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Assessment of the Coral Reefs of the Turks and Caicos Islands (Part 1: Stony Corals and Algae)

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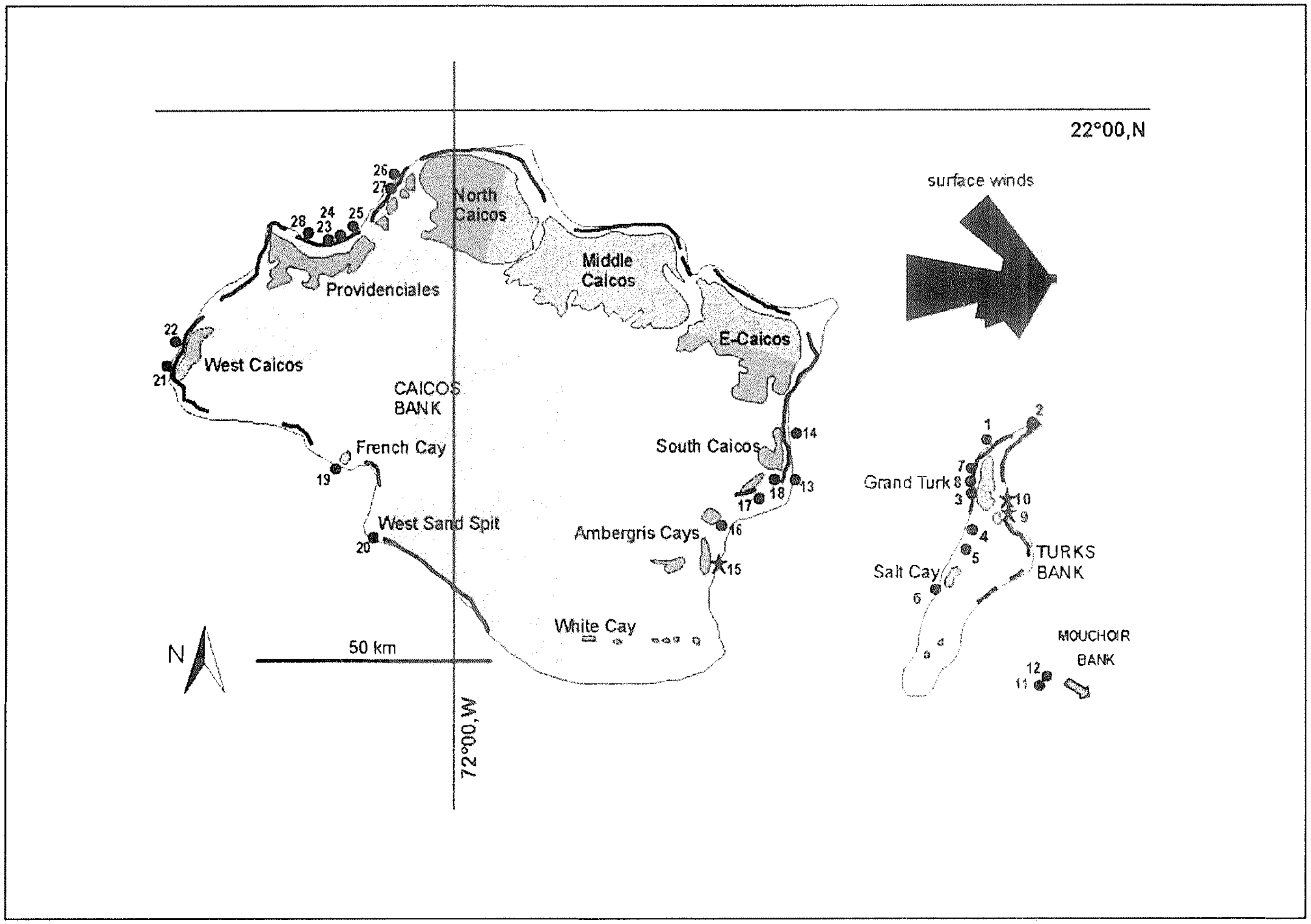

Figure 1. AGRRA survey sites in the Turks and Caicos Islands. See Table 1 for site codes. Wind rose for the southern Bahamas, from R.N. Ginsburg in P.A. Scholle, and N.P. James (1995).

ASSESSMENT OF THE CORAL REEFS OF THE TURKS AND CAICOS ISLANDS (PART 1: STONY CORALS AND ALGAE)

BY

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ABSTRACT

Major constituents of the benthic reef community (stony corals, algae) were assessed in 28 reefs on the Caicos, Turks and Mouchoir Banks. Living stony coral cover ranged from 8-28%, averaging 18% overall. *Montastraea annularis* and *M. faveolata* of "intermediate" sizes (<100 cm) dominated all examined reefs. Live *Acropora palmata* and *A. cervicornis* were scarce. The most frequently recruiting scleractinians were *Porites astreoides* and *Agaricia agaricites; Montastraea* recruits were uncommon. Old partial-colony mortality (overall mean=23%) was greater than recent partial-colony mortality (mean=3%). Crustose coralline algae and turf algae were generally more abundant than macroalgae. Mouchoir Bank, with the most isolated reefs, was in relatively poor condition, which suggests that remoteness alone does not protect coral reefs.

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INTRODUCTION

The Turks and Caicos Islands (TCI), which lie at 21° to 22° N and 71° to 72° 30′ W, consist of 8 islands (7 of which are inhabited) and approximately 40 low-lying cays distributed among two banks (Turks Bank, Caicos Bank) plus part of the entirely submerged Mouchoir Bank (Fig. 1). Over 300 km of coral reef surround the Turks and Caicos Islands (Wells, 1988). The prevailing easterly trade winds (see windrose for the TCI area in Fig. 1) create a clear differentiation on the banks into a windward eastern side with generally choppy conditions and a leeward western side that is usually calm. The banks have narrow, discontinuous, shelf-edge reef (SER) systems (sensu Blanchon and Jones, 1997) of variable depth, relief, and stony coral abundance (Chiappone et al., 1996). Along the western parts of the Caicos and Turks Banks, shallow fringing reefs are developed shoreward of the SERs. Shallow patch reefs also surround many of the islands and cays. Underwater visibility is considered good everywhere.

The reefs and banks of the Turks and Caicos Islands have been studied by Wanless and Dravis (1989), Sullivan et al. (1994), Gaudian (1995, unpublished report), Chiappone et al. (1996) and Steiner (1999). In the context of the ongoing general deterioration of reef health in the entire Caribbean basin (e.g., Ginsburg, 1994), these isolated islands, with relatively small human population pressures, are of particular interest as landmark study sites. Information to date indicates that the Turks and Caicos reefs are generally in good condition with some pollution impacts evident near the islands of Providenciales and Grand Turk (e.g., Sullivan et al., 1994; Lang et al., 1998; Steiner, 1999; Woodley et al., 2000). Hence, they can be used for comparison with other sites subjected either to direct continental influences or to higher impacts, both natural and anthropogenic.

This study presents: 1) the August 1999 Atlantic and Gulf Rapid Reef Assessment (AGRRA) results for benthic reef condition; 2) an evaluation of differences between shallow versus deep reefs and between windward versus leeward reefs; and 3) a qualitative comparison of reefs on the three banks (which are known to experience different levels of resource extraction). Our AGRRA fish surveys for the Turks and Caicos Islands are presented by Hoshino et al. (this volume).

