mangrove S.	S22	1998	130	73.0 ± 4.5	2.5 ± 0.5	25.0 ± 3.0	27.5 ± 3.0	9	3	6
Bights-all[1]			**744**	**90.5 ± 14.0**	**3.0 ± 1.5**	**31.0 ± 6.5**	**33.5 ± 6.0**	**12.0 ± 3.7**	**6.1 ± 4.1**	**4.9 ± 3.2**
Congo Town	S23	1998	138	93.5 ± 4.5	3.0 ± 0.5	30.0 ± 3.0	33.0 ± 3.0	13	8.5	3.5
Long Bay Cay	S24	1998	124	88.0 ± 5.0	15.0 ± 2.5	28.0 ± 3.0	41.0 ± 3.0	3	80	1.5
North Rock	*S25*	*1997*	*146*	*119.0 ± 7.0*	*7.5 ± 1.0*	*52.0 ± 3.0*	*58.5 ± 2.5*	*18*	*0.5*	*7*
North Grassy	*S26*	*1997*	*132*	*109.5 ± 7.0*	*6.0 ± 1.0*	*47.5 ± 3.0*	*53.0 ± 3.0*	*12*	*2.5*	*13*
Delta	*S27*	*1997*	*123*	*119.0 ± 6.0*	*3.0 ± 0.5*	*40.0 ± 3.0*	*43.0 ± 3.0*	*4*	*1*	*4*
Pigeon	*S28*	*1997*	*117*	*131.5 ± 8.5*	*7.5 ± 1.0*	*41.0 ± 3.0*	*48.5 ± 3.0*	*7*	*0*	*31*
South Andros all[1]			**780**	**110.0 ± 16.5**	**7.0 ± 4.5**	**40.0 ± 9.5**	**46.0 ± 9.0**	**9.5 ± 5.8**	**15.4 ± 31.8**	**10.0 ± 11.0**

[1]Stony corals (#) = sum; all other columns = means ± standard deviation.
[2]1997 values are inflated relative to 1998 due to changes in assessment methodology.

Table 2B. Size and condition (mean ± standard deviation) of all stony corals (≥25 cm diameter), in first 10 transects/site, by fore-reef sites off Andros (*1997 sites are italicized*).

