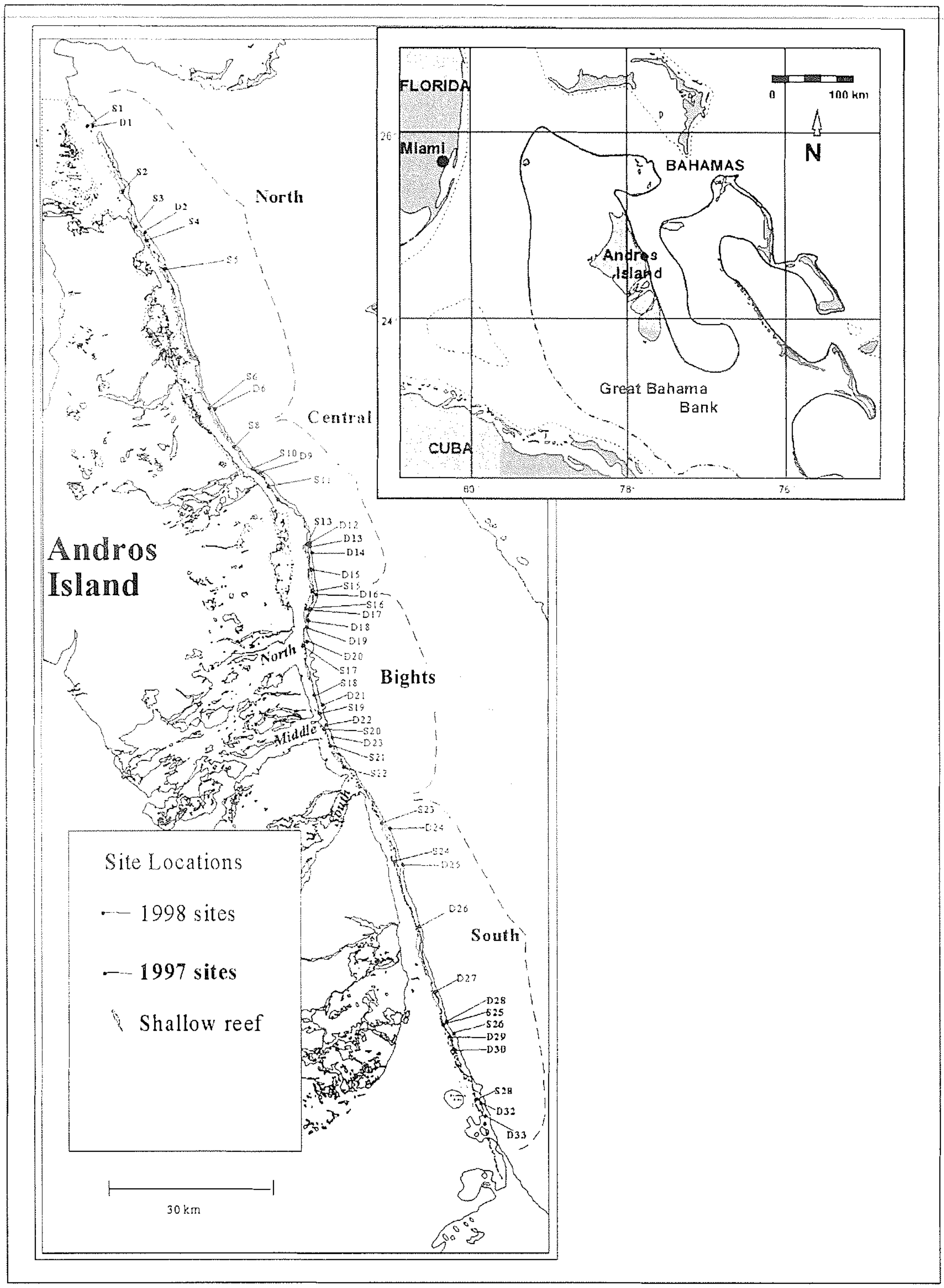

Figure 1. Location of Andros Island, the Bahamas (inset) and the 1997 and 1998 AGRRA survey sites in four areas (North, Central, Bights, South) off eastern Andros. See Tables 1A, 1B for site codes.

ASSESSMENT OF ANDROS ISLAND REEF SYSTEM, BAHAMAS (PART 2: FISHES)

BY

PHILIP A. KRAMER,[1] KENNETH W. MARKS,[2]
and TIMOTHY L. TURNBULL[3]

ABSTRACT

Coral reef fish assemblages were surveyed at 48 reef-crest and fore-reef habitats along approximately 200 km of reefs on the eastern side of Andros Island in August of 1997 and 1998. A total of 164 species were recorded in roving diver surveys, averaging 55 species per site. Select species density averaged 37.4 individuals/100m^2 in belt transects and was significantly more abundant in reef crests than fore reefs. The select fish assemblages were dominated by scarids, haemulids, and acanthurids, while serranids were ubiquitous but present in low densities (<0.5/100m^2). Small differences in the community structure of four geographic areas (north, central, bights, south) are indicative of well-mixed populations. Species richness and abundance were comparatively low, particularly in fore-reef habitats, although mean size and biomass were relatively high. The Andros reef fish assemblages may be naturally limited by low recruitment, lack of nursery habitat, or possibly by high levels of predation. The entire reef system may be at high risk to even modest increases in fishing.

INTRODUCTION

Intact fish assemblages are integral to the functioning of coral reefs and patterns in their diversity, abundance, and size can be used to understand underlying ecological processes such as recruitment, predation, and herbivory. These patterns vary at different spatial and temporal scales and are likely to be influenced by habitat variables such as topographic complexity (e.g., Connell and Kingsford, 1998; Núñez-Lara and Arias-González, 1998), live coral cover (e.g., Bell and Galzin, 1984), depth (e.g., Lewis and Wainwright, 1985), wave energy (McGehee, 1994; Mejia and Garzón-Ferreira, 2000),

---

[1] Marine Geology and Geophysics, Rosensteil School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL, 33149. Email: pkramer@rsmas.miami.edu

[2] Reef Environmental Education Foundation, 98300 Overseas Highway, Key Largo, FL, 33037. Email: kema@adelphia.net

[3] Andros Conservancy and Trust, P.O. Box 21667, Ft. Lauderdale, FL 33335. Email: tturnbullspyglass@att.net

and cross shelf position (Lindeman et al., 1998) as well as species interactions (e.g., predation, competition), suitability of substratum (e.g., algal cover, Lawson et al., 1999), and larval availability and recruitment patterns (e.g., Cowen et al., 2000). The application of comprehensive habitat-based sampling programs (e.g., Ault et al., 2001) has proven effective in gaining insight into complex patterns of fish assemblages.

The spatial variation in the abundance and distribution of fish communities off Andros Island, Bahamas, one of the most extensive reef systems in the Western Atlantic, is poorly known. The reef tract parallels the eastern side of the island extending 217 km from Joulters Cays in the north to Saddleback Cays in the south. Shallow reef crests and outer slope reefs are the principal reef types although lagoonal patch reefs are also present. The presence of extensive, topographically complex reef crests and fore reefs (Kramer et al., this volume) would tend to suggest that suitable habitat is sufficiently available to support abundant and diverse fish populations off Andros Island.

Historically, fishing has been mostly local, artisanal-level fishing concentrated in the central and southern regions of Andros, with relatively little commercial activity. Harvesting has probably altered fish communities less significantly than reported for other areas in the Caribbean (e.g., Roberts, 1995). However, in the past decade commercial fishing has increased, with larger operations particularly active south of the bights in Mangrove Cay and South Andros. Significant fishing effort is concentrated in December and January around several large Nassau grouper *(Epinephelus striatus)* spawning aggregations located in central and southern Andros. Little data are available on fishing pressures, since statistics on landing sites and total fishing effort are not recorded (Bahamas Reef Environmental Education Foundation and Macalister Elliot and Partners, 1998, unpublished report).

In this paper, we present the results from a large-scale (>100 km) habitat-based assessment of the fishes off Andros Island reefs using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) methodology and examine how elements of species richness, density, and biomass vary spatially and between habitat types. Information on the status of fish communities can provide an essential baseline critical for management and conservation efforts of fishes, particularly targeted species. Spatial trends and the condition of principal reef-building corals and algal populations are presented in Kramer et al. (this volume).

METHODS

Andros Island is located in the central Bahamas where the Great Bahamas Bank meets the Tongue of the Ocean (Fig. 1). An extensive yet discontinuous fringing bank barrier reef parallels the eastern side of the island. Reef crests are dominated by colonies of *Acropora palmata* (live and standing dead) and display varying degrees of development controlled, in part, by wave energy, reef aspect, and the presence of freshwater creeks. Fore reefs range from hard-bottom assemblages dominated by gorgonians to reefs composed of dense coral growth dominated by the three morphotypes of the *Montastraea annularis* species complex, which reach heights of 2-3 m off the bottom. Structurally developed fore reefs are often associated with well-developed reef crests and occur at "intermediate" depths of 7-12 m.

The Andros reef tract (Fig. 1) was divided into four geographic areas: north (N); central (C); bights (B); and south (S). Fish surveys were conducted at the same locations as the benthic surveys (Kramer et al., this volume) and are representative of the better-developed reefs within two stratified habitat types (shallow reef crest and intermediate-depth fore reef). In 1997, 17 sites (8 at 1-3 m depth, 9 at 8-12 m) located mainly in the northern and southern areas were surveyed. In 1998, the 31 surveyed sites (15 shallow and 16 deep) were located in all four areas (Tables 1A, 1B). At each site, a combination of belt transects and roving diver surveys were used to assess the fish community structure using the AGRRA methodology at the same time that benthic characteristics [including live stony coral cover, density of "large" (≥25 cm diameter) stony corals, relative algal cover] were evaluated.

In 1997, the AGRRA Version 1.0 fish protocol was employed, except that only 2-5 belt transects (each 50 x 2 m) were made at each site because our underwater time was limited. All species and all sizes of haemulids (grunts), scarids (parrotfishes), and serranids (groupers) present in the belt transects were counted during these surveys. In 1998, when AGRRA Version 2.0 (see Appendix One, this volume) was used, 10 belt transects, each 30 x 2 m, were deployed at each site except at four locations (S5, S11, S20, D10 having 6, 4, 5, and 9 transects, respectively). In 1998, counts of serranids were restricted to species of *Epinephelus* and *Mycteroperca*, while scarids and haemulids less than 5 cm in length were not tallied, but the number of fish species quantified in the belt transects was expanded to include bar jack (*Caranx ruber*), yellowtail damsel (*Microspathodon chrysurus*), barracuda (*Sphyraena barracuda*), hogfish *(Lachnolaimus maximus),* Spanish hogfish *(Bodianus rufus)* and all balistids. In 1998, swimming speeds were 6-8 minutes per 30 m transect, while in 1997 they were 8-10 minutes per 50 m transect. Two of the authors (Marks, Turnbull) conducted the fish transects both years, and all roving diver species richness counts were done by the same surveyor (Marks). Fish identification was based on Humann (1994).