METHODS

Survey sites (Fig. 1) were selected with the assistance of locally available diving and sailing maps, charts (British Admiralty, U.S. Navy), maps in publications, and aerial photographs. We chose strategically accessible reefs (e.g., at established dive sites with mooring buoys) that were considered representative of special interests (i.e., reported to be heavily impacted, or of touristic, fisheries and/or conservation value). Although an effort was made to space sites as evenly as possible within all available exposures and reef types, small boats and prevailing sea conditions restricted our surveys to areas of moderate exposure and/or short traveling distance. However, a mix of 11 moderately exposed and 17 sheltered reefs were obtained. The northern side of the Caicos Bank and much of Mouchoir Bank were not exhaustively investigated. On Turks Bank we sampled all available habitats within the appropriate depth intervals, but largely ignored the southern area south of Salt Cay. Since an *Acropora palmata* reef-crest zone was not encountered in any of the areas examined, we surveyed three shallow patch reefs at depths of 2.5-6.5 m (Table 1). The patch reefs had been constructed primarily of *A. palmata,* still had some live colonies of this species, and were considered representative of several other patch reefs that we also visited. Elsewhere we made qualitative notes of the abundance of *A. palmata.* The remaining surveys were located in depths of 9.5-22.5 m on the seaward margin of spurs in the SERs. Nine were high-relief (>5 m) and 16 had lower relief (<5 m) but all showed groove-and-spur morphology with sand-filled channels running between the reef lobes.

Three divers executed the AGRRA Version 2.1 benthos protocol (see Appendix One, this volume) using the following modifications: pockets of sand underlying the transect line were not measured; assessments were made for each stony coral of 10 cm or greater diameter beneath the transect line; colony height and diameter were measured to the nearest 5 cm or, when possible, the nearest cm. *Porites furcata* and *P. divaricata* were not separated from *P. porites*, and species of *Agaricia* were not determined but about 90% of the surveyed corals are thought to have been *A. agaricites* with most of the rest consisting primarily of *A. fragilis* and *A. humilis*. Diseases were characterized by criteria established by Antonius (1995), Santavy and Peters (1997), and Peters (1997). We looked for damselfish tending algal gardens on the individually surveyed corals but none were recorded. Species that are small as adults (e.g., *Favia fragum*) were not included in the counts of stony coral "recruits." Sediment was removed from the algal quadrats by fanning the substratum two or three times by hand after scoring the cover of algal turfs and macroalgae but prior to estimating the abundance of crustose coralline algae. Absolute algal abundance estimates frequently exceeded 100% since each layer was estimated separately.

Numerous consistency checks were performed. Prior to beginning the survey, all divers performed measurements on the same transect and the results were compared. This process was repeated until results were homogeneous within the group. In total, five training transects were necessary. During the surveys, divers repeatedly discussed coral identification and interpretation of mortality, disease, algal cover, etc. The field guide used for identification of marine organisms was Human (1993).

For statistical evaluations, the reefs were grouped into three ecological units: shallow *Acropora palmata*-built patch reefs; high-relief SERs; and low-relief SERs. All data were found to be normally distributed with Kolmogoroff-Smirnow one-sample tests for normality of distribution. Parametric testing statistics were used to compare groups by means of the student's t-test or one-way analysis of variance and Tukey's post-hoc test to identify significant groupings. Differences between the three banks were not tested for significance since the sample size (n=2) on Mouchoir Bank was not representative. The SERs were also grouped for testing according to expected exposure regime with all reefs on the eastern sides of the banks considered "moderately exposed " and those on the western side to be "sheltered." The three patch reefs all were in exposed locations, hence "windward" versus "leeward" comparisons were not possible for this habitat type.

RESULTS

Stony Corals

A total of 3,270 corals were surveyed in 289 transects on three banks and around 11 islands in the Turks and Caicos Islands. Live stony coral cover averaged ~18% overall (Table 1). No significant differences were found between the patch reef and the high-relief or low-relief SERs (ANOVA, F=1.749, p=0.195), despite clear evidence of previous *A. palmata* mortality (numerous large skeletons in the framework) in the former. Differences of exposure were just significant (t-test, F=4.3, p=0.05), the percentage of live coral cover being higher in the moderately exposed SERs (mean=20.5, sd=6.8, n=8) than in the sheltered SERs (mean=14.6, sd=3.3, n=17). The very low coverage (7.5%) seen on one high-relief SER (TC5) was largely due to a local limitation in the amount of suitable habitat as the spurs were dissected into patches each ≤10 m across and separated from the others by pockets of sand.

Scleractinian growth, particularly on Turks Bank, was most profuse in the area immediately adjacent to the platform margin. In some instances two platform edges were found, a shallower rim at 10-15 m depth and a deeper edge seaward of a small (10-50 m wide) plateau at around 30-35 m (best developed near South Caicos). Stony coral growth was always densest on the outer edge of the shallower shelf. Steep slopes exhibited few scleractinians but in many areas dense populations of black corals, *Cirrhipathes* sp. and *Antipathes* spp., were observed (particularly in TC 7 on Turks Bank). On gentler (<40° inclination) reef slopes, stony corals were abundant to depths of 50 m on Turks Bank (in TC8), the platy coral facies in places (e.g., TC19) being well over 50% at 25-30m depth.

Of the stony corals that were ≥10 cm in diameter, *A. palmata* was most common in the patch reefs, while poritids (*Porites porites, P. astreoides*) were more abundant here than in the deeper SERs (Fig. 2). Indeed, *P. astreoides* became increasingly common with decreasing water depth (and thus increasing hydrodynamic exposure). *Montastraea annularis* and *M. faveolata* were the most abundant stony corals in deeper water with the *M. annularis* complex constituting about 40% of all the colonies in the SERs (Fig. 2). *A. cervicornis* was present but rare (<1% in SERs) on the Caicos and Turks Banks. It is interesting to note that *Dendrogyra cylindrus*, which is generally uncommon in most