Fore-reef Site name	Site Code	Year	Stony corals (#)	Stony corals Diameter (cm)	Partial-colony mortality (%) Recent[2]	Partial-colony mortality (%) Old	Partial-colony mortality (%) Total	Stony corals (%) Standing dead	Stony corals (%) Bleached	Stony corals (%) Diseased
N. Joulters	*D1*	*1997*	*166*	*65.0 ± 2.5*	*11.0 ± 1.5*	*21.0 ± 2.0*	*32.0 ± 2.0*	*2.5*	*0.5*	*1*
Nichols	*D2*	*1997*	*168*	*72.0 ± 4.0*	*11.0 ± 1.5*	*33.0 ± 2.5*	*43.0 ± 2.5*	*7*	*3*	*2*
Conch	*D3*	*1997*	*77*	*57.5 ± 3.5*	*6.0 ± 1.5*	*19.0 ± 3.0*	*25.0 ± 3.0*	*1.5*	*2.5*	*1.5*
Bucket	*D4*	*1997*	*58*	*70.5 ± 7.0*	*2.0 ± 0.5*	*30.0 ± 3.5*	*32.0 ± 3.5*	*0*	*14*	*1.5*
N. Staniard	*D5*	*1997*	*77*	*60.5 ± 5.0*	*7.0 ±1.5*	*39.5 ± 4.0*	*46.0 ± 4.0*	*6.5*	*4*	*1.5*
S. Staniard 2	D6	1998	99	54.0 ± 4.0	4.0 ± 1.5	16.5 ± 2.0	20.5 ± 2.5	2	8	7
S. Staniard 1	*D7*	*1997*	*87*	*59.5 ± 3.5*	*8.0 ± 1.5*	*33.5 ± 3.5*	*40.5 ± 3.5*	*5.5*	*10.5*	*1*
North Andros-all[1]			**732**	**62.5 ± 6.5**	**7.0 ± 3.5**	**27.5 ± 8.5**	**34.0 ± 9.5**	**3.5 ± 2.7**	**6.0 ± 4.9**	**2.2 ± 2.1**
S .Love Hill	*D8*	*1997*	*98*	*69.0 ± 3.5*	*12.0 ± 2.0*	*37.5 ± 3.5*	*48.5 ± 3.5*	*2*	*1*	*12*
Coffee	*D9*	*1997*	*113*	*55.5 ± 3.0*	*16.5 ± 2.0*	*31.0 ± 3.0*	*46.5 ± 3.0*	*4.5*	*2.5*	*9*
West Klein	D10	1998	89	47.5 ± 2.0	24.5 ± 3.5	16.0 ± 3.0	39.0 ± 3.5	3.5	13.5	42.5
S. Autec	*D11*	*1997*	*74*	*66.5 ± 4.0*	*19.0 ± 2.5*	*30.0 ± 3.0*	*48.0 ± 3.5*	*2.5*	*4*	*2.5*
S. sLong Rock	*D12*	*1997*	*135*	*59.5 ± 2.5*	*14.0 ± 1.5*	*25.0 ± 2.0*	*39.0 ± 2.5*	*0*	*5*	*8*
Long Rock	D13	1998	110	58.5 ± 3.0	39.0 ± 4.0	27.0 ± 3.5	58.5 ± 3.5	7.5	11	27.5
Mid Long Rock	*D14*	*1997*	*110*	*55.0 ± 3.0*	*13.5 ± 1.5*	*22.5 ± 2.0*	*36.0 ± 2.5*	*1*	*5.5*	*7.5*
Green Cay	D15	1998	37	41.0 ± 3.5	15.5 ± 5.0	13.0 ± 3.5	28.0 ± 5.5	2.5	2.5	13.5
Sugar Rock	D16	1998	78	34.0 ± 1.0	8.5 ± 2.5	20.5 ± 3.0	28.5 ± 3.5	1.5	5	16.5