Statistical analyses were performed with the program Statistica (Version 5.1). Transect averages of fish density were calculated for each site based on the number of transects deployed and represented as the mean number per transect adjusted to a common unit area of 100 m^2. Parameters were analyzed by students t-test and by 1- and 2-way Analysis of Variance (ANOVA). The four geographic areas (N, C, B, S) were analyzed by ANOVA with sites hierarchically nested under areas as random factors. Density and biomass data were checked to ensure that variances met assumptions of homoscedasticity. Regression analysis was used to examine relationships between fish data and benthic habitat variables (coral cover, coral size, coral frequency, depth).

RESULTS

A total of 164 species, plus several other unidentified species of silversides, herrings, and anchovies, were documented during the roving diver surveys for the entire Andros reef tract (http://www.reef.org). For the reef-crest sites, a total of 126 species were observed during ~30 hours of roving bottom time (Table 1A). In the fore reefs, 144 species were observed during ~33 hours of bottom time (Table 1B). The average number of species encountered per site was 54 in the reef crests (average roving bottom time =78 minutes, n=23 sites) and 56 in the fore reefs (average roving bottom time=79 minutes, n=25 sites). Total species richness within an area (N, C, B, S) ranged from 113-128; approximately 60% of all recorded species were seen in each geographic area. Differences were found in the presence or absence of rare species with low sighting frequencies. For example, several species only seen in northern Andros included black durgon *(Melichthys niger)*, trunkfish *(Lactophyrys trigonus)*, and spotted trunkfish *(L. bicaudalis)* whereas the diamond blenny *(Malacoctenus boehlkei)* and porkfish *(Anisotrematus virginicus)* were seen in the bights and southern areas but not in the central or northern areas.

A total of 50 fish species were counted (out of a possible 72 AGRRA species) within the belt transects. Forty-four transect species were counted in the reef crests compared to 47 in the fore reefs. Ten AGRRA species not recorded in transects were seen during roving diver surveys at low (<30%) sighting frequencies. In 1998, an average of 21.5 fish species was recorded within transects at each site (n=31 sites). Reef crests had slightly more species (mean=22.5, n=15 sites) on average than fore reefs (mean=20.5, n=16 sites). Species similarity between the four areas of Andros was high with over 75% of the AGRRA-listed transect species counted within at least three of the four areas.

The total number of adult AGRRA fishes in the belt transects was 8,800 with 6,281 individuals counted in reef-crest habitats and 2,519 in fore-reef habitats (all sites and both years combined). Reef-crest communities were dominated by haemulids (37%), scarids (25%), acanthurids (20%), and lutjanids (14%), while fore reefs contained a higher proportion of scarids (46%) and substantially fewer haemulids (7%) (Fig. 2).

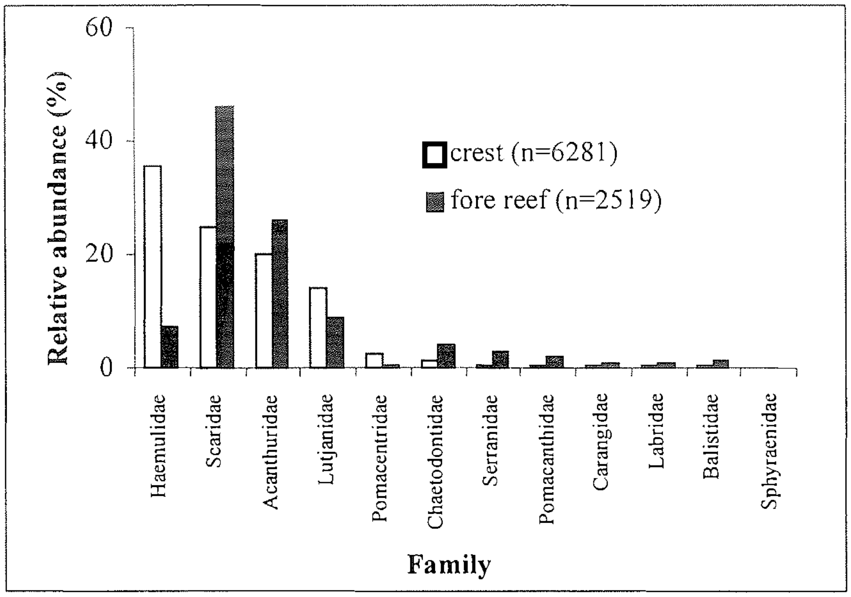

Figure 2. Relative abundance of AGRRA fishes in reef crests and fore reefs pooled for both years off Andros, Bahamas.

Mean fish density for surveyed transect species was 37.4 individuals/100 m^2 (both habitats and both years combined). Mean family density and biomass for the surveyed species are shown in Figure 3. Higher fish densities were recorded in the 1998 surveys (overall mean=47.7/ 100m^2) than in 1997 (overall mean=19.2/100m^2). Statistically significant differences were detected for both herbivorous fishes (scarids ≥5 cm, acanthurids, *M. chrysurus*) (t- test, df=46, t=-3.7, p<0.001) and for carnivores (hameulids ≥5 cm, lutjanids, select serranids) (t- test, df=46, t=-3.44, p<0.01). When the data for all sites and both years are combined, large, free-ranging herbivores (scarids ≥5 cm, acanthurids) had relatively high densities (19.5/100 m^2), more than three times that of major piscivores (select serranids, lutjanids) (4.6/100 m^2) (Tables 2A,B). For both survey years (all densities in numbers/100m^2), the reef crests contained significantly more fish (mean=58.1, sd=45.3, n=23 sites) than were found in the fore reefs (mean=18.3, sd=7.8, n=25 sites) (t-test, df=46, t=-4.3, p<0.0001). Moreover, the highest recorded fish densities (>100/100m^2) consistently occurred in reef crests (e.g., S11, S18, S23) while the lowest densities (<8/100m^2) were in fore reefs (e.g., D6, D12, D16). Total AGRRA fish density patterns are strongly weighted by scarid, acanthurid, and haemulid densities, all of which were significantly higher in reef-crest habitats (scarids ≥5 cm, p<.001; acanthurids, p<0.00001; haemulids ≥5 cm, p<0.001). Families with fewer sightings, including the Chaetedontidae Serranidae, and Balistidae, all had higher densities in the fore reefs (Fig. 3).

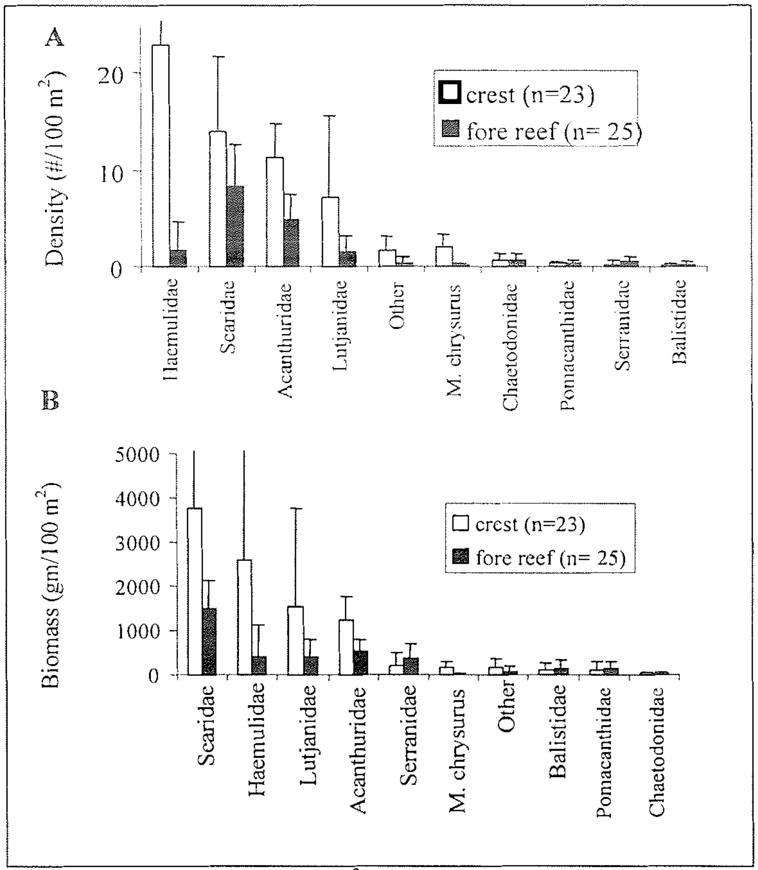

Figure 3. (**A**) Density (mean no. fish/100 m^2 ± standard deviation) and (**B**) biomass (mean g/100 m^2 ± standard deviation) for AGRRA fishes, pooled for both habitats (reef crests and fore reefs) and both years (1997 and 1998) off Andros, Bahamas. Other = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Sphyraena barracuda.*

A comparison between the relative abundance of species observed in transects versus their abundance (calculated as the sum of density x sighting frequency) in the roving diver surveys is shown in Figure 4 for the 15 most commonly observed AGRRA species for both years combined. Several species of haemulids (e.g., French grunt, *Haemulon flavolineatum)* and lutjanids (e.g., mahogany snapper, *Lutjanus. mahogoni)* had clumped distributions with high concentrations only in several shallow sites.

Scarids were well represented with a total of 10 species seen in belt transects in all surveys combined and a higher species richness in fore-reef sites. The two most abundant species were stripped parrotfish *(Scarus croicensis)* and stoplight parrotfish *(Sparisoma viride)* (Fig. 5A). The sizes of most adult parrotfishes were considered "average" for their species with approximately 20% in the 31-40 cm class range (Fig. 5A). All three species of acanthurids were present off Andros (average site density=7.9/100 m^2, n=48 sites), with nearly twice as many encountered in reef crests (n=1,258 in 23 sites) as in fore reefs (n=652 in 25 sites). Blue tangs *(Acanthurus coeruleus)* made up 61% of the acanthurids seen in the belt transects followed by ocean surgeons (*A. bahianus)* (25%), and doctorfish *(A. chirurgus)* (14%). Most acanthurids were in the 11-20 cm size class. Another potentially important herbivore, the Bermuda chub *(Kyphosus sectatrix)* was rare off Andros (sighting frequency of 31% in the roving diver surveys) and usually occurred as isolated individuals.