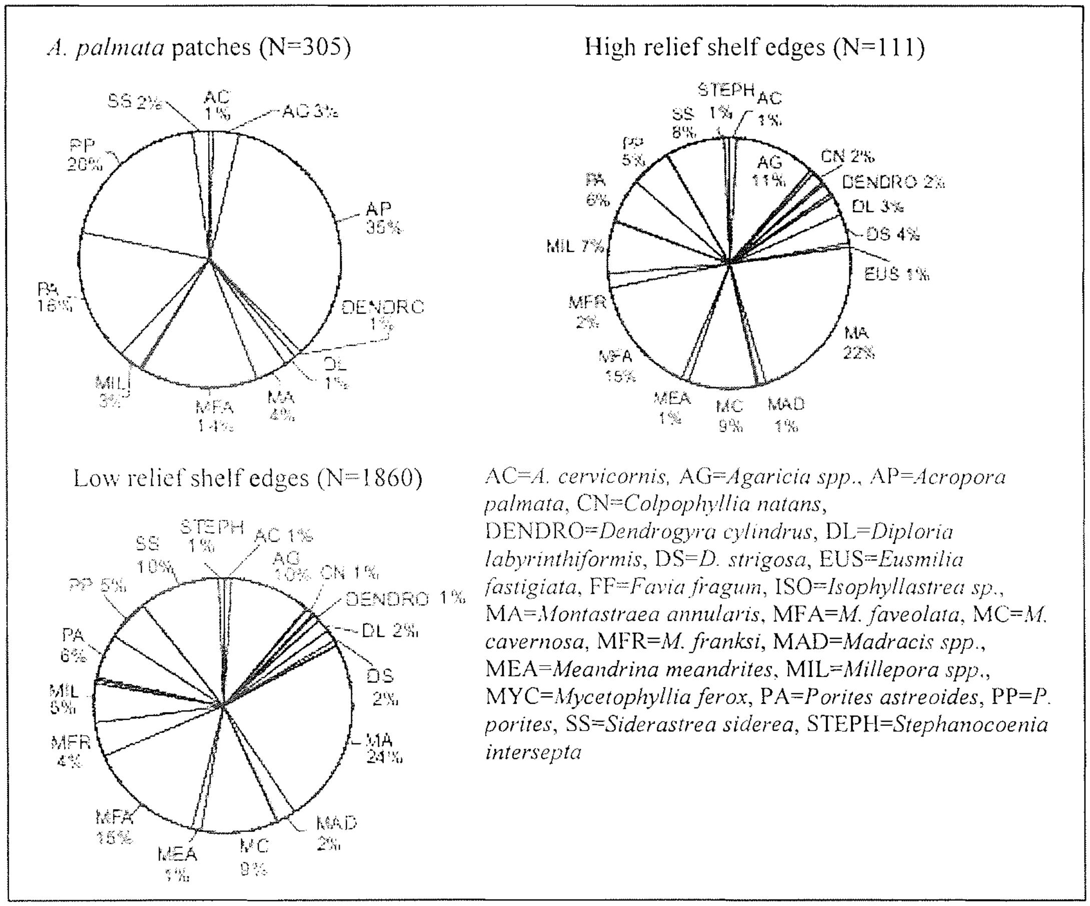

Figure 2. Species composition and mean relative abundance of the most abundant stony corals (≥10 cm diameter) in *Acropora palmata* patch reefs, low-relief shelf-edge reefs and high-relief shelf-edge reefs in the Turks and Caicos Islands.

Caribbean areas, obtained counts of 1-2% overall with no apparent preference for any particular depth zone and was particularly conspicuous on Turks Bank.

For colonies ≥10 cm in diameter, the average maximum diameter (Table 2) ranged between 26 cm in a high-relief SER (TC5) and 103 cm in a patch reef (TC9); their average maximum height varied from 16.5 cm (in TC1, a high-relief SER) to 66 cm (in TC9). Average maximum diameter and height were both significantly higher in the patch reefs than in the deeper reefs (ANOVA for greatest diameter $F=18.5$, $p<0.001$; for greatest height $F=14.7$, $p<0.001$), but no significant differences in size were found between the high-relief and low-relief SERs. Nor were any differences in diameter or height found between moderately exposed and sheltered SERs (t-tests, $f=0.71$, $p=0.401$ for diameter; $F=1.91$, $p=0.181$ for height).

Amongst the more common corals, *Acropora palmata* showed a polymodal size distribution which was somewhat skewed towards the larger (>100 cm) size classes (Fig. 3A,B). The size-frequency distributions of *Montastraea annularis* and *M. faveolata* were

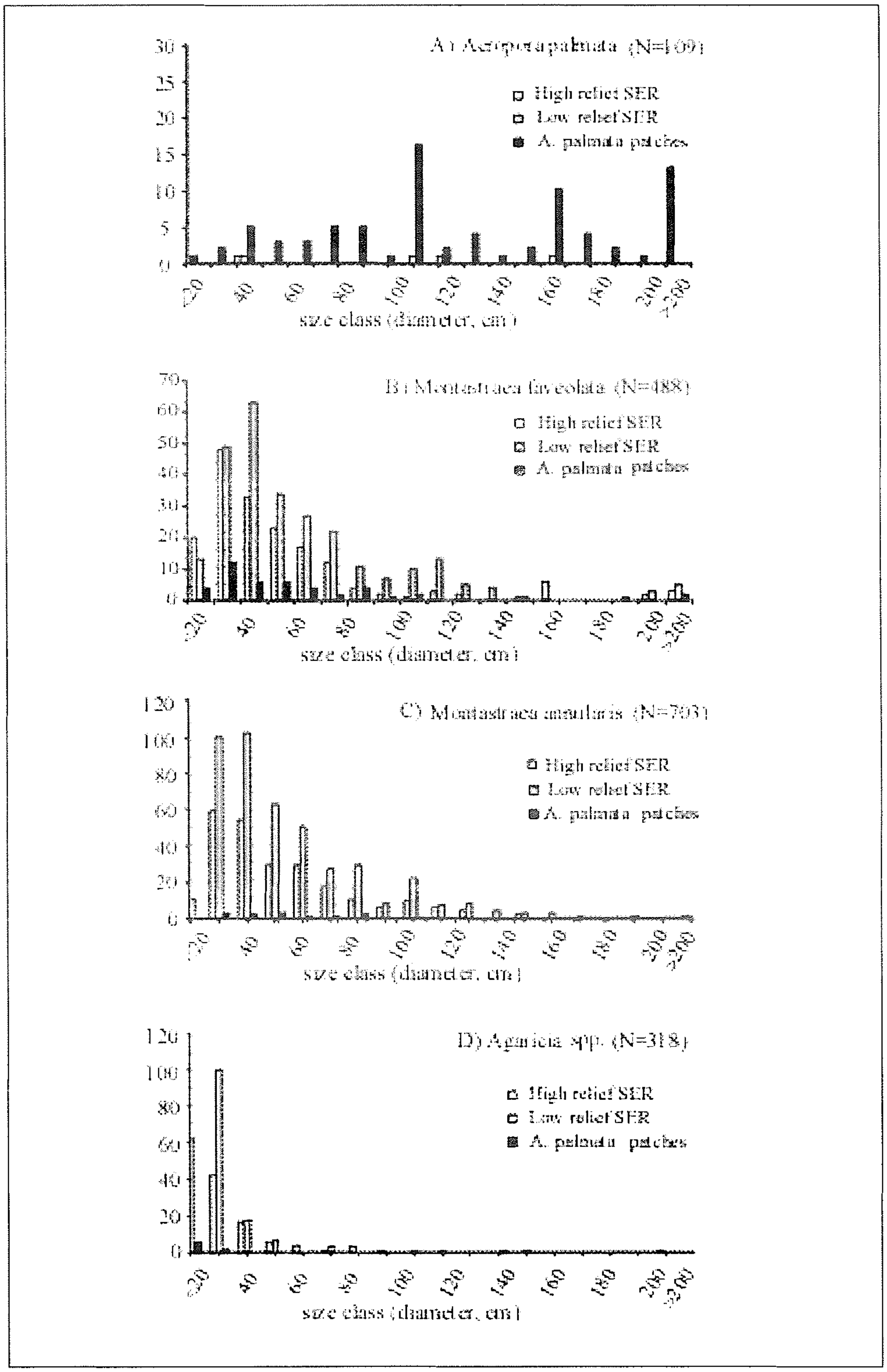

Figure 3A. Size-frequency distributions of ≥10 cm diameter colonies of (**A**) *Acropora palmata,* (**B**) *Montastraea faveolata,* (**C**) *M. annularis*, and (**D**) *Agaricia* spp. in *Acropora palmata* patch reefs, low-relief shelf-edge reefs and high-relief shelf-edge reefs in the Turks and Caicos Islands.