Central Andros-all[1]			**844**	**54.0 ± 11.5**	**18.0 ± 9.0**	**24.5 ± 7.5**	**41.5 ± 10.0**	**2.7 ± 2.2**	**5.5 ± 4.1**	**15.4 ± 12.4**
Bristol Galley	D17	1998	74	38.5 ± 2.0	15.0 ± 3.5	24.0 ± 4.0	37.5 ± 4.5	7	4	23
Autec 2	D18	1998	46	39.0 ± 3.0	8.5 ± 4.0	22.5 ± 5.5	29.0 ± 5.5	11	11	6.5
Autec 2-South	D19	1998	81	46.5 ± 3.5	11.0 ± 3.0	29.0 ± 4.0	38.0 ± 4.0	8.5	0	11
N. Bight	D20	1998	115	54.5 ± 3.5	12.5 ± 2.5	20.0 ± 2.5	30.5 ± 3.0	5	2.5	15.5
Autec 3	D21	1998	89	39.5 ± 2.0	14.5 ± 3.0	20.5 ± 3.0	34.0 ± 3.5	2	8	21.5
Middle Bight	D22	1998	106	51.5 ± 3.5	16.0 ± 3.0	22.5 ± 3.0	37.5 ± 3.5	4.	2	22.5
Mangrove N.	D23	1998	47	34.0 ± 1.5	7.0 ± 2.0	17.5 ± 3.5	24.5 ± 3.5	0	6.5	6.5
Bights-all[1]			**558**	**43.5 ± 7.5**	**12.0 ± 3.5**	**22.5 ± 3.5**	**33.0 ± 5.0**	**5.4 ± 3.8**	**4.8 ± 3.8**	**15.2 ± 7.3**
Congo Town	D24	1998	122	53.5 ± 2.5	42.5 ± 3.5	25.5 ± 3.0	62.0 ± 3.0	2.5	2.5	32
Long Bay Cay	D25	1998	110	43.0 ± 2.0	20.5 ± 3.5	23.0 ± 3.0	40.0 ± 3.5	5.5	4.5	25.5
Oasis	D26	1998	127	72.5 ± 5.0	2.0 ± 0.5	26.0 ± 2.5	28.0 ± 2.5	2.5	1.5	3
High Point Cay	D27	1998	114	45.5 ± 2.0	5.0 ± 1.5	20.5 ± 2.5	25.5 ± 2.5	2	2.5	8
North Rock	*D28*	*1997*	*124*	*63.5 ± 3.5*	*9.0 ± 1.5*	*29.5 ± 2.5*	*38.0 ± 2.5*	*1.5*	*0*	*1.5*
North Grassy	*D29*	*1997*	*92*	*54.0 ± 4.0*	*8.5 ± 1.5*	*33.5 ± 3.0*	*42.0 ± 3.0*	*1*	*2*	*2*
South Grassy	*D30*	*1997*	*125*	*69.0 ± 3.5*	*10.0 ± 1.0*	*39.0 ± 2.5*	*49.0 ± 2.5*	*5*	*1*	*4*
Delta	*D31*	*1997*	*90*	*53.0 ± 2.5*	*11.0 ±2.5*	*31.5 ± 3.0*	*42.0 ± 3.5*	*3.5*	*1*	*3.5*
Pigeon	*D32*	*1997*	*97*	*68.5 ± 4.5*	*13.5 ± 2.5*	*45.0 ± 4.0*	*56.0 ± 3.5*	*12.5*	*1*	*6*
Saddleback	*D33*	*1997*	*123*	*63.5 ± 3.0*	*11.0 ± 1.5*	*29.5 ± 2.5*	*40.5 ± 2.5*	*2.5*	*4*	*12*
South Andros-all[1]			**1124**	**58.5 ± 10.0**	**13.5 ± 11.5**	**30.5 ± 7.5**	**42.5 ± 11.0**	**3.8 ± 3.3**	**2 ± 1.4**	**9.8 ± 10.6**