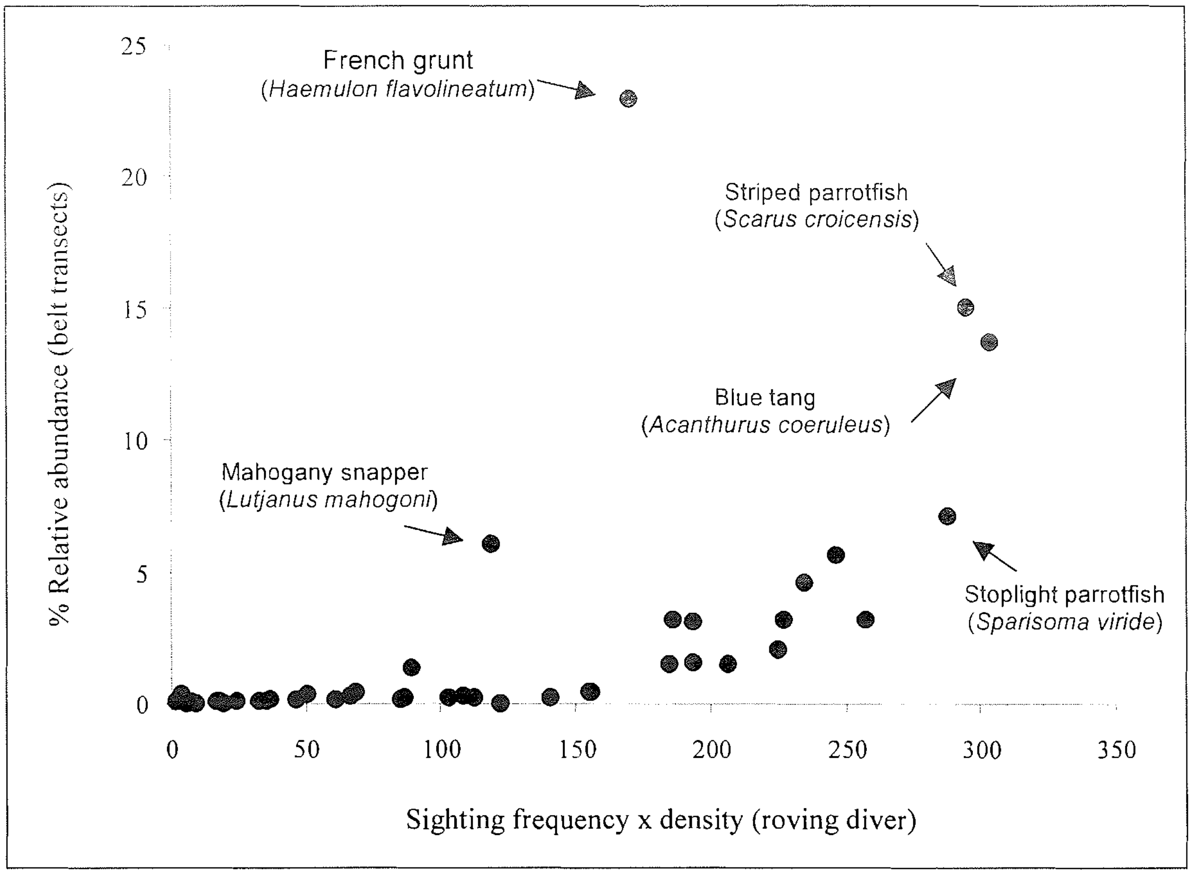

Figure 4. Relationship between relative abundance in belt transects and roving diver surveys (∑density x sighting frequency in 1997 + 1998) for the 15 most commonly observed AGRRA fish species off Andros, Bahamas.

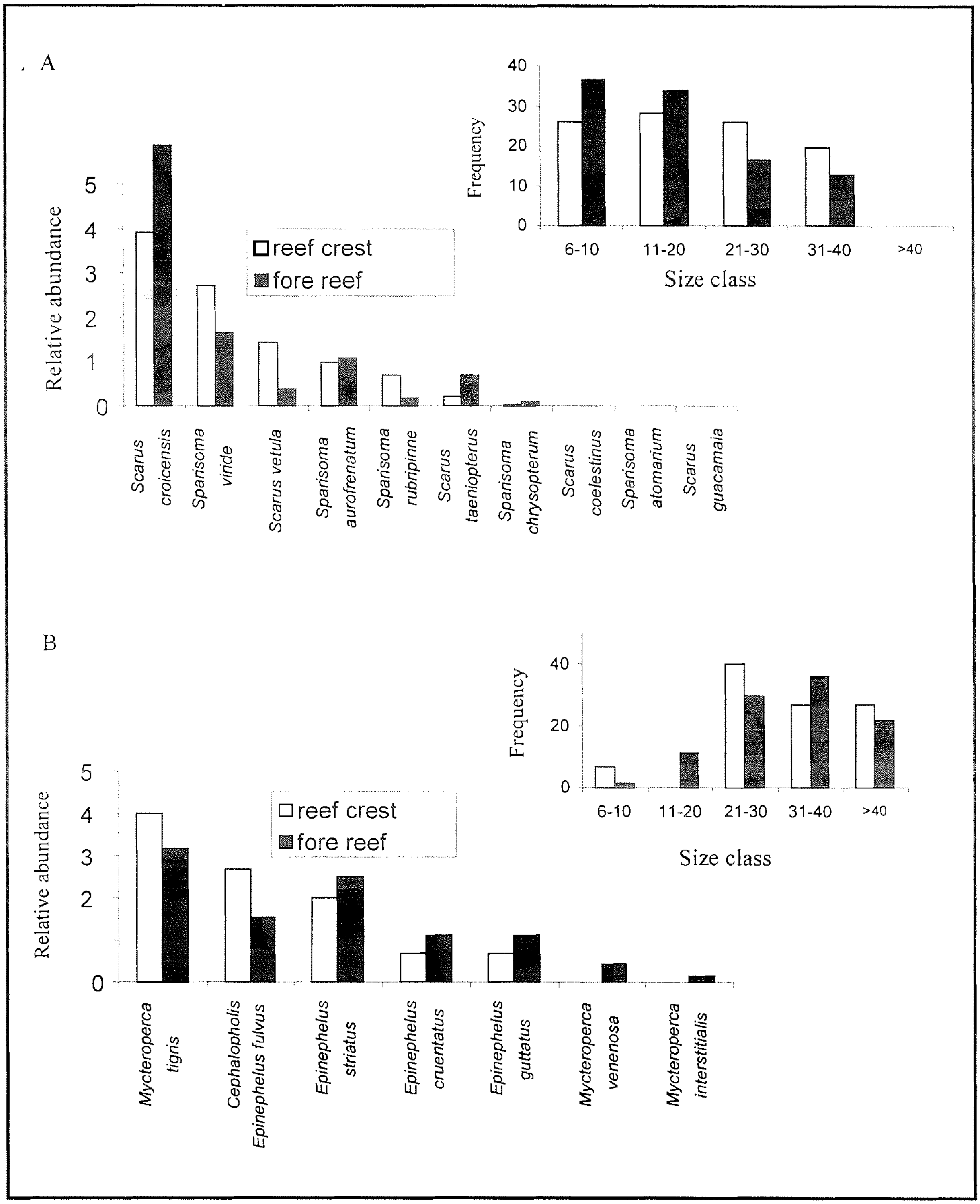

Figure 5. Relative species abundance and size frequency distribution in cm of (**A**) scarids ≥5 cm and (**B**) serranids in reef crests and fore reefs off Andros, Bahamas.

The yellowtail damselfish (*M. chrysurus*) was observed at 96% of reef-crest sites (Table 3A, roving diver sighting frequency) at belt transect densities of 1.9/100 m^2, but at only 26% of fore reef sites at densities of 0.1/100 m^2. Other territorial damselfish including (in order of sighting frequency in the roving diver surveys) bicolor *(Stegastes partitus),* threespot *(S. planifrons)*, dusky *(S. fucus)*, longfin *(S. diencaeus)*, and cocoa *(S. variabilis)* were similarly most abundant in reef-crest habitats. The roving diver sighting frequency for serranids was high on Andros (e.g., they were observed at nearly all sites). Within belt transects, serranids composed 0.5% of the AGRRA fishes counted in reef crests and 3% in fore-reef sites (Fig. 2). The most frequently encountered serranid species in the belt transects, in order of abundance, were tiger grouper (*Mycteroperca tigris*), coney (*Epinephelus fulvus*), Nassau grouper (*E. striatus*), graysby (*E. cruentatus),* and red hind (*E. guttatus*) (Fig. 5B). Yellowmouth grouper (*M. interstitialis*) and yellowfin grouper (*M. venenosa*) were present in fore-reef habitats only, and other serranids, including black grouper (*M. bonaci*) and rock hind (*E. adscensionis*), were only seen during roving diver surveys. The density of serranids within transects was quite low, averaging only 0.39 individuals/100 m^2 for all years and sites combined. Significant differences in serranid density were detected between the reef crests and fore reefs (t-test, df=46, t=-2.4 $p<0.05$) but not among the four areas (N, C, B, S) (1-way ANOVA, df=3, MS=0.38, F=2.6, p=0.06). The sizes of adult groupers counted in transects were large, with nearly 30% of all groupers being greater than 40 cm in length (Fig. 5B).

Eleven species of grunts were observed (roving diver surveys), with greater mean densities in belt transects at reef crests (22.8/100 m^2) than in fore reefs (1.7/100 m^2). Ten species of snapper were observed during roving diver surveys; schoolmasters (*Lutjanus apodus*) and yellowtail snappers (*Ocyurus chrysurus*) were seen most frequently (Table 3A, B). Snapper densities in belt transects averaged 7.1/100 m^2 on reef crests and 1.5/100 m^2 on fore reefs. Mean snapper density for the shallow sites was significantly ($p<0.05$) higher in the bights (14.8/100 m^2) than in the other geographic areas.

Within each of the four areas, variation in total fish density was higher at the within- and between-site scale, particularly for reef-crest habitats, than among the geographic areas. For example, Figure 6 shows the variability in transect abundance at three spatial scales for scarids and acanthurids. Most of the variation (~80%) occurred at the within-site scale, with the remainder at the between-site scale. No significant differences were detected among the four areas of Andros (N, C, B, S) for either total species density (1-way ANOVA, df=3, MS=826, F=0.6, p=0.63) or total fish biomass (1-way ANOVA, df=3, MS=390259, F=1.4, p=0.25). Only grouper biomass was statistically different among the four areas (1-way Anova, df=3, MS=373576, F=4.2, $p<0.05$) mainly because few were seen on northern reef crests.