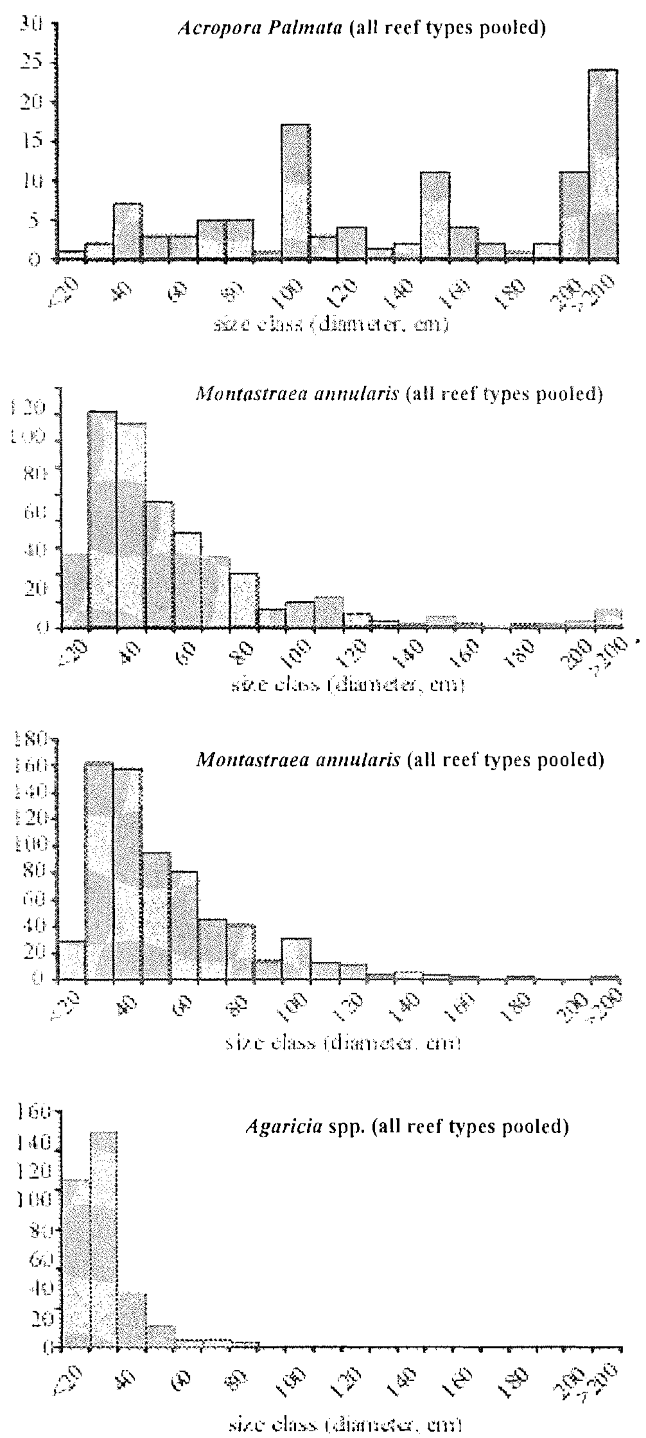

Figure 3B. Size-frequency distributions of ≥10 cm diameter colonies of (**A**) *Acropora palmata,* (**B**) *Montastraea faveolata,* (**C**) *M. annularis*, and (**D**) *Agaricia* spp. pooled for all reefs in the Turks and Caicos Islands.

clearly skewed to the "intermediate sizes" (20-70 cm for *M. annularis*, 20-90 cm for *M. faveolata*). Most of the *Agaricia* spp. (primarily *A. agaricites*) were less than 30 cm in maximum diameter. The colonies of *A. cervicornis* in the Caicos and Turks Banks were relatively small (rarely >1 m in diameter).

The density of stony coral recruits (Table 3) in the 1,156 algal quadrats ranged from 0.02/0.0625 m^2 in a patch reef (TC9) to 0.8/0.0625 m^2 in a low-relief SER (TC27). By far the most common (Fig. 4) were *Porites astreoides* followed by *Agaricia* spp. (mostly *A. agaricites*). *Montastraea annularis* and *M. faveolata* were present but in low abundance. No acroporid recruits were encountered during the surveys. Recruit density did not differ significantly between the patch reefs and either the high-relief or the low-relief SERs (ANOVA, F=2.92, p=0.072). There were no differences in recruitment between the moderately exposed and sheltered SERs (t-test, F=0.22, p=0.641).

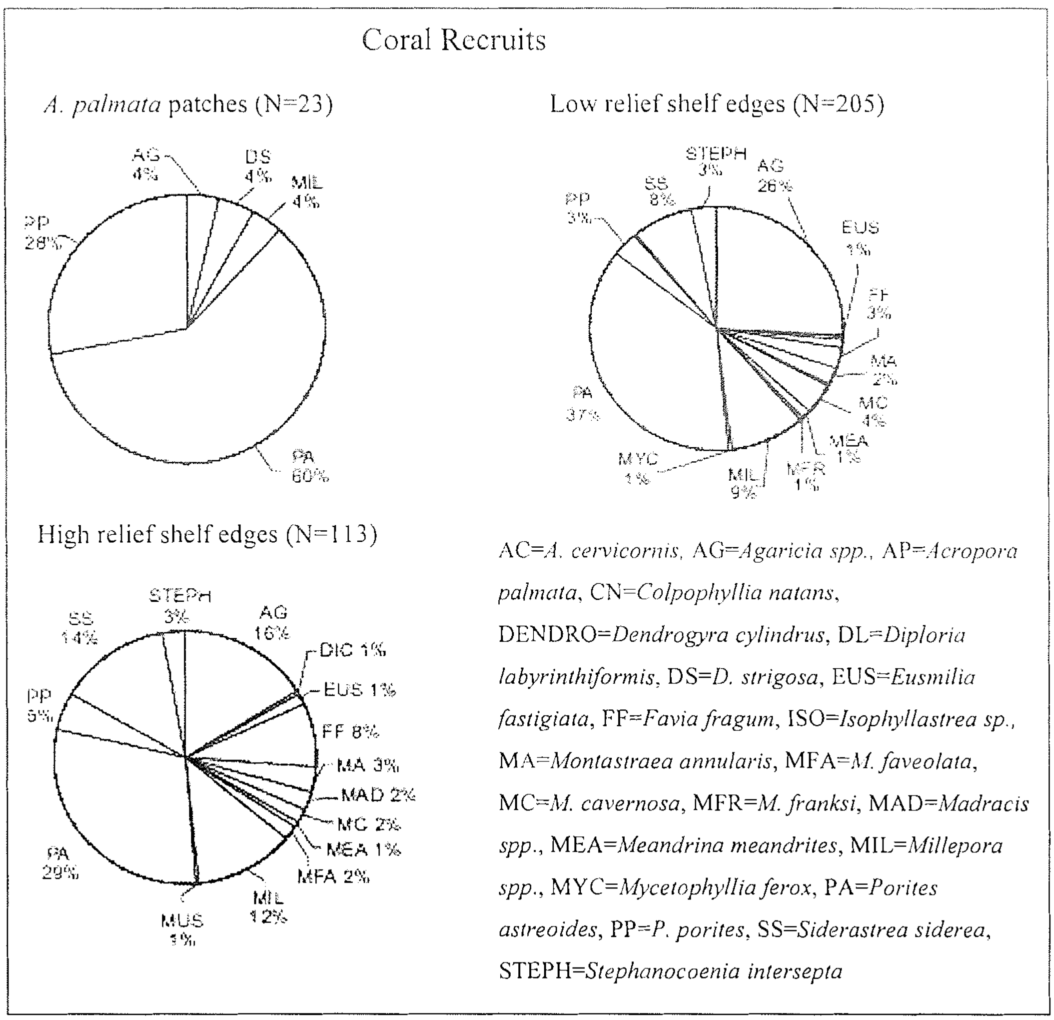

Figure 4. Species composition and mean relative abundance of all stony coral recruits (≤2 cm diameter, excluding species that are small as adults) in *Acropora palmata* patch reefs, low-relief shelf-edge reefs and high-relief shelf-edge reefs in the Turks and Caicos Islands.

Stony Coral Condition

On average, nearly 5% of the ≥10 cm diameter stony corals on each reef were diseased. The percentages of diseased stony corals were highest in one site on Mouchoir Bank (17% in TC 12) and in two sites on Caicos Bank (13% in each of TC26 and TC27), while the lowest values were found on Turks Bank (Table 2). The percent of affected colonies did not differ significantly between the patch reefs and either type of SER (ANOVA, F=0.223, p=0.802). Moreover, there were no differences between the moderately exposed and sheltered SERs (t-test, F=0.05, p=0.998).