[1]Stony corals (#) = sum; all other columns = means ± standard deviation.
[2]1997 values are inflated relative to 1998 due to changes in assessment methodology.

Table 3A. Algal characteristics, and density of stony coral recruits and of *Diadema antillarum* (mean ± standard deviation), by reef-crest sites off Andros (*1997 sites are italicized*).

Reef Crest Site Name	Site Code	Year	Quadrats (#)	Relative Abundance (%) Macroalgae	Turf algae	Crustose coralline algae	Macroalgal Height[2]	Index[3]	Recruits (#/.0625 m^2)	*Diadema* (#/100 m^2)
N. Joulters	*S1*	*1997*	*53*	*6.5 ± 10.0*	*43.0 ± 11.0*	*50.5 ± 6.0*	---	---	*0.2 ± 0.4*	*0*
Golding	*S2*	*1997*	*40*	*7.5 ± 12.0*	*39.5 ± 13.5*	*53.0 ± 11.5*	---	---	*0.0 ± 0.2*	*0*
Morgan	*S3*	*1997*	*44*	*8.0 ± 8.5*	*51.5 ± 16.5*	*40.5 ± 18.0*	---	---	*0.3 ± 0.5*	*0*
Coconut Point	*S4*	*1997*	*41*	*8.5 ± 15.0*	*44.0 ± 16.5*	*47.5 ± 14.5*	---	---	*0.1 ± 0.3*	*0*
Mahore	S5	1998	45	12.0 ± 16.0	49.5 ± 18.5	38.5 ± 17.0	3	82	0.1 ± 0.4	1
S. Staniard 2	S7	1998	34	13.0 ± 7.5	64.5 ± 22.0	22.5 ± 19.5	2	41	0.1 ± 0.3	0
S. Staniard 1	*S6*	*1997*	*36*	*3.5 ± 6.0*	*49.5 ± 16.0*	*47.0 ± 15.5*	---	---	*0.2 ± 0.3*	*0*
North Andros-all[1]			**293**	**8.0 ± 3.0**	**49 ± 8.0**	**43.0 ± 10.5**	**2.5 ± 0.5**	**61.5 ± 29.0**	**0.2 ± 0.1**	**0.1 ± 0.4**
N. Love Hill	S8	1998	40	17.0 ± 23.0	39.5 ± 25.0	43.5 ± 27.0	2.5	79	0.4 ± 0.8	0
S. Love Hill	*S9*	*1997*	*60*	*18.5 ± 15.5*	*41.0 ± 27.5*	*40.5 ± 29.5*	---	---	*0.3 ± 0.7*	*0*
China Point	S10	1998	44	10.5 ± 9.5	37.0 ± 25.5	52.5 ± 26.5	2	28	0.1 ± 0.5	0
Red Rock	S11	1998	18	13.5 ± 21.5	57.0 ± 26.0	29.5 ± 27.0	1	15	0.1 ± 0.2	0
S. Autec	*S12*	*1997*	*42*	*26.0 ± 21.0*	*38.0 ± 22.5*	*35.5 ± 24.0*	---	---	*0.3 ± 0.5*	*0.9*
S. Long Rock	*S13*	*1997*	*46*	*14.5 ± 14.0*	*40.5 ± 14.5*	*45.0 ± 19.0*	---	---	*0.2 ± 0.4*	*0*
Mid Long Rock	*S14*	*1997*	*92*	*9.5 ± 10.5*	*50.5 ± 24.5*	*39.5 ± 26.0*	---	---	*0.4 ± 0.6*	*0*
Sugar Rock	S15	1998	37	8.0 ± 8.5	50.0 ± 20.5	42.0 ± 22.0	1.5	23	0.2 ± 0.8	0
Central Andros-all[1]			**379**	**14.0 ± 5.5**	**44.0 ± 7.0**	**42 ± 8.0**	**1.5 ± 1.0**	**36.5 ± 29.0**	**0.3 ± 0.1**	**0.1 ± 0.3**
Autec 2-South	S16	1998	46	10.5 ± 11.0	44.5 ± 23.0	44.5 ± 25.0	1	24	0.0 ± 0.2	0
N. Bight	S17	1998	55	13.5 ± 20.0	45.0 ± 21.5	39.0 ± 18.0	1.5	26	0.1 ± 0.6	0
Big Wood	S18	1998	54	26.0 ± 20.5	37.0 ± 23.5	36.5 ± 26.0	2.5	99	0.1 ± 0.4	4
Autec 3	S19	1998	54	9.0 ± 12.0	46.5 ± 25.0	44.5 ± 28.5	1.5	22	0.1 ± 0.7	0
Middle Bight	S20	1998	54	13.5 ± 20.0	40.0 ± 21.0	46.0 ± 22.5	1.5	39	0.1 ± 0.3	2.5
Mangrove C.	S21	1998	65	10.5 ± 13.5	40.5 ± 21.0	48.5 ± 22.0	1.5	47	0.2 ± 0.5	0
Mangrove S	S22	1998	64	20.5 ± 17.5	42.0 ± 18.0	37.5 ± 18.0	2.5	88	0.2 ± 0.5	0
Bights-all[1]			**392**	**15.0 ± 6.0**	**42.0 ± 3.5**	**42.5 ± 4.5**	**1.5 ± 0.5**	**49.0 ± 31.5**	**0.1 ± 0.1**	**1 ± 1.5**
Congo Town	S23	1998	69	11.5 ± 15.5	13.5 ± 19.0	44.0 ± 19.0	1.5	26	0.1 ± 0.4	2.5
Long Bay Cay	S24	1998	54	11.0 ± 14.5	14.0 ± 19.0	41.0 ± 19.5	2	43	0.1 ± 0.3	0
North Rock	*S25*	*1997*	*50*	*14.5 ± 19.0*	*29.5 ± 21.0*	*56.0 ± 16.0*	---	---	*0.1 ± 0.4*	*0*
North Grassy	*S26*	*1997*	*51*	*10.5 ± 11.5*	*43.0 ± 19.5*	*47.0 ± 17.5*	---	---	*0.4 ± 0.7*	*0*
Delta	*S27*	*1997*	*44*	*11.5 ± 12.0*	*30.5 ±15.0*	*58.0 ± 16.5*	---	---	*0.3 ± 0.5*	*0*
Pigeon	*S28*	*1997*	*44*	*18.0 ± 15.0*	*40.5 ± 15.0*	*41.5 ± 18.0*	---	---	*0.2 ± 0.4*	*0*
South Andros-all[1]			**312**	**12.5 ± 3.0**	**28.5 ± 12.5**	**48.0 ± 7.5**	**1.5 ± 0.5**	**34.5 ± 12.0**	**0.2 ± 0.1**	**0.5 ± 1.0**