A significant positive relationship was found between chaetodontid density and live stony coral cover in fore reefs ($p<0.01$), but not in reef crests. Analysis of herbivore-macroalgal index relationships within each of the habitat types was significant ($p<0.05$) only among fore reefs and not reef crests. However, when the two habitats were combined a significant inverse relationship ($p<0.001$) was found between the macroalgal index (a proxy for macroalgal biomass) and herbivore biomass in 1998 (Fig. 7). The best fit line shown in the figure is a log-fit with reef-crest and fore-reef sites separately circled. A significant negative relationship also existed for depth and herbivore biomass

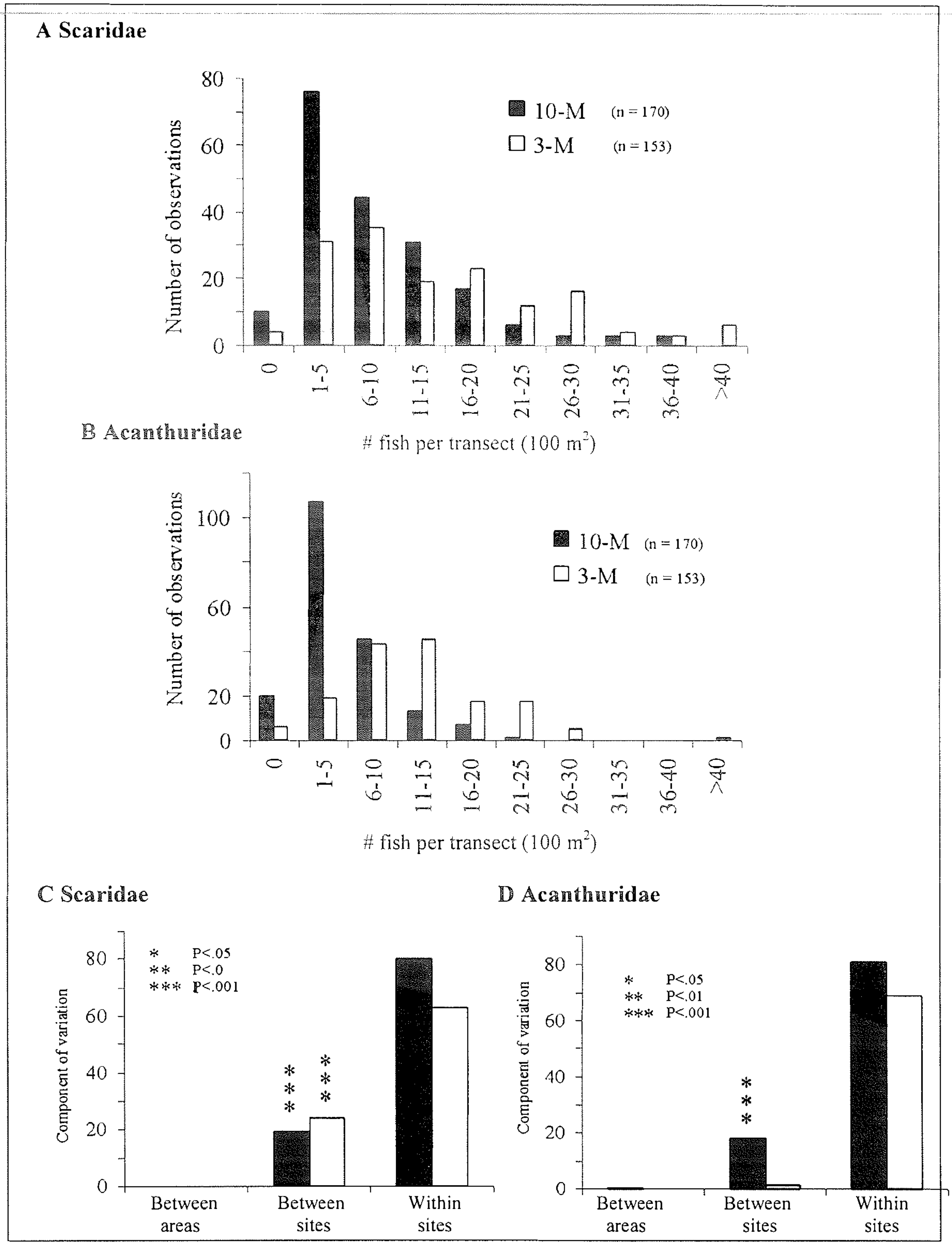

Figure 6. Frequency distribution of fish density recorded within 100 m^2 transects for (**A**) scarids ≥5 cm and (**B**) acanthurids for both reef-crest and fore-reef habitats. Breakdown of the components of variation in fish transect densities at three spatial scales (within a site, between sites, and between areas) for (**C**) scarids ≥5 cm and (**D**) acanthurids in both reef-crest and fore-reef habitats. *** = level of significance is indicated by number of stars.

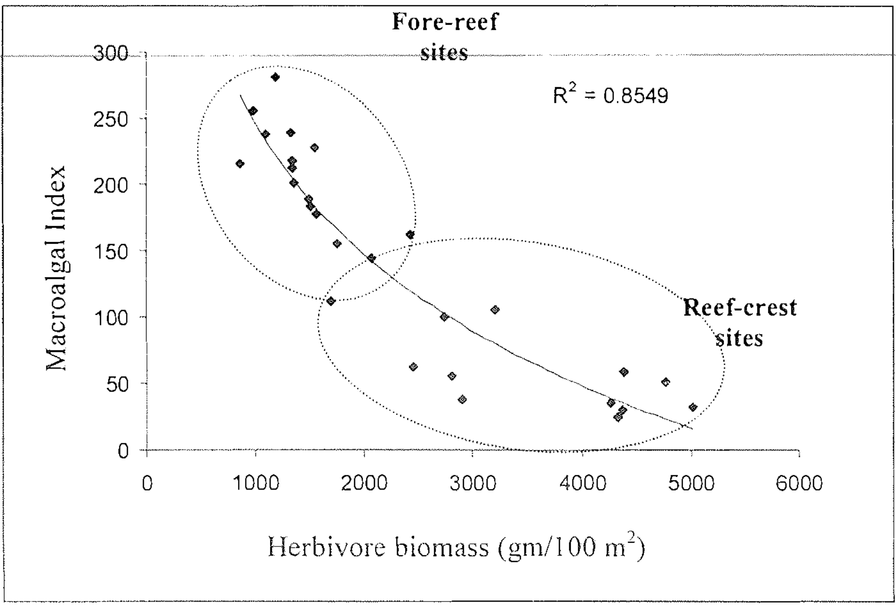

Figure 7. Regression of mean herbivore biomass (acanthurids, scarids ≥5 cm, and *Microspathodon chrysurus*) and mean macroalgal index, for 27 sites (all depths combined) assessed during 1998, excluding sites with insufficient (n<10) belt transects.

($p<0.001$) when all 98 sites were combined. A general inverse pattern between the piscivore density and herbivores was observed within shallow habitats. A weakly significant positive relationship existed between herbivore and piscivore density within only deep sites ($p=0.034$).

DISCUSSION

Species richness and relative family and species dominance documented during our surveys are similar to those reported in other western Atlantic reefs (Turnigan and Acosta, 1989; also see www.reef.org). However, fish densities along Andros Island are lower, particularly on fore reefs, than in some other areas of the Bahamas (Sluka et al., 1996) and Caribbean (Schmitt, unpublished data; Lewis and Wainwright, 1985; Kramer, this volume). Given the presence and extent of well-developed reef-crest and fore-reef habitats and the relatively modest fishing pressures, a greater abundance of fishes was expected. The lack of strong spatial differences in community structure or abundance among the four geographic areas suggest that the processes governing the structure of the Andros fish populations are fairly uniform along the entire eastern reef tract.

Low fish abundance in the fore reefs may be a result of limited larval supply, unsuccessful pre- and post-settlement processes, or lack of nearby juvenile habitat. No scientific surveys have been conducted on larval abundances, recruitment patterns, nursery habitat, and current patterns along Andros. The majority of larval recruitment is likely to be from local sources since the shallow, extensive carbonate platform banks surrounding the Tongue of the Ocean probably form natural barriers restricting entry of external larvae. Flow through Providence Channel is relatively low (Busby et al., 1966) and may not play a significant role in recruitment dynamics. Thus, fish populations may be influenced primarily by local recruitment processes rather than by input from external larval sources (Cowen et al., 2000) and local gyres, or eddies may play a significant role in their abundance.

In addition to larval supply, low fish abundances on Andros may be influenced by the availability of adjacent juvenile habitat. Nagelkerken et al. (2001) found that proximity of nearby mangroves and seagrass influenced the abundance of *Ocyurus chrysurus* and *Scarus croicensis* in Curaçao, while the presence of available seagrass nursery habitat affected *Sparisoma chrysopterum*, *Sphyraena barracuda*, and several species of *Lutjanus* and *Haemulon*. Along the eastern coast of Andros, dense seagrass beds are uncommon (total area <6 km^2) (Kramer, unpublished data) and their paucity may be a limiting factor affecting fish abundance. However, the numerous creeks and bights along the mainland would appear to be ideal nursery habitats particularly as many are lined by mangroves. The relative importance of local versus external recruitment and the role of nursery habitat availability in structuring fish communities off Andros warrant further investigation.

Based on our data, variance in the total density and biomass of the AGRRA fishes is mainly attributable to intrinsic habitat characteristics such as coral cover and structural complexity (Kramer et al., 1999), habitat type and depth, and sampling biases. Differences in fish assemblages between sites of similar habitat type may also result from species interaction variables (not discussed here).

The significant positive relationship between chaetodontid density and live stony coral cover observed on Andros' fore reefs may be associated with high habitat dependency or specialized microhabitat use (Robertson, 1996). The distribution of groupers has also been correlated to habitat features, particularly topographic complexity (Connell and Kingsford, 1998; Sluka et al., 1996, 2001), which may explain the relatively high abundance of *M. tigris* and other large-body-size groupers in the network of tunnels and overhangs between the 1-3 m tall columns of the *Montastraea annularis* species complex in the fore reefs. Roberts and Ormond (1987) found the availability of shelter holes to influence the abundance of some fishes (scarids, acanthurids, labrids, and pomacentrids) while live coral cover was only important for chaetodontids. Although not examined in this study, other parameters such as adjacent habitat diversity, patch size, proximity to tidal channels, and distance from mainland may also influence fish distribution on Andros. Distinguishing which habitat factors are most important in structuring fish communities is difficult since many coexist or are additive, thus a more experimental approach isolating specific variables is needed to better understand factors governing these spatial patterns.