Healthy patches of *Acropora palmata* and *A. cervicornis* were only encountered in Caicos Bank on the southwestern (between Providenciales and West Caicos) and southeastern (at TC15) sides, and in the two patch reefs on the eastern side of Turks Bank (TC9, TC10). Three of the small colonies of *A. cervicornis* in the SER reefs (one each in TC3, TC26 and TC28) had white-band disease, and three of the patch-reef *A. palmata* (two in TC9, one in TC10) exhibited similar characteristics. Only a few cases of black-band disease were encountered. White plague was common, and about 75% of the 130 diseased colonies belonged the *Montastraea annularis* complex (*M. faveolata* 43%, *M. annularis* 27%, *M. franksi* 5%). No bleaching at all was captured in the dataset; neither was any damage by damselfish observed.

Mortality patterns (as a percent of affected upper colony surfaces) were somewhat different between shallow and deeper water (Fig. 5). Values for recent partial-colony mortality (hereafter recent mortality) varied from <0.5% in a patch reef (TC10) to 7.5% in a low-relief SER (TC18) and values of old partial-colony mortality (hereafter old mortality) from 12.5% in a high-relief SER (TC2) to 47% in a patch reef (TC9). Percentages of both old mortality and total (recent + old) mortality were slightly higher in the moderately exposed SERs (old mortality mean=24.9, sd=7.9; total mortality=36.1, sd=3.9) than in the sheltered SERs (old mortality=20.4, sd=3.4; total mortality=31.3, sd=3.9).

Recent mortality showed no significant differences between the patch reefs and the SERs (ANOVA, F=1.045, p=0.367). Both old mortality and total mortality differed significantly between the patch reefs and the high- and low-relief SERs, although the latter did not differ from each other (ANOVA for old mortality F=7.33, p=0.03; for total mortality F=10.2, p<0.001). Recent mortality did not differ between the moderately exposed and sheltered SERs (t-test, F=4.05, p=0.056) whereas significant differences were found in old mortality (t-test, F=10.4, p=0.004) and total mortality (t-test, F=8.5, p=0.008), being higher in the sheltered sites than in the moderately exposed SERs.

No examples of stony corals having experienced 100% recent mortality were encountered. Less than 5% were "standing dead" (100% mortality and still in original growth position) (Table 2), except in two of the patch reefs (TC9-20.5%, TC10-15.5%) where much of the reef framework was made of large, long-dead skeletons of *Acropora*

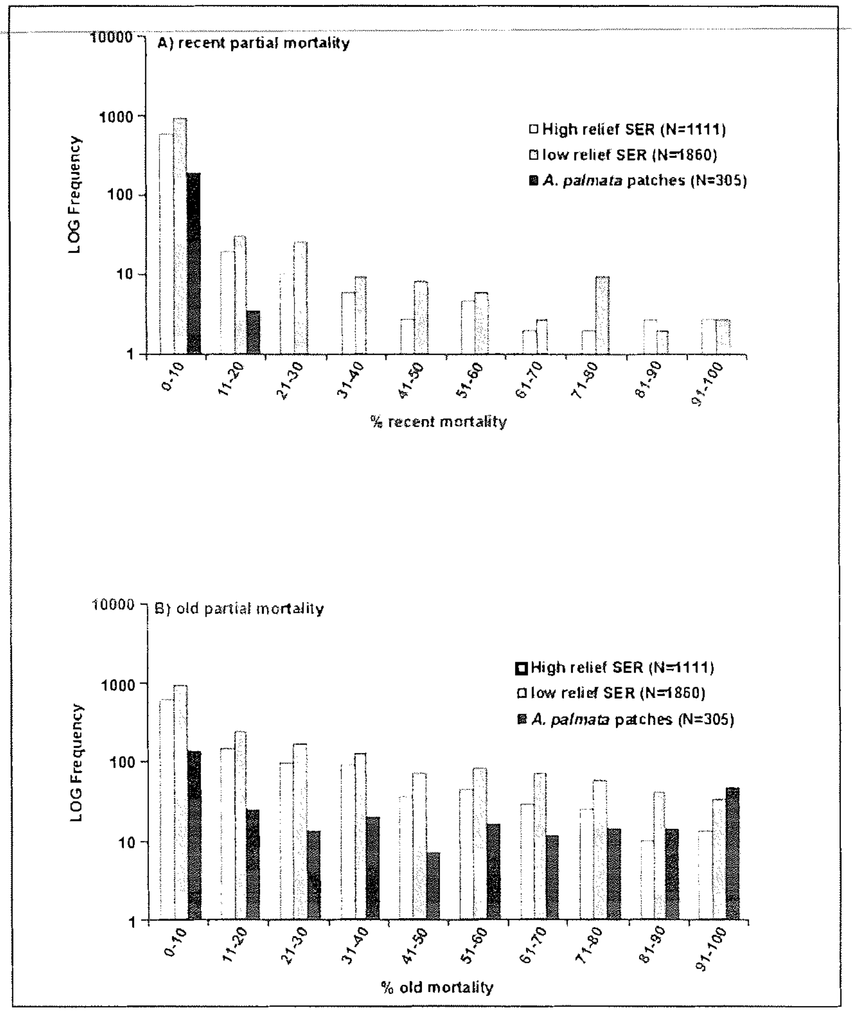

Figure 5. Log-frequency distributions of (**A**) recent partial colony mortality and (**B**) old partial colony mortality of all stony corals (≥10 cm diameter) in *Acropora palmata* patch reefs, low-relief shelf-edge reefs and high-relief shelf-edge reefs in the Turks and Caicos Islands.

palmata. The differences in standing dead corals between the patch reefs and the SERs were significant (ANOVA, F=21.77, p<0.001). On the Mouchoir Bank, only isolated and badly damaged ridges of *A. palmata* were observed in shallow habitats and in many cases the coral skeletons were heaps of large rubble. Diseases (possibly including aspergillosis) in sea fans and other gorgonians were only observed in very rare instances and did not enter the dataset.

Algae and *Diadema antillarum*

Macroalgae constituted the most abundant algal functional group in the algal quadrats in one patch reef (TC15) and were codominant with crustose coralline algae in the other two (Table 3). In the SERs, turf algae predominated in nine, crustose coralline algae were predominant in eight, these two algal groups were approximately equally abundant in six reefs and two had essentially equal abundances of all three algal groups. Thus, turfs and crustose corallines were about equally common in all but the shallow patch reefs, where macroalgae were comparatively abundant.

Macroalgal heights averaged less than 1 cm in 18 reefs, and from 1-2 cm in seven reefs (Table 3). By far the tallest algae (about 7 cm high) were found in a high-relief SER at Mouchoir Bank (TC11) where clumps of *Turbinaria* were seen to be overgrowing colonies of *Montastraea* spp. Macroalgal indices (absolute abundance of macroalgae x macroalgal height) were highest here and in the patch reefs (particularly TC15).

There were no significant differences in crustose coralline algal abundance between patch reefs and either type of SER (ANOVA, $F=1.14$, $p=0.335$), but macroalgal abundance, turf algal abundance, macroalgal height and macroalgal index differed significantly between the patch reefs and the SERs, which did not differ from each other (ANOVAs for macroalgae, $F=16.6$, $p<0.001$; for turf algae, $F=5.6$, $p=0.009$; for macroalgal height, $F=3.633$, $p=0.041$; for macroalgal index, $F=8.07$, $p=0.002$). The abundance of macroalgae, turf algae and crustose coralline algae did not differ significantly between sheltered and moderately exposed SERs (t-tests, $F=0$, $p=0.998$ for macroalgae; $F=0.52$, $p=0.477$ for algal turfs $F=0.29$, $p=0.594$ for crustose coralline algae). However, macroalgal height and macroalgal index (a proxy for biomass) were significantly greater in moderately exposed SERs (height: 1.7 ± 2.2cm, index: 40.6 ± 79.5) than in the sheltered SERs (height: 0.6 ± 0.4 cm; index: 10.2 ± 15.9) (t-test, $F=7.25$, $p=0.013$ for macroalgal height; $F=7.54$, $p=0.011$ for macroalgal index). No relationship was noted between either macroalgal height or macroalgal index and the number of stony coral recruits in the quadrats.