[1]Quadrats (#) = sum; all other columns = means ± standard deviation.
[2]Heights measured as maximum canopy heights in 1997 are not included.
[3]Macroalgal index = relative abundance of macroalgae x macroalgal height.

Table 3B. Algal characteristics, and density of stony coral recruits and of *Diadema antillarum* (mean ± standard deviation), by fore-reef sites off Andros (*1997 sites are italicized*).

Fore Reef Site Name	Site Code	Year	Quadrat (#)	Relative Abundance (%)			Macroalgal		Recruits (#/.0625 m^2)	*Diadema* (#/100 m^2)
				Macroalgae	Turf algae	Crustose coralline algae	Height[2]	Index[3]		
N. Joulters	D1	*1997*	35	49.0 ± 18.0	10.0 ± 13.5	41.0 ± 18.5	---	---	0.3 ± 0.6	0
Nichols	D2	*1997*	42	35.5 ± 15.0	17.0 ± 13.0	47.5 ± 14.0	---	---	0.5 ± 0.6	0
Conch	D3	*1997*	30	60.0 ± 32.0	26.5 ± 26.5	14.0 ± 14.0	---	---	0.3 ± 0.6	0
Bucket	D4	*1997*	24	25.5 ± 8.5	45.0 ± 22.0	29.5 ± 18.5	---	---	0.7 ± 0.8	0
N.Staniard	D5	*1997*	21	33.5 ± 18.5	44.0 ± 26.0	22.5 ± 8.0	---	---	0.5 ± 0.6	0
S. Staniard 2	D6	1998	45	35.0 ± 14.0	27.5 ± 18.5	37.5 ± 19.0	3.5	162	0.4 ± 1.1	1
S. Staniard 1	D7	*1997*	24	36 ± 10.0	46.0 ± 18.0	22.5 ± 18.0	---	---	0.8 ± 1.0	0
North Andros-all[1]			**221**	**39.0 ± 11.5**	**31.0 ± 14.0**	**30.5 ± 12.0**	**3.5**	**162**	**0.5 ± 0.2**	**0.2 ± 0.4**
S .Love Hill	D8	*1997*	37	61.0 ± 19.5	25.0 ± 14.5	14.5 ± 12.0	---	---	0.9 ±1.2	0
Coffee	D9	*1997*	51	56.5 ± 17.0	13.5 ± 14.5	30.0 ± 14.0	---	---	0.7 ± 0.9	0
West Klein	D10	1998	45	48.0 ± 19.5	28.0 ± 18.0	24.0 ± 11.5	3.5	177	0.5 ± 0.9	0
S .Autec	D11	*1997*	33	74.0 ± 17.5	6.5 ± 9.5	19.0 ± 16.0	---	---	0.7 ± 1.0	0
S. Long Rock	D12	*1997*	38	62.5 ± 20.5	10.5 ± 11.5	27.0 ± 16.0	---	---	0.9 ± 0.9	0
Long Rock	D13	1998	46	48.0 ± 20.0	30.0 ± 19.5	22.0 ± 13.0	3.0	145	0.1 ± 0.4	0
Mid Long Rock	D14	*1997*	33	59.0 ± 15.0	9.5 ± 12.0	31.5 ± 10.5	---	---	0.7 ± 0.8	0
Green Cay	D15	1998	62	54.5 ± 20.0	15.5 ± 19.0	30.0 ± 14.0	3	212	0.7 ± 0.8	0
Sugar Rock	D16	1998	56	41.5 ± 12.5	21.0 ± 16.5	37.5 ± 15.0	3.5	215	0.9 ±1.0	0