Although acanthurids are known to prefer shallow habitats, the high abundance of scarids in reef crests off Andros is surprising since other studies have typically found their densities to be greater in deeper water (Lewis and Wainwright, 1985; also see Horn, 1989). The high abundance of acanthurids and scarids in the shallow reef crests, as well as the large size of scarids, probably result in significantly greater herbivory here than in the fore reefs. Algal communities in each habitat reflect these presumed differences in herbivory, and the strong inverse relationship between macroalgal index and herbivore biomass (Fig. 7) implies top-down control over algal assemblages. At shallow depths, the algal community is predominantly crustose corallines and turf algae, both of which are indicative of well-grazed surfaces (Steneck and Dethier, 1994). In contrast, the fore reefs have few grazed surfaces and are dominated by fleshy algae (e.g., *Dictyota* spp., *Microdictyon marinum*) (Kramer et al., this volume). Reduction of herbivory with depth has been related to decreased trophic carrying capacity (Hay and Goertemiller, 1983; Steneck, 1988). Physical factors such as sedimentation and wave energy may also contribute to algal composition in particular habitats (e.g., Fabricius and De'ath, 2001). In addition, the lack of preferred food and the increased risk of predation may also influence herbivore movements and levels of grazing.

The scarcity of the important grazing sea urchin, *Diadema antillarum*, (Kramer et al., this volume) is also a major factor in explaining the dominance of macroalgae in the fore reefs off Andros. Historically, *Diadema* was the dominant herbivore off Andros (Miner, 1933; Newell and Rigby, 1951), but populations severely declined during 1983 as in other areas of the Caribbean (e.g., Lessios et al., 1984). Following the *Diadema* die-off, Morrision (1988) found that erect, resistant macroalgal species increased at intermediate depths on heavily fished Jamaican reefs. Robertson (1991) found that the abundance of two herbivorous acanthurids, *Acanthurus coeruleus* and *A. chirurugus*, increased significantly on Panama patch reefs after the die-off of *Diadema*. It appears that herbivorous fishes along Andros may have filled the trophic niche of *Diadema* as dominant grazers on high-relief reef crests but not in fore reefs. These results emphasize the importance of herbivory on Andros' coral and algal communities. The recovery of *Diadema* to its former population densities may be a critical first step towards reducing macroalgae in the fore reefs.

The risk of predation may influence the spatial patterns of prey fishes (e.g., Reinthal and Macintyre, 1994), and may also partially explain the lower densities of scarids and acanthurids on Andros' fore reefs. The high relief (2-4 m) and structurally complex arrangement of corals and pinnacles associated with intermediate depth fore-reef zones would appear to be ideal for predators because of the abundance of ambush locations. However, a weakly significant positive relationship was found between the densities of key herbivores and piscivores in the fore reefs off Andros, suggesting that other factors are also important. It is also possible that the distribution of predators determined from snapshot daytime surveys are not indicative of overall levels of predation. If fish predation on Andros' fore reefs is unusually high, it must still be explained why densities of predators (serranids, lutjanids) are low compared to other Bahamian island groups (Sluka et al., 1996). Our survey protocol may have systematically underestimated their abundance as transect methods have been found to underreport the density of fish species with wide ranges or low abundances (Thresher and Gunn, 1986). Furthermore, the size and number of transects can also greatly influence density estimates (Sale and Sharp, 1983). Significantly fewer fish were recorded in nearly all families (including serranids) in the 1997 surveys compared to the 1998 surveys which is thought to be a direct result of the low number of transects employed at each site. However, temporal and spatial differences in the fish community for the two sample periods cannot be ruled out as additional factors.

Relief and structural complexity of the habitat, by providing hiding places, may also directly influence reported fish abundances for predatory and sedentary species. It is possible that for both survey years rare and cryptic species off Andros, including most groupers, may have been systematically undersampled in fore reefs because of the unusually high relief (2-4 m) of the columnar corals. A pilot comparison between 30 m fish transects swum in 7 minutes (standard) versus 15 minutes (extended) revealed that significantly greater numbers of serranids were seen when observers had more time to look beneath overhangs and into tunnels. Thus, observed densities of groupers may be related to the structural complexity of the substratum; the reason for the low abundance of other ecologically important (e.g., herbivores, corallivores) or commercially significant fish (e.g., snappers) in fore reefs remains unexplained.

Low fish abundance, particularly of commercially significant species, on Andros fore reefs may be an indication that the entire reef tract is overfished (Roberts, 1995). Fishing pressures on Andros are thought to be light-to-moderate in comparison to many other areas of the Caribbean and are mainly targeted towards large-bodied groupers (e.g., *M. tigris, E. striatus* and *M. interstitialis*) and snappers (e.g., *Lutjanis analis, L. synagris and O. chrysurus*). Commercial and subsistence fishers also target species such as barracuda, triggerfish, hogfish, and some grunts. Although fish such as angelfish, parrotfish, and surgeonfish are not yet targeted, there may be significant bycatch associated with trap fishing that extends to lower trophic levels (T. Turnbull, personal observation).

The result of targeted fishing often leads to a decrease in the size and abundance of harvested species or, in more severe cases, to the loss of those species (e.g., Roberts, 1995; Koslow et al., 1988). Were the Andros reef tract as overfished as other reefs in the Caribbean, we might expect targeted guilds such as serranids to be dominated by species having small adult body sizes (*Epinephelus fulvus, E. cruentatus* and *E. guttatus*). In fact, large-bodied targeted species (*M. tigris* and *E. striatus*) were two of the most frequently seen serranids on Andros and nearly 30% of all groupers that were observed within transects were very large (>40 cm length). In addition, Andros is one of the few locations in the Bahamas to have at least two well-documented grouper spawning aggregations (at High Cay and Tinker Rocks, respectively). These aggregations are estimated to contain hundreds to thousands of fishes during spawning periods, although historic numbers are suspected to have been much higher (T. Turnbull, personal observations).

Commercial fishing intensity has increased in the last several years, driven by higher market prices (Bahamas Reef Environmental Education Foundation and Macalister Elliot and Partners, 1998, unpublished report), particularly in southern Andros where illegal fishing by non-Bahamian residents occurs. Given the low abundance of fishes and the growing demand for targeted fish species, its fish populations are likely to be vulnerable to even modest increases in fishing intensity. Several large marine protected areas have been proposed along Andros, and at least two are in the process of being implemented (G. Larson, personal communication). In addition, in 1999 and 2000, the Bahamas Fisheries Department prohibited fishing at the High Cay aggregation site during critical spawning periods (five days around the full moon in December-February) in an effort to reduce fishing pressures. However, the aggregation was not closed in 2001. The implementation of adaptive management strategies, such as a seasonal closure on the grouper fishery, is essential for maintaining sustainable fish populations along Andros.

ACKNOWLEDGMENTS

This project was funded by a grant from the Committee for Research and Exploration of the National Geographic Society (Grant #6046-970). The AGRRA Organizing Committee facilitated financial support as described in the Forward to this volume as did the Hachette Filipacchi Foundation and Carolina Skiffs. Special thanks to W. Bryant, M. McGarry, and S. Cawthon for their adept piloting skills. The late Captain R. Gaensslen generously provided the use of his vessel, *The Captain's Lady*, in 1997. Go Native Yacht Charters is thanked for partial charter sponsorship of their 60' catamaran in 1998. E. Fisher assisted with data entry; J. Lang and P. Richards Kramer provided many useful comments on this manuscript. We are grateful to the Bahamas Department of Fisheries for granting permission to conduct Andros fieldwork.

REFERENCES

Ault, J.S., S.G. Smith, J. Luo, G.A. Meesters, J.A. Bohnsack, and S.L Miller
2001. *Baseline multispecies coral reef fish stock assessments for the Dry Tortugas.* Final Report, Univ. Miami, RSMAS, Miami, FL 123 pp.

Bell, J.D., and R. Galzin
1984. Influence of live coral cover on coral reef fish communities. *Marine Ecology Progress Series* 15:265-274.

Busby, R.F., C.V. Bright, and A. Pruna
1966. *Ocean bottom reconnaissance off the east coast of Andros Island, Bahamas.* Technical Report 189. US. Naval Oceanographic Office, Washington, DC. 58 pp.

Connell, S.D., and M.J. Kingsford
1998. Spatial, temporal and habitat-related variation in the abundance of large predatory fish at One Tree Reef, Australia. *Coral Reefs* 17:49-57.

Cowen, R.K., K.M.M. Lwiza, S. Sponaugle, C.B. Paris, and D.B. Olson
2000. Connectivity of marine populations: Open or closed? *Science* 287:857-859.

Done, T.J., and R.E. Reichelt
1998 Integrated coastal zone and fisheries ecosystem management: generic goals and performance indices. *Ecological Applications* 8:110-118.

Fabricius, K., and G. De'ath
2001. Environmental factors associated with the spatial distribution of crustose coralline algae on the Great Barrier Reef. *Coral Reefs* 19: 303-309.

Hay, M.E., and T. Goertemiller
1983. Between habitat differences in herbivore impact on Caribbean coral reefs. Pp. 97-102. In: M.L. Reaka (ed.), *The Ecology of Deep and Shallow Coral Reefs Vol. 1.* Symposia Series for Undersea Research, NOAA Undersea Research Program, Rockville, Maryland.

Horn, M.H.

1989. Biology of marine herbivorous fishes. *Oceanography and Marine Biology Annual Reviews* 27:167-272.

Humann, P.

1994. *Reef Fish Identification. Florida Caribbean, Bahamas.* 2nd Edition. New World Publications. 396 pp.

Koslow, J.A., F. Hanley, and R. Wicklund

1988. Effects of fishing on reef fish communities at Pedro Bank and Port Royal Cays, Jamaica. *Marine Ecology Progress Series* 43:201-212.

Kramer, P.A., P.R. Kramer, and R.N. Ginsburg

1999. Spatial patterns of reef habitats and linkages to fish populations on Andros Island, Bahamas. *Abstracts of 52nd Annual Meeting of the Gulf and Caribbean Fisheries Institute*, November 1-5, 1999. Key West, Florida.

Lawson, G.L., D.L. Kramer, and W. Hunte

1999. Size-related habitat use and schooling behavior in two species of surgeonfish (*Acanthurus bahianus* and *A. coeruleus*) on a fringing reef in Barbados, West Indies. *Environmental Biology of Fishes* 54:19-33.

Lessios, H.A., D.R. Robertson, and J.D. Cubit

1984. Spread of *Diadema* mass mortality through the Caribbean. *Science* 35:335-337.

Lewis, S.M., and P.C. Wainwright

1985. Herbivore abundance and grazing intensity on a Caribbean coral reef. *Journal of Experimental Marine Biology and Ecology* 87:215-228.

Lindeman K.C., G.A. Diaz, J.E. Serafy, and J.S. Ault

1998. A spatial framework for assessing cross-shelf habitat use among newly settled grunts and snappers. *Gulf and Caribbean Fisheries Institute* 50:385-416.

McGehee, M.A.

1994. Correspondence between assemblages of coral reef fishes and gradients of water motion, depth, and substrate size off Puerto Rico. *Marine Ecology Progress Series* 105:243-255.