No *Diadema antillarum* were found in any of the belt transects, nor elsewhere in the TCI reefs.

DISCUSSION

Notwithstanding the moderately low total cover by live stony corals, the reef ecosystems in the Turks and Caicos Islands gave the overall impression of being in good condition. The large amounts of standing dead stony corals in two of the patch reefs were clear evidence that the presently low cover of live stony corals reflected at least one previous mortality event. This was not the case on the SERs where the stony corals were in good health with a low prevalence of standing dead colonies (range 0-4%, n=25 reefs), hence their relatively low cover (usually <25%) may be a natural phenomenon. Since all the investigated reefs are within the influence of bank waters, it is possible that the latter exert a strong control over their scleractinian communities. Warmed or cooled bank waters spilling over the reefs may sufficiently stress scleractinians so as to preclude faster growth or higher recruitment. As the Turks and Caicos Islands are also situated within one of the main hurricane paths, some control may also be exerted by high wave-energy events (e.g., Blanchon and Jones, 1997). The higher cover of live stony corals in the more exposed locations suggests greater influence by bank waters than by waves, which would be expected to produce the reverse pattern; however, it is alternatively possible that stony corals grow faster in windward reefs.

Few healthy patches of *A. palmata* were present either in the surveyed patch reefs or in patches that were visited but not surveyed. (It may be that more could be found on the northern reefs between North Caicos and East Caicos; however, we were not able to survey this area.) For example, patch reefs built by dead or partly dead colonies of *A. palmata* cover extensive areas on the windward (eastern) side of Turks Bank and near Ambergris Cay in southeastern Caicos Bank. These 'long-dead' colonies of *A. palmata* may have been caused by diseases since intact skeletons were common. No information on the timing of death is available; however, it appears that many *Acropora* were already dead when surveyed by Sullivan et al. (1994).

Some of the partially living colonies of *A. palmata* exhibited signs of what appeared to be infection by white-band disease. A measure of uncertainty as to the cause of the *present* die-back remains, however, since local fisheries and nature conservation authorities mentioned occurrences of fishing with chemicals (dish-washing liquid, possibly bleach or gasoline) in these patch reefs. Therefore, what we interpreted as white-band disease might rather have been recent mortality triggered by exposure to toxins. However, we saw no direct evidence of fishing with toxic substances.

A. cervicornis was not seen in Mouchoir Bank which is likely to be an artifact of incomplete sampling. On the Caicos and Turks Banks, the small colonies of *A. cervicornis* possibly represented a new generation of recruits or survivors from a previous mortality event. By selective removal of *A. cervicornis*, previous outbreaks of disease could have contributed to the overall low cover of live stony corals. In contrast to the Cayman Islands, where large reef areas are covered by skeletons of *A. cervicornis*, no such skeletal remains were observed in the TCI. Had *A. cervicornis* been more common previously and killed by disease, its skeletons must have completely disappeared due to in-situ erosion or down-slope transport into deepwater, but given the persistence of its skeletons in the fossil record this scenario seems unlikely. The presence of white-band disease in some colonies of *A. cervicornis* is, however, evidence that acroporid diseases were present in the TCI.

The absence of bleached stony corals and of 100% recently dead colonies are indications that no catastrophic mortality events had occurred shortly before our surveys were made. We thus presume that the mass bleaching event of 1998 had only minimal impact in the TCI. Similarly, the low count of standing dead colonies in the SERs indicates a similar absence of major mortality outbreaks in these deeper reef habitats for at least several previous years. The generally low rates of recent mortality (mean=3%) suggest that much of the reef system was in good condition overall. Nevertheless, in a quarter of the examined reefs the ≥10 cm stony corals exhibited moderately high rates of disease

(6.5-17%). Our surveys may have coincided with an outbreak of white plague that had disproportionately affected colonies of *Montastraea faveolata*.

The paucity of *Acropora palmata* recruits (none encountered in the 1,411 quadrats) and the skewed size distribution of the ≥10 cm sized corals are suggestive of a pulse-like population replenishment by rare, high-recruitment events. The general skewness of the *Montastraea* distributions towards intermediate sizes may indicate that most of the colonies were of similar ages (resulting from a strong recruitment pulse), and/or be an indication of strong asexual recruitment by fragmentation or, less likely, that they simply do not grow very large in the TCI. Recruitment by small planulating scleractinians like *Porites astreoides* and *Agaricia agaricites* was an order of magnitude higher than by the larger, spatially dominant brooders (e.g., *Acropora, Montastraea*) in accord with general experience elsewhere in the wider Caribbean (e.g., Smith, 1992).

That macroalgal height was greater in the windward reefs than in the leeward reefs, notwithstanding their comparatively low hydrodynamic resistance compared to crustose coralline algae and algal turfs, is surprising. The overall scarcity of macroalgae, which accounted for <20% of the benthic algae in 75% (21/28) of the surveyed reefs is encouraging. However, our qualitative impression on Mouchoir Bank was one of unusually strong macroalgal overgrowth over dead stony corals. Whether this is a sign of degradation or a transient temporal phenomenon could only be verified with time-series data.

High cover by macroalgae is generally seen as a sign of deteriorating reef quality (e.g., Steneck, 1994), in part because they restrict the recruitment of stony corals (Rogers et al., 1984). Coral planulae are thought to settle preferentially on crustose coralline algae (Johnson et al., 1991), hence rates of coral recruitment may be lower when crustose corallines are scarce. Although a high abundance of macroalgae did not always correlate with a low recruit count (Table 3), it was associated with some of the lowest recruitment observed on the Mouchoir Bank and near Ambergris Cay. However, it has to be noted that AGRRA sample sizes are not large enough to warrant detailed comparisons among sites or make a credible estimate of recruitment at any given site.

In general we found that the reefs on Mouchoir Bank, which lacks any human population, were in worse condition than in our survey sites on the Turks and Caicos Banks, which was an unexpected result. The part of the Mouchoir Bank within Turks and Caicos Islands territory is difficult to police and protect and is the target of an intense, mostly illegal, fishery. Fishing vessels (reputedly mostly from the Dominican Republic) were reported to sometimes use fishing methods that are destructive to corals. Also, overharvesting of herbivores facilitates the expansion of macroalgae over corals. Remoteness from human population need not necessarily translate into "pristine" and "healthy" reefs. Rather, from our survey it appears that controlled use of reef resources near a moderately dense population may be more sustainable than largely uncontrolled activities in remote locations.

ACKNOWLEDGMENTS

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Table 1. Site information for AGRRA coral and algal surveys in the Turks and Caicos Islands.