Central Andros all[1]			**401**	**56.0 ± 9.5**	**18.0 ± 9.0**	**26.0 ± 7.0**	**3.2 ± 0.3**	**187 ± 33**	**0.7 ± 0.2**	**0**
Bristol Galley	D17	1998	48	45.5 ± 21.0	18.0 ± 20.5	36.5 ± 15.0	4.0	238	0.8 ± 1.1	0
Autec 2	D18	1998	62	51.5 ± 13.0	11.0 ± 9.0	37.5 ± 10.5	3.5	281	0.7 ±1.1	2
Autec 2-South	D19	1998	44	40.0 ± 15.5	24.0 ± 24.0	36.0 ± 18.5	3.0	178	0.4 ± 0.7	0
N. Bight	D20	1998	47	45.0 ± 15.5	21.0 ± 22.5	33.5 ± 16.0	3.0	202	0.8 ±1.2	0
Autec 3	D21	1998	49	44.0 ± 16.0	14.0 ± 17.5	42.0 ± 18.0	3.0	185	0.6 ± 0.7	0
Middle Bight	D22	1998	48	42.0 ± 13.0	14.0 ± 15.5	44.0 ± 14.0	3.7	255	0.6 ± 1.0	0
Mangrove N.	D23	1998	70	50.5 ± 19.0	15.5 ± 17.0	34.0 ± 22.0	3.0	238	0.2 ± 0.6	0
Bights-all[1]			**368**	**45.5 ± 4.0**	**17.0 ± 5.0**	**37.5 ± 4.0**	**3.3 ± 0.4**	**226 ± 38**	**0.6 ± 0.2**	**0.3 ± 0.7**
Congo Town	D24	1998	48	50.0 ± 24.0	13.5 ± 19.0	36.5 ± 23.0	4.0	218	0.3 ± 0.7	0
Long Bay Cay	D25	1998	50	50.0 ± 16.5	14.0 ±1 9.0	36.0 ± 17.5	3.5	223	0.4 ± 0.7	4
Oasis	D26	1998	50	31.5 ± 19.5	29.0 ± 25.5	39.5 ± 17.5	3.0	140	0.6 ± 1.2	0
High Point Cay	D27	1998	35	41.5 ± 16.0	16.0 ± 21.5	42.5 ± 19.5	3.5	190	0.9 ± 1.2	2
North Rock	D28	*1997*	33	49.5 ± 12.5	3.5 ± 6.0	47.5 ± 13.0	---	---	1.1 ± 1.5	0
North Grassy	D29	*1997*	26	43.0 ± 25.0	10.0 ± 16.0	47.0 ± 24.0	---	---	0.9 ± 1.8	0
South Grassy	D30	*1997*	31	49.0 ± 15.0	4.0 ± 7.0	46.5 ± 12.0	---	---	0.6 ± 0.8	0
Delta	D31	*1997*	43	41.0 ± 15.0	4.0 ± 6.5	55.0 ± 16.0	---	---	1.1 ± 1.3	0
Pigeon	D32	*1997*	39	48.5 ± 15.5	9.0 ± 11.0	42.5 ± 12.5	---	---	1.7 ± 1.7	0
Saddleback	D33	*1997*	37	48.0 ± 16.0	5.5 ± 9.0	46.5 ± 15.0	---	---	0.9 ± 1.1	0
South Andros-all[1]			**392**	**45.5 ± 6.5**	**11.0 ± 8.0**	**38.5 ± 3.0**	**3.3 ± 0.4**	**193 ± 38**	**0.9 ± 0.4**	**0.6 ± 1.4**

[1]Quadrats (#) = sum; all other columns = means ± standard deviation.
[2]Heights measured as maximum canopy heights in 1997 are not included.
[3]Macroalgal index = relative abundance of macroalgae x macroalgal height.

Pp. 76-99 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.