Mejia, L.S., and J. Garzón-Ferreira

2000. Reef fish community structure in four atolls of the San Andres Providencia archipelago (southwestern Caribbean). *Revista de Biologia Tropical* 48:883-896.

Miner, R.W.

1933. Diving in coral gardens. *Natural History* 33:461-476.

Morrison, D.

1988. Comparing fish and urchin grazing in shallow and deeper coral reef algal communities. *Ecology* 69:1367-1382.

Nagelkerken, I., S. Kleijnen, T. Klop, R.A.C.J. van den Brand, E.C. de la Moriniere, and G. van der Velde

2001. Dependence of Caribbean reef fishes on mangroves and seagrass beds as nursery habitats: a comparison of fish faunas between bays with and without mangroves/seagrass beds. *Marine Ecology Progress Series* 214:225-235.

Newell, N.D., and J.K. Rigby

1951. Shoal-water geology and environs, eastern Andros Island, Bahamas. *Bulletin of the American Museum of Natural History* 97:1-30.

Núñez-Lara, E., and J.E. Arias-González
1998. The relationship between reef fish community structure and environmental variables in the southern Mexican Caribbean. *Journal of Fish Biology* 53(A): 209-221.

Reinthal, P.N., and I.G. Macintyre
1994. Spatial and temporal variations in grazing pressure by herbivorous fishes: Tobacco Reef, Belize. *Atoll Research Bulletin* 425:1-11.

Roberts, C.M.
1995. Effects of fishing on the ecosystem structure of coral reefs. *Conservation Biology* 9:988-995.

Roberts, C.M., and R.F.G. Ormond
1987. Habitat complexity and coral reef fish diversity and abundance on Red Sea fringing reefs. *Marine Ecology Progress Series* 41:1-8.

Robertson, D.R.
1991. Increases in surgeonfish populations after mass mortality of the sea urchin *Diadema antillarum* in Panama indicate food limitation. *Marine Biology* 111: 437-444.

Robertson, D.R.
1996. Interspecific competition controls abundance and habitat use of territorial Caribbean damselfishes. *Ecology* 77:885-899.

Sale, P.F., and B.J. Sharp
1983. Correction for bias in visual transect censuses of coral reef fishes. *Coral Reefs* 2:37-42.

Sluka, R.D., M. Chiappone, and K.M.S. Sealey
2001. Influence of habitat on grouper abundance in the Florida Keys, USA. *Journal of Fish Biology* 58:682-700.

Sluka, R.D., M. Chiappone, K.M. Sullivan, and R. Wright
1996. *Habitat and Life in the Exuma Cays, Bahamas. Status of Groupers and Coral Reefs in the Northern Cays. Supplemental Volume: Appendices.* The Nature Conservancy, Florida and Caribbean Marine Conservation Science Center. Coral Gables, FL. 216 pp.

Steneck, R.S.
1988. Herbivory on coral reefs: a synthesis. *Proceedings of the Sixth International Coral Reef Symposium*, Australia 1:37-49.

Steneck, R.S., and M. Dethier
1994. A functional-group approach to the structure of algal-dominated communities. *Oikos* 69:476-498.

Thresher, R.E., and J.S. Gunn
1986. Comparative analysis of visual census techniques for highly mobile, reef-associated predators (Carangidae). *Environmental Biology of Fishes* 17:93-116.

Turnigan, R.G. and A.B. Acosta
1989. An analysis of the fish assemblages on a coral patch reef on Puerto Rico. *Proceedings of the 43rd Gulf and Caribbean Fisheries Institute*, November 1990, Miami, Florida, pp. 245-258.

Table 1A. Reef-crest site information for AGGRA fish surveys off Andros Island, Bahamas (*1997 sites are italicized*).

Reef crest site name	Site code	Latitude (N° ')	Longitude (W° ')	Survey date	Depth (m)	% live stony coral cover (%± se)	Macroalgal relative abundance (%± se)	Bottom time (min.)	Fish transects (#/m)	Roving diver fish species (#)
N. Joulters	*S1*	*25.31322*	*78.03433*	*Aug 15 97*	*2.5*	---	*6.5 ± 10.0*	*125*	*4/50*	*74*
Golding	*S2*	*25.22392*	*78.08557*	*Aug 18 97*	*1.5*	---	*7.5 ± 12.0*	*95*	*4/50*	*57*
Morgan	*S3*	*25.1601*	*78.0029*	*Aug 17 97*	*1.5*	---	*8.0 ± 8.5*	*90*	*3/50*	*62*
Coconut Point	*S4*	*25.12885*	*77.98303*	*Aug 17 97*	*1.5*	---	*8.5 ± 15*	*100*	*5/50*	*60*
Mahore	S5	25.06367	77.93783	Aug 21 98	1	43.0 ± 14.5	12.0. ± 16	80	6/30	70
S. Standard 2	S7	24.84493	77.86098	Aug 20 98	0.5	41.0 ± 22.5	13.0 ± 7.5	60	10/30	45
North Andros-all								550		**98**
N. Love Hill	S8	24.77435	77.80772	Aug 18 98	1	41.5 ± 14.0	17.0 ± 23.0	70	10/30	47
China Point	S10	24.75133	77.80767	Aug 18 98	1	54.0 ± 31.0	10.5 ± 9.5	60	10/30	54
Red Rock	S11	24.72917	77.77017	Aug 7 98	1	37.0 ± 15.5	13.5 ± 21.5	60	4/30	63
S. Long Rock	*S13*	*24.63067*	*77.691*	*Aug 9 97*	*3*	---	*14.5 ± 14.0*	*185*	*2/50*	*47*
Sugar Rock	S15	24.5448	77.68372	Aug 10 98	2	20.0 ± 11.0	8.0 ± 8.5	60	10/30	50
Central Andros-all								435		**90**
Autec2-South	S16	24.484	77.699	Aug 11 98	1	24.0 ± 11.5	10.5 ± 11.0	90	10/30	56
N. Bight	S17	24.4395	77.69807	Aug 12 98	2	33.5 ± 9.0	13.5 ± 20.0	65	10/30	48
Big Wood	S18	24.36703	77.68235	Aug 13 98	1.5	36.0 ± 11.0	26.0 ± 20.5	60	10/30	47
Autec 3	S19	24.34315	77.67068	Aug 12 98	1	39.5 ± 15.5	9.0 ± 12.0	60	10/30	44
Middle Bight	S20	24.3069	77.65638	Aug 13 98	1.5	35.5 ± 10.5	13.5 ± 20.0	60	5/30	49
Mangrove C.	S21	24.29167	77.6462	Aug 13 98	1.5	25.0 ± 10.5	10.5 ± 13.5	60	10/30	55
Mangrove S.	S22	24.25315	77.62917	Aug 13 98	1	30.0 ± 13.5	20.5 ± 17.5	60	10/30	56
Bights-all								455		**78**
Congo Town	S23	24.3013	77.64788	Aug 15 98	1	30.5 ± 14.5	11.5 ± 15.5	60	10/30	53
Long Bay	S24	24.09793	77.53703	Aug 16 98	1	35.5 ± 11.5	11.0 ± 14.5	60	10/30	48
North Rock	*S25*	*23.79092*	*77.42637*	*Aug 14 97*	*2*	---	*14.5 ± 19.0*	*80*	*3/50*	*52*
North Grassy	*S26*	*23.77822*	*77.41902*	*Aug 15 97*	*2*	---	*10.5 ± 11.5*	*80*	*3/50*	*61*
Pigeon	*S28*	*23.6965*	*77.377*	*Aug 11 97*	*1.5*	---	*18.0 ± 15.0*	*75*	*4/50*	*54*
South Andros								355		**85**
Reef crests- all								1795		**126**

Table 1B. Fore-reef site information for AGGRA fish surveys off Andros Island, Bahamas (*1997 sites are italicized*).

Fore reef site name	Site code	Latitude (N° ′)	Longitude (W° ′)	Survey date	Depth (m)	% live stony coral cover (mean ± se)	Macroalgal rel. abundance (mean ± se)	Bottom time (min.)	Fish transects (#/m)	Roving diver fish species (#)
N. Joulters	*D1*	*25.3132*	*78.0856*	*Aug 16 97*	*6.5*	---	*49.0 ± 18.0*	*90*	*4/50*	*70*
Nichols	*D2*	*25.1438*	*72.9875*	*Aug 17 97*	*9.5*	---	*35.5 ± 15.0*	*85*	*5/50*	*52*
S. Staniard 2	D7	24 50 630	77 56 437	Aug 20 98	9	37.0 ± 13.0	35.0 ± 14.0	60	10/30	49
North Andros-all								**235**		**84**
West Klein	D10	24.7450	77.7847	Aug 7 98	10.5	24.5 ± 8.0	48.0 ± 19.5	215	9/30	59
S. Long Rock	*D12*	*24.6307*	*77.6910*	*Aug 9 97*	*8*	---	*62.5 ± 20.5*	*95*	*2/50*	*61*
Long Rock	D13	24.6260	77.6910	Aug 8 98	8.5	22.5 ± 8.0	48.0 ± 20.0	---	10/30	---
Mid Long Rock	*D14*	*24 37 547*	*77 41 587*	*Aug 9 97*	*9.5*	---	*59.0 ± 32.0*	*185*	*5/50*	*89*
Green Cay	D15	24.5958	77.6933	Aug 9 98	11	11.0 ± 4.0	54.5 ± 20.0	90	10/30	58
Sugar Rock	D16	24.5402	77.6821	Aug 10 98	11.5	18.0 ± 7.0	41.5 ± 12.5	90	10/30	58
Central Andros-all								**675**		**104**
Bristol Galley	D17	24.5263	77.6892	Aug 10 98	11.5	17.0 ± 5.0	45.5 ± 21.0	85	10/30	54
Autec 2	D18	24.5064	77.6970	Aug 11 98	12.5	9.0 ± 3.0	51.5 ± 13.0	70	10/30	61
Autec 2-South	D19	24.4833	77.6965	Aug 11 98	10.5	15.0 ± 5.0	40.0 ± 15.5	70	10/30	53
N. Bight	D20	24.4393	77.6962	Aug 12 98	9.5	31.0 ± 12.5	45.0 ± 15.5	70	10/30	56
Autec 3	D21	24.3432	77.6707	Aug 14 98	10.5	25.5 ± 10.5	44.0 ± 16.0	60	10/30	50
Middle Bight	D22	24.3097	77.6530	Aug 14 98	9	28.0 ± 8.0	42.0 ±13.0	60	10/30	53
Mangrove N.	D23	24.3011	77.6478	Aug 14 98	9.5	5.5 ± 3.0	50.5 ± 19.0	50	10/30	35
Bights-all								**415**		**102**
Congo Town	D24	24.3012	77.6479	Aug 15 98	10.5	21.0 ± 15.5	50.0 ± 24.0	70	10/30	70
Long Bay Cay	D25	24.0997	77.5334	Aug 16 98	10.5	19.0 ± 9.0	50.0 ± 16.5	60	10/30	63
Oasis	D26	23.9476	77.3867	Aug 16 98	6	45.5 ± 21.0	31.5 ± 19.5	75	10/30	72
High Point Cay	D27	23.4200	77.4600	Aug 17 98	9	35.0 ± 7.5	41.5 ± 16.0	60	10/30	54
North Rock	*D28*	*23.7965*	*77.4222*	*Aug 13 97*	*7.5*	---	*49.5 ± 12.5*	*75*	*5/50*	*43*
North Grassy	*D29*	*23.7803*	*77.4168*	*Aug 13 97*	*9.5*	---	*43.0 ± 25.0*	*75*	*4/50*	*55*
South Grassy	*D30*	*23.7285*	*77.3974*	*Aug 12 97*	*7.5*	---	*49.0 ±15.0*	*80*	*4/50*	*41*
Pigeon	*D32*	*23.6945*	*77.3742*	*Aug 11 97*	*9*	---	*48.5 ±15.5*	*80*	*3/50*	*36*
Saddleback	*D33*	*23.6767*	*77.3703*	*Aug 11 97*	*8.5*	---	*48.0 ± 16.0*	*95*	*4/50*	*52*
South Andros-all								**660**		**116**
Fore reefs - all								**1985**		**144**

Table 2A. Density (mean ± sd) of AGRRA fishes by site in reef crests off Andros Island (*1997 sites are italicized*).