Site Name	Site code	Latitude (° ' N)	Longitude (° ' W)	Survey date	Depth (m)	Benthic transects (#)	≥10 cm stony corals (#/10 m)	% live stony coral cover (mean ± sd)
A. palmata patch reefs								
b/w Round and Gibbs Cay	TC9	21 26.307	71 06.628	Aug 17 99	3.5	13	8	10.5 ± 3.0
E.of S. end of Grand Turk	TC10	21 27.534	71 06.818	Aug 17 99	2.5	13	7	8.0 ± 4.0
Ambergris Cay 1	TC15	--	--	Aug 20 99	6.5	12	9	15.5 ± 6.5
High relief shelf-edge reefs								
Lighthouse Point (anchor)	TC1	21 31.139	71 08.037	Aug 14 99	17.5	10	11	16.0 ± 9.0
North Point (anchor)	TC2	21 32.220	71 06.553	Aug 14 99	16.0	13	10.5	16.5 ± 6.0
Coral Garden	TC3	21 27.493	71 09.301	Aug 14 99	11.5	11	14	25.5 ± 7.0
N. of Salt Cay (anchor)	TC5	21 22.408	71 12.078	Aug 15 99	12.0	10	8.5	7.5 ± 2.0
Mouchoir Bank	TC11	20 59.159	70 47.008	Aug 18 99	22.5	11	11.5	10.5 ± 4.0
The Arch	TC13	21 28.996	71 31.062	Aug 19 99	10.5	10	12.5	20.5 ± 5.0
Ambergris Cay 2	TC16	21 22.359	71 35.949	Aug 20 99	20.0	12	10	12.5 ± 8.5
The Pinnacles (Grace Bay)	TC23	21 48.841	72 11.219	Aug 26 99	10.0	10	12.5	31.0 ± 9.5
Football Field	TC26	21 54.381	72 06.916	Aug 27 99	19.0	8	16.5	28.5 ± 7.5
Low-relief shelf-edge reefs								
West of Little Sand Key	TC4	21 23.658	71 10.088	Aug 15 99	9.5	10	10.5	14.5 ± 6.0
Casey's Wall (anchor, W. of Salt Cay)	TC6	21 18.201	71 13.388	Aug 16 99	11.5	9	14.5	24.5 ± 6.5
Black Forest	TC7	21 28.754	71 09.211	Aug 16 99	11.5	9	13	21.0 ± 4.5
Chief Minister's House	TC8	21 26.443	71 09.294	Aug 16 99	16.5	9	12.5	24.0 ± 8.5
Mouchoir Bank	TC12	21 01.369	70 49.108	Aug 18 99	13.5	11	14	17.0 ± 6.0
Airplane	TC14	21 32.762	71 27.348	Aug 19 99	16.5	10	11.5	13.5 ± 3.5
(No Name)	TC17	21 28.029	71 33.125	Aug 21 99	15.5	11	11	14.5 ± 2.0
Fish Hole	TC18	21 29.072	7130.629	Aug 21 99	13.0	11	10.5	12.0 ± 3.0
French Cay	TC19	21 29.357	72 13.456	Aug 23 99	14.5	10	0	22.0 ± 6.0
West Sand Spit	TC20	21 23.285	72 08.637	Aug 23 99	13.5	10	12	20.0 ± 10.0
Spanish Anchor (West Caicos wall)	TC21	21 38.739	72 28.473	Aug 24 99	15.5	11	8	12.5 ± 4.0
West Caicos Wall-middle	TC22	21 39.890	72 28.211	Aug 24 99	18.5	9	12	22.0 ± 4.5
Coral Gables (North side of Provo)	TC24	21 49.080	72 11.010	Aug 26 99	11.0	8	12.5	22.0 ± 8.5
Grace Bay (North of TC24)	TC25	21 49.809	72 10.395	Aug 26 99	10.0	10	10.5	14.0 ± 6.0
Grouper Hole	TC27	--	--	Aug 27 99	11.5	8	15	31.0 ± 7.0
Aquarium West	TC28	21 48.518	72 13.542	Aug 27 99	17.5	10	11	12.5 ± 3.5
All sites (mean ± sd)						**1.3**	**11.1**	**18.0 ± 5.5**

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

Site name/Site code	Stony corals			Partial-colony mortality (%)			Stony corals (%)		
	#	Diameter (cm)	Height (cm)	Recent	Old	Total	Standing dead	Bleached	Diseased
A. palmata patch reefs									
b/w Round and Gibbs Cay/TC9	107	103.0 ± 95.0	66.0 ± 74.0	1.0 ± 7.5	47.0 ± 40.5	61.5 ± 36.0	20.5	0	4.5
E.of S. end of Grand Turk/TC10	91	78.5 ± 77.5	54.0 ± 57.0	<0.5 ± 0.5	41.0 ± 40.0	56.5 ± 36.0	15.5	0	4.5
Ambergris Cay 1/TC15	107	55.5± 50.5	33.0 ± 27.5	3.0 ± 12.5	21.0 ± 28.0	34.0 ± 29.5	3	0	7
High relief shelf-edge reefs									
Lighthouse Point (anchor)/TC1	112	29.0 ± 17.5	16.5 ± 14.0	0.5 ± 2.0	18.5 ± 23.5	29.5 ±2 3.5	0	0	2
North Point (anchor)/TC2	136	37.5 ± 26.5	20.0 ± 15.0	1.5 ± 7.0	12.5 ± 16.5	22.0 ± 18.0	0	0	2
Coral Garden/TC3	154	40.5 ± 24.0	26.0 ± 16.5	5.5 ± 18.5	21.5 ±2 4.0	34.0 ± 27.5	2.5	0	3
N. of Salt Cay (anchor)5/TC5	84	26.0 ± 14.5	18.5 ± 16.5	1.0 ± 6.0	20.0 ± 27.0	31.5 ± 28.0	1	0	3
Mouchoir Bank/TC11	126	31.5 ±1 4.0	26.5 ± 14.5	4.0± 9.5	31.5 ± 26.5	41.5 ± 26.0	4	0	7
The Arch/TC13	123	44.0 ± 28.0	29.0 ± 20.5	1.5 ± 4.5	25.0 ± 25.0	32.0 ± 24.	1	0	4
Ambergris Cay 2/TC16	117	32.0 ± 20.0	21.5 ± 15.0	4.5 ± 13.5	15.0 ± 20.0	27.5 ± 23.5	0	0	1
The Pinnacles (Grace Bay)/TC23)	127	50.0 ± 41.5	39.0 ± 38.5	2.5 ± 9.5	16.5 ± 19.0	24.5 ± 21.5	0	0	2
Football Field/TC26	132	48.0 ± 29.0	28.0 ± 17.0	3.5 ± 1.0	18.5 ± 23.5	30.0 ± 25.5	1.5	0	13
Low-relief shelf-edge reefs									
West of Little Sand Cay/TC4	105	37.5 ±22.0	22.0 ± 17.5	3.0 ± 10.5	27.5 ± 29.0	38.5 ± 31.5	2	0	1
Casey's Wall (anchor, W. of Salt Cay) /TC6	132	40 5 ±2 6.5	25.5 ± 19.0	1.0 ± 4.5	21.5 ± 26.0	32.0 ± 25.5	0	0	2
Black Forest/TC7	118	40.5 ±1 9.0	27.5 ± 18.0	2.0 ± 11.0	27.0 ± 24.5	33.5 ± 25.0	0	0	2
Chief Minister's House/TC8	111	57.0 ± 44.0	37.0 ± 28.0	4.9 ± 13.0	22.5 ± 24.5	34.0 ± 26.5	2	0	1
Mouchoir Bank/TC12	153	53.0 ± 41.5	33.5 ± 23.5	6.0 ± 13.0	29.0 ± 29.5	43.5 ± 30.5	2.5	0	17
Airplane/TC14	116	38.0 ± 24.0	27.0 ± 18.5	2.5 ± 9.5	34.0 ± 31.0	45.0 ± 30.5	3.5	0	4
(No Name)/TC17	123	37.5 ± 19.0	25.0 ± 14.0	2.5 ± 10.0	31.5 ±3 1.0	41.0 ± 30.0	1.5	0	4
Fish Hole/TC18	117	33.0 ±18.5	21.5 ± 14.0	7.5 ± 17.5	21.5 ± 24.5	36.5 ± 29.0	1.5	0	2
French Cay/TC19	128	43.5 ± 23.5	30.5 ± 20.5	2.5 ± 10.5	18.5 ± 23.0	31.0 ± 25.5	0	0	2
West Sand Spit/TC20	118	42.0 ±29.5	31.0 ± 21.5	1.0 ± 4.0	17.0 ± 22.0	25.5 ± 22.5	0	0	3
Spanish Anchor (West Caicos wall) /TC21	90	45.0 ±33.0	32.5 ± 24.5	3.5 ± 12.5	22.0 ± 27.0	34.5 ± 29.0	2	0	9
West Caicos Wall-middle/TC22	110	59.0 ± 47.5	36.5 ± 33.5	3.0 ± 9.5	20.5 ± 26.0	36.0 ± 29.5	3.5	0	9
Coral Gables (North side of Provo) /TC24	101	49.0 ± 33.5	33.0 ± 28.5	3.5 ± 12.5	16.5 ± 22.0	26.0 ± 25.0	1	0	4
Grace Bay (North of TC24)/TC25	106	39.5 ± 21.0	30.5 ± 19.0	1.5 ± 10.0	22.5 ± 26.5	35.0 ± 27.0	0	0	6
Grouper Hole/TC27	121	51.5 ± 39.0	37.5 ± 28.5	2.5 ± 10.0	19.5 ± 23.5	29.0 ± 26.5	1	0	13
Aquarium West/TC28	111	32.5 ± 15.0	22.0 ± 14.0	2.5± 10.0	17.0 ± 23.0	29.0 ± 26.0	2.5	0	6
All sites (mean ± sd)	**119**	**45.2±38.7**	**30.1 ± 28.2**	**2.8 ± 10.7**	**23.2 ± 27.1**	**34.8 ± 28.5**	**2.5**	**0**	**5**