Reef crest site name	Site code	Year	Herbivores (#/100m^2)			Carnivores (#/100m^2)			Total AGRRA fishes (#/100m^2)
			Acanthuridae	Scaridae (≥5 cm)	*Microspathodon chrysurus*	Haemulidae (≥5 cm)	Lutjanidae	Serranidae[2]	
N. Joulters	*S1*	*1997*	*7 ± .5*	*11 ± 6*	---	*15 ± 19.5*	*0.5 ± 0.5*	*0*	*33 ± 21.5*
Golding	*S2*	*1997*	*13.5 ± 7.5*	*10.5 ± 10.5*	---	*10.5 ± 9*	*3 ± 4*	*0*	*37 ± 18*
Morgan	*S3*	*1997*	*12 ± 12.5*	*7.5 ± 4*	---	*27.5 ± 13.5*	*0.5 ± 0.5*	*0*	*47.5 ± 12*
Coconut Point	*S4*	*1997*	*7 ± 4*	*5 ± 6*	---	*0.5 ± 0.5*	*0.5 ± 1*	*0*	*13.5 ± 9*
Mahore	S5	1998	14.5 ± 6.5	39.5 ± 21.5	2.5 ± 3.5	3.5 ± 5.5	0.5 ± 0.5	0	62.5 ± 24.5
S. Standard 2	S7	1998	14 ± 7.5	23 ± 24.5	1 ± 1.5	0.5 ± 0.5	8.5 ± 12	0	48 ± 27.5
North Andros[1]			**11.3 ± 3**	**15.9 ± 13**	**1.9 ± 1**	**9.5 ± 10**	**2.1 ± 3**	**0**	**40.4 ± 17**
N. Love Hill	S8	1998	12 ± 6.5	8.5 ± 8.5	0.5 ± 1.5	2 ± 3.5	2 ± 2.5	0	26.5 ± 10.5
China Point	S10	1998	8 ± 4	9.5 ± 4.5	0	48.5 ± 70	4 ± 5.5	0	72.5 ± 72
Red Rock	S11	1998	9.5 ± 2	14 ± 5	3.5 ± 3.5	179.5 ± 107.5	13 ± 21.5	0	221.5 ± 104
S. Long Rock	*S13*	*1997*	*11.5*	*8*	*0*	*0*	*0*	*0*	*20*
Sugar Rock	S15	1998	12 ± 8	23.5 ± 13.5	1 ± 1.5	4.5 ± 5.5	2 ± 3.5	1.5 ± 1.5	45.5 ± 27
Central Andros[1]			**10.7 ±2**	**12.6 ±3**	**1.1 ± 2**	**46.9 ±84**	**4.1 ± 6**	**0.3 ± 0**	**77.2 ± 94**
Autec2-South	S16	1998	10.5 ± 4.5	13.5 ± 12.5	1 ± 1	14 ± 11.5	32.5 ± 65.5	1 ± 1.5	74 ± 74
N. Bight	S17	1998	12.5 ± 5	20 ± 13	2 ± 2.5	13 ± 14	9.5 ± 10	0.5 ± 0.5	60.5 ± 22
Big Wood	S18	1998	9.5 ± 8	9 ± 7	3.5 ± 5.5	72 ± 102	20.5 ± 23	0.5 ± 1	117 ± 117
Autec 3	S19	1998	16 ± 7	18 ± 18	4 ± 3	4.5 ± 6	8 ± 8	0.5 ± 1	53 ± 19
M. Bight	S20	1998	15.5 ± 2	15 ± 9.5	1 ± 1.5	14.5 ± 20	14.5 ± 19.5	0.5 ± 1	63.5 ± 38.0
Mangrove C.	S21	1998	11.5 ± 8.5	16 ± 10	1.5 ± 1.5	23.5 ± 31.5	11.5 ± 16	0.7 ± 1	66.5 ± 40.5
Mangrove S.	S22	1998	14 ± 7	11 ± 9	0.5 ± 1	12 ± 15.5	7.5 ± 10.5	0 ± 0.5	47.5 ± 23.3
Bights[1]			**12.7 ± 3**	**14.7 ± 4**	**2.0 ± 1**	**21.9 ± 28**	**14.8 ± 10**	**0.5 ± 0**	**68.7 ± 25**
Congo Town	S23	1998	18 ± 13	14 ± 7.5	4 ± 3	61 ± 38	19 ± 17.5	0	118.5 ± 53.0
Long Bay	S24	1998	13.5 ± 8.5	22 ± 9	2.5 ± 2.5	7.5 ± 10.5	7.5 ± 13	0 ± 0.5	53.5 ± 22.5
NorthRock	*S25*	*1997*	*5.5 ± 1.5*	*7.5 ± 8.5*	---	*1 ± 1*	*0.5 ± 0.5*	*0 ± 0.5*	*15.5 ± 8.5*
North Grassy	*S26*	*1997*	*7 ± 1*	*8 ± 7*	---	*10.5 ± 9.5*	*0*	*0.5 ± 0.5*	*27 ± 13*
Pigeon	*S28*	*1997*	*5.5 ± 3.5*	*6 ± 4.5*	---	*0*	*0*	*0*	*13.5 ± 7.5*
South Andros[1]			**9.9 ± 5**	**11.5 ± 6**	**3.3 ± 1**	**16.0 ± 23**	**5.3 ± 7**	**0.2 ± 0**	**52.9 ± 35**

[1] Mean ± standard error ; [2] *Epinephelus* spp. and *Myceteroperca* spp.

Table 2B. Density (mean ± sd) of AGRRA fishes by site in fore reefs off Andros Island (*1997 sites are italicized*).

Reef crest site name	Site code	Year	Herbivores (#/100m²)			Carnivores (#/100m²)			Total AGRRA fishes (#/100m²)
			Acanthuridae	Scaridae (≥5 cm)	*Microspathodon chrysurus*	Haemulidae (≥5 cm)	Lutjanidae	Serranidae[2]	
N. Joulters	*D1*	*1997*	*3 ± 1.5*	*10.5 ± 5*	---	*15 ± 16.5*	*1 ± 0*	*1 ± 1*	*30 ± 12.5*
Nichols	*D2*	*1997*	*2.5 ± 1*	*2.5 ± 2*	---	*0 ± 0.5*	*0*	*0*	*6 ± 2*
S. Staniard 2	D6	1998	12 ± 5.5	11 ± 7	0.5 ± 1.5	1 ± 1.5	2 ± 4	0.5 ± 1	29 ± 12.5
North Andros[1]			**5.7 ± 5.4**	**8.1 ± 4.8**	**0.7 ± 0**	**5.4 ± 8.1**	**0.9 ± 0.9**	**0.4 ± 0.4**	**21.7± 13.7**
West Klein	D10	1998	6.5 ± 4.5	10 ± 6.5	0	1.5 ± 1	1.5 ± 1.5	1 ± 1	23.5 ± 10
S. Long Rock	*D12*	*1997*	*2*	*1.5*	---	*3.5*	*0.5*	*0*	*7.5*
Long Rock	D13	1998	6.5 ± 4.5	14 ± 10.5	0	2.5 ± 2.5	2 ± 3	1 ± 1.5	29 ± 14.5
Mid Long Rock	*D14*	*1997*	*2.5 ± 1*	*2.5 ± 2*	---	*0 ± 0.5*	*0*	*0*	*6 ± 2*
Green Cay	D15	1998	2.5 ± 2.5	15.5 ± 9	0	0.5 ± 0.5	1 ± 1.5	1 ± 1	21 ± 11
Sugar Rock	D16	1998	4 ± 4	5 ± 4.5	0	0.3 ± 1	2.5 ± 4	1.5 ± 1.5	14.5 ± 10.5
Central Andros[1]			**4 ± 2**	**8.1 ± 6**	**0**	**1.3 ± 1**	**1.2 ± 1**	**0.7 ± 1**	**16.9 ± 9**
Bristol Galley	D17	1998	3.5 ± 2.5	12 ± 10.5	0	1.5 ± 2	2 ± 4	0.5 ± 1	21 ± 15
Autec 2	D18	1998	4.5 ± 2.5	6.5 ± 6.5	0	0.5 ± 1	2 ± 2	1 ± 1	16 ± 6.5
Autec 2-South	D19	1998	3.5 ± 3	5.5 ± 4.5	0	0	4.5 ± 10.5	0.5 ± 1	15 ± 10.5
N. Bight	D20	1998	6 ± 3	5.5 ± 4.5	0.5 ± 0.5	1 ± 1	2 ± 2.5	1 ± 1	20 ± 8.5
Autec 3	D21	1998	5 ± 3	17.5 ± 13.5	0	0 ± 0.5	2 ± 2.5	0 ± 0.5	27 ± 13.5
Middle Bight	D22	1998	4 ± 3	11.5 ± 7	0	0 ± 0.5	2 ± 3	0 ± 0.5	19.5 ± 8.5
Mangrove N.	D23	1998	6.5 ± 6	3.5 ± 2.5	0	0 ± 0.5	0	0.5 ± 1	11.5 ± 6.5
Bights[1]			**4.7 ± 1**	**8.9 ± 5**	**0**	**0.5 ± 0**	**2.0 ± 1**	**0.6 ± 0**	**18.5 ± 5**
Congo Town	D24	1998	3.5 ± 3	9 ± 7.5	0 ± 0.5	1 ± 2	1 ± 1.5	0.5 ± 1	17.5 ± 10
Long Bay Cay	D25	1998	3.5 ± 4	12.5 ± 8.5	0	1 ± 1.5	0 ± 0.5	0.5 ± 1	19 ± 10
Oasis	D26	1998	13.5 ± 6.5	7 ± 4.5	0.5 ± 1.5	3.5 ± 3.5	7.5 ± 8.5	0.5 ± 0.5	35.5 ± 15.5
High Point Cay	D27	1998	5 ± 3	8 ± 6	0	1.5 ± 1.5	3 ± 5	0.5 ± 0.5	19.5 ± 8
North Rock	*D28*	*1997*	*5 ± 3*	*4 ± 4.5*	---	*0.5 ± 0.5*	*0.4 ± 0.5*	*0*	*10 ± 6.5*
North Grassy	*D29*	*1997*	*4 ± 3.5*	*8 ± 7.5*	---	*2 ± 2*	*0*	*0.5 ± 0.5*	*15 ± 13.5*
South Grassy	*D30*	*1997*	*5 ± 2*	*5 ±2*	---	*0.5 ± 0.5*	*0*	*0.5 ± 0.5*	*11 ± 2.5*
Pigeon	*D32*	*1997*	*2.5 ± 1.5*	*7 ± 6.5*	---	*1.5 ± 1.5*	*0.5 ± 0.5*	*0*	*13.5 ± 12*
Saddleback	*D33*	*1997*	*3.5 ± 4*	*11.5 ± 6*	---	*1.5 ± 0.6*	*1 ± 1.5*	*1 ± 1.5*	*20.5 ± 12*
South Andros[1]			**5 ± 3**	**8.1 ± 3**	**0.2 ± 0**	**1.4 ± 1**	**1.4 ± 2**	**0.4 ± 0**	**17.9 ± 8**

[1] Mean ± standard error ; [2] *Epinephelus* spp. and *Myceteroperca* spp.

Table 3A. Twenty-five most frequently sighted fish species during roving diver surveys for all reef-crest sites combined off Andros Island, with density (mean ± sd) for species counted in belt transects.

Scientific name	Common name	Roving Diver			Belt transect 1998 density (#/100m^2)
		Sighting Frequency (SF)	Density (1-4)	SF x Density	
Reef-crest sites					
Thalassoma bifasciatum	Bluehead	100	3.5	350	----
Acanthurus coeruleus	Blue Tang	100	3.3	330	7.2 ± 6.7
Abudefduf saxatilis	Sergeant Major	100	3	300	----
Halichoeres garnoti	Yellowhead Wrasse	100	2.8	280	----
Acanthurus bahianus	Ocean Surgeonfish	100	2.8	280	3.6 ± 4.2
Lutjanus apodus	Schoolmaster	100	2.7	270	3.5 ± 7.4
Aulostomus maculatus	Trumpetfish	96	1.9	182	----
Sparisoma viride	Stoplight Parrotfish	96	3	287	4.7 ± 5.4
Microspathodon chrysurus	Yellowtail Damselfish	96	2.9	278	1.9 ± 2.7
Scarus vetula	Queen Parrotfish	96	2.8	268	2.4 ± 3.2
Haemulon sciurus	Bluestriped Grunt	96	2.5	240	2.4 ± 4.9
Ophioblennius atlanticus	Redlip Blenny	96	2.5	240	----
Scarus croicensis	Striped Parrotfish	92	3.2	293	6.4 ± 9.0
Sparisoma aurofrenatum	Redband Parrotfish	92	2.9	266	1.5 ± 2.1
Sparisoma rubripinne	Redfin Parrotfish	92	2.8	256	1.2 ± 2.2
Ocyurus chrysurus	Yellowtail Snapper	92	2.6	238	0.9 ± 3.0
Haemulon plumieri	White Grunt	92	2.5	229	0.7 ± 1.6
Haemulon flavolineatum	French Grunt	88	3.2	280	21.0 ± 49.9
Chromis cyanea	Blue Chromis	88	3.1	271	----
Stegastes partitus	Biolor Damselfish	88	2.8	245	----

Table 3B. Twenty-five most frequently sighted fish species during roving diver surveys for all fore-reef sites combined off Andros Island, with density (mean ± sd) for species counted in belt transects.

Scientific name	Common name	Roving Diver			Belt transect 1998 density (#/100m^2)
		Sighting Frequency (SF)	Density (1-4)	SF x Density	
Fore-reef sites					
Acanthurus coeruleus	Blue Tang	97	3	290	3.5 ± 4.0
Sparisoma viride	Stoplight Parrotfish	97	2.9	280	1.6 ± 2.6
Thalassoma bifasciatum	Bluehead	94	3.4	318	----
Chromis cyanea	Blue Chromis	94	3.1	290	----
Scarus croicensis	Striped Parrotfish	94	3	281	5.6 ± 7.3
Stegastes partitus	Bicolor Damselfish	94	3	281	----
Aulostomus maculatus	Trumpetfish	94	1.9	178	----
Gramma loreto	Fairy Basslet	90	3	271	----
Sparisoma aurofrenatum	Redband Parrotfish	90	2.7	244	1.0 ± 1.7
Ocyurus chrysurus	Yellowtail Snapper	90	2.5	226	1.1 ± 3.4
Canthigaster rostrata	Sharpnose Puffer	90	2.4	217	----
Caranx ruber	Bar Jack	90	2.3	208	0.2 ± 0.9
Lutjanus apodus	Schoolmaster	90	2.3	208	0.8 ± 2.8
Stegastes planifrons	Threespot Damselfish	90	2.2	199	----
Mycteroperca tigris	Tiger Grouper	90	1.9	172	0.2 ± 0.5
Clepticus parrae	Creole Wrasse	87	3.7	322	----
Coryphopterus personatus	Masked Goby	87	3.5	305	----
Halichoeres garnoti	Yellowhead Wrasse	87	2.7	235	----
Haemulon plumieri	White Grunt	87	2.1	183	0.3 ± 0.7
Chaetodon capistratus	Foureye Butterflyfish	87	2.1	183	0.7 ± 1.3

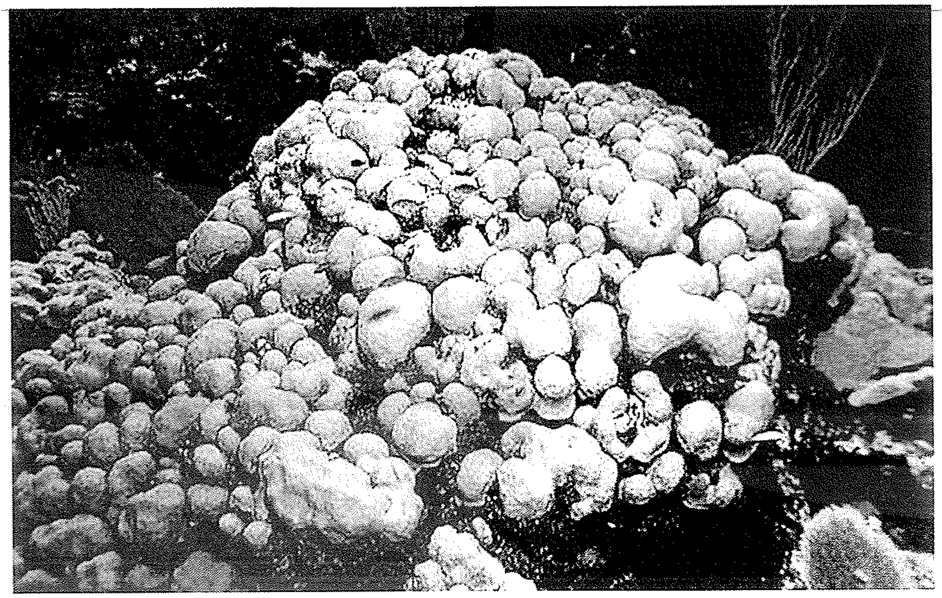

Plate 4A. The need for large-scale comparable data on coral reef condition in the Western Atlantic led to the initiation of the AGRRA Program and the development of its key reef health indicators. Given their importance in constructing the three-dimensional framework of coral reefs, the condition of scleractinian and hydrozoan corals, like this *Montastraea annularis*, is a primary focus of the AGRRA benthos protocol. (Photo Robert S. Steneck)

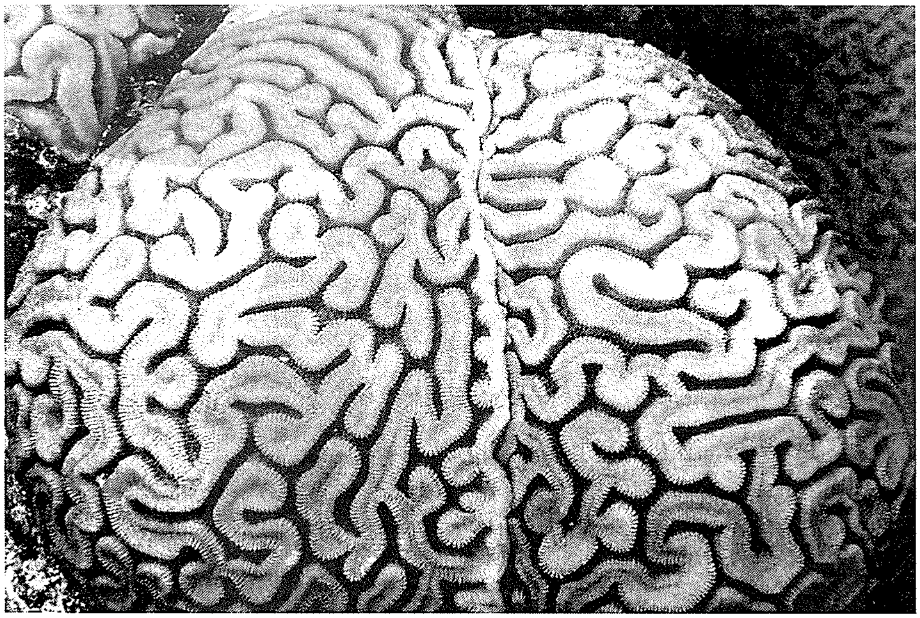

Plate 4B. Distinguishing colony boundaries before estimating size or partial mortality is essential. A colony is defined on the basis of common skeletal or live tissue connections and/or by polyp size and color. Two closely adjacent colonies of *Diploria labyrinthiformis* are recognized by a thin lip of raised skeleton and live tissues. Common skeleton at the bases of the lobes of *Montastraea annularis* (Plate 3A), help in the recognition of individual colonies. (Photo Robert W. Steneck)