Table 3. Algal characteristics, density of stony coral recruits and *Diadema antillarum* (mean ± standard deviation) by site in the Turks and Caicos Islands.

Site name	Quadrats (#)	Absolute abundance (%)			Macroalgal		Recruits	*Diadema*
		Macroalgae	Turf algae	Crustose coralline algae	Height (cm)	Index[1]	(#/.0625 m²)	(#100 m²)
A. palmata patch reefs								
b/w Round and Gibbs Cay/TC9	55	45.0 ± 35.0	28.5 ± 32.0	51.0 ± 36.5	2.2 ± 1.2	92	0.02±0.1	0
E.of S. end of Grand Turk/TC10	60	38.0 ± 30.5	26.5± 23.0	36.0 ± 24.5	1.8 ± 1.2	71	0.2±0.5	0
Ambergris Cay 1/TC15	60	62.0 ±25.5	14.0 ± 20.5	24.0 ± 16.0	3.8 ± 2.8	235	0.2±0.6	0
High relief shelf-edge reefs								
Lighthouse Point (anchor)/TC1	45	16.5 ± 19.0	28.0 ± 25.5	55.5 ± 26.5	1.0 ± 1.0	16	0.3±0.6	0
North Point (anchor)/TC2	65	26.0 ± 17.5	22.5 ± 25.0	51.5 ± 23.5	2.0 ± 3.2	49	0.1±0.3	0
Coral Garden/TC3	55	4.0 ± 11.5	51.0 ± 28.5	45.5 ± 26.5	0.2 ± 0.6	<1	0.4±0.6	0
N. of Salt Cay (anchor)/TC5	50	17.0 ± 19.5	34.0 ± 23.5	48.5 ± 27.0	0.8 ± 0.8	13	0.3±0.6	0
Mouchoir Bank/TC11	55	33.5 ± 25.5	32.0 ± 23.0	34.0 ± 20.0	7.0 ± 5.4	233	0.2±0.5	0
The Arch/TC13	50	2.5 ± 7.0	52.5 ± 25.5	45.0 ± 25.0	0.2 ± 0.6	<1	0.6±1.3	0
Ambergris Cay 2/TC16	60	11.5 ± 16.5	24.0 ± 22.0	64.5 ± 27.5	1.6 ± 3.0	17	0.3±0.7	0
The Pinnacles (Grace Bay/TC23)	50	0.5 ± 3.0	58.0 ± 21.0	41.5 ± 21.0	0.2 ± 0.2	<1	0.2±0.5	0
Football Field/TC26	40	39.0 ± 35.0	28.5 ± 29.5	32.5 ± 27.0	1.2 ± 1.0	43	0.2±0.5	0
Low-relief shelf-edge reefs								
West of Little Sand Key/TC4	50	8.5 ± 13.5	49.5 ± 24.5	42.5 ± 27.0	0.6 ± 0.8	5	0.5±0.8	0
Casey's Wall (anchor, W. of Salt Cay)/TC6	45	4.0 ± 8.0	53.5 ± 22.0	43.0 ± 19.0	0.6 ± 1.0	2	0.2±0.5	0
Black Forest/TC7	45	2.0 ± 6.5	79.5 ± 18.5	18.5 ± 18.5	0.2 ± 0.8	.5	0.4±0.7	0
Chief Minister's House/TC8	41	1.0 ± 2.5	84.5 ± 19.5	34.5 ± 32.5	0.8 ± 2.4	<1	0.3±0.5	0
Mouchoir Bank/TC12	55	11.0 ± 19.5	54.0 ± 19.0	35.0 ± 19.0	1.8 ± 3.6	20	0.1±0.4	0
Airplane/TC14	47	6.5 ±13.5	36.5 ± 22.0	57.0 ± 22.0	0.6 ± 1.0	4	0.5±0.9	0
(No Name) /TC17	55	1.5 ± 6.5	46.5 ± 19.5	52.0 ± 20.5	0.2 ± 0.6	<1	0.3±0.6	0
Fish Hole/TC18	54	2.5 ± 6.5	49.0 ± 27.5	48.5 ± 26.5	0.4 ± 0.8	<1	0.4±0.8	0
French Cay/TC19	50	37.5 ± 25.0	15.5 ± 21.0	47.5 ± 28.5	1.6 ± 1.0	56	0.2±0.5	0
West Sand Spit/TC20	50	13.5 ±22.0	47.5 ± 30.5	39.0 ± 26.0	0.8 ± 1.0	9	0.3±0.7	0
Spanish Anchor (West Caicos wall) /TC21	49	13.5 ± 22.5	35.5 ± 20.0	51.0 ± 19.5	0.8 ± 1.0	11	0.4±0.6	0
West Caicos Wall-middle/TC22	45	14.5 ± 17.5	45.0 ± 24.0	40.0 ± 19.5	0.8 ± 0.8	12	0.4±0.7	0
Coral Gables (North side of Provo) /TC24	40	1.0 ± 4.0	55.5 ± 23.5	43.0 ± 22.5	0.2 ± 0.4	<1	0.6±0.9	0
Grace Bay (North of TC24)/TC25	50	<0.5 ± 0.5	62.0 ± 24.0	38.0 ± 24.0	<0.1 ± 0.2	<1	0.5±0.6	0
Grouper Hole/TC27	40	1.5 ± 4.0	66.0 ± 23.5	33.0 ± 23.5	0.2 ± 0.6	<1	0.8±1	0
Aquarium West/TC28	50	8.5 ±11.5	39.5 ± 29.5	52.5 ± 25.0	0.6 ± 0.8	5	0.4±0.7	0
All sites (mean ± sd)	**50.4**	**18.4±28.3**	**52.2 +35.1**	**55.7 ± 35.9**	**1.2± 2.4**	**21.82**	**0.3±0.7**	

[1]Macroaalgal index = absolute macroalgal abundance x macroalgal height