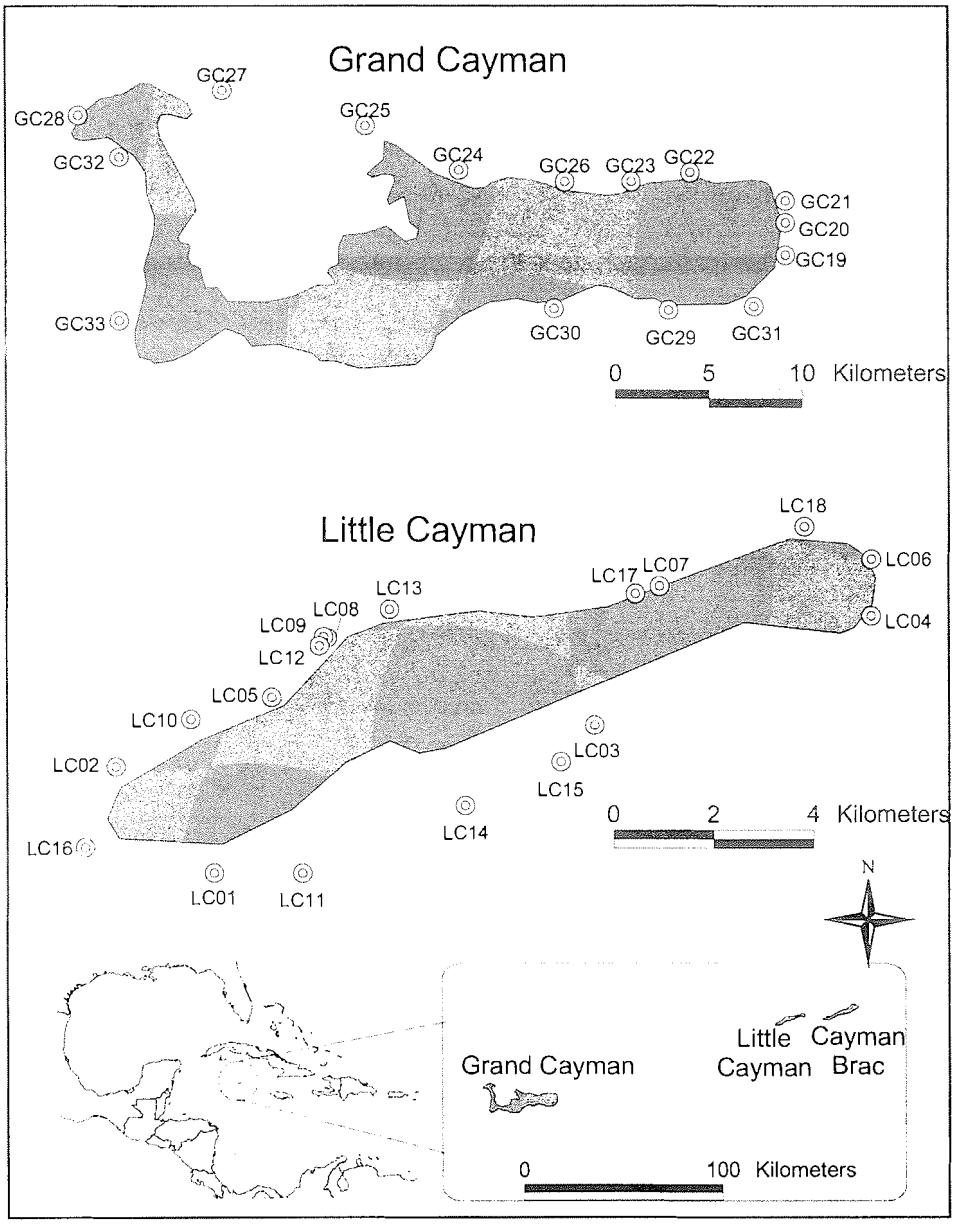

Figure 1. AGRRA survey sites in Grand Cayman and Little Cayman, Cayman Islands. See Table 1 for site codes.

STATUS OF CORAL REEFS OF LITTLE CAYMAN AND GRAND CAYMAN, BRITISH WEST INDIES, IN 1999 (PART 2: FISHES)

BY

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ABSTRACT

The fish assemblages at 33 sites around the islands of Grand Cayman and Little Cayman were assessed in June 1999 for the Atlantic and Gulf Rapid Reef Assessment initiative using belt transects and Roving Diver Technique surveys. A comprehensive species list, with 58 new records, was compiled for the Cayman Islands based on these data and survey data from the Reef Environmental Education Foundation database. In general, the reefs on Little Cayman appeared to support larger and more individual fishes than those of Grand Cayman. A multidimensional scaling ordination plot showed no clear island pattern but did reveal that the windward or leeward location of each site was an important factor affecting fish community composition. All but two sites followed a pattern of distinct windward and leeward clusters, and these clusters also correlated to macroalgal abundance. The relationship between macroalgal abundance and herbivore density was analyzed and significant correlations were found with surgeonfishes (Acanthuridae) and parrotfishes (Scaridae) using multiple regression.

INTRODUCTION

Fishes have the potential to provide sensitive indices of reef health. Certain predatory fish species dominate the top of coral reef food webs, hence their density reflects a vast number of human and natural disturbances from habitat alteration to direct exploitation (Ferreira et al., 1998). Similarly, the presence and abundance of herbivorous fishes affect algal composition and cover (Ogden and Lobel, 1978).

In response to concerns about the widespread deterioration of reef condition in the Caribbean basin, the Atlantic and Gulf Rapid Reef Assessment (AGRRA) initiative was designed to provide a regional perspective using a standardized methodology. The rapid assessment protocol is focused on three main components of the reef community: stony corals, fish, and algae. As part of this initiative, the reefs of Grand Cayman (GC) and Little Cayman (LC) were assessed in June 1999.

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The Cayman Islands are a British Crown Colony located in the western Caribbean. The three islands lie between 19° 15' and 19° 45' N latitude and between 79° 44 ' and 81° 27' W longitude (Fig. 1). GC is the largest and most populous. LC lies approximately 145 km to its east-northeast and is about 10 km from Cayman Brac. The three islands are limestone, horst-and-graben structures associated with the Cayman Ridge (Jones, 1994). Freshwater is scarce and the islands lack rivers and streams. The fringing reefs that surround most of the islands contain shallow reef crests (rubble ramparts) as well as mid-shelf and shelf-edge fore reefs (Blanchon and Jones, 1997). These fringing reefs are particularly well-developed on the windward (eastern and southern) coasts of both islands. Other submerged benthic habitats include seagrass beds and mangrove fringes.

The level of human disturbance on GC is significantly greater than on LC, which is relatively remote and undeveloped. Anthropogenic impacts on GC reefs include habitat destruction from anchors and increased suspended sediment load from dredging and mangrove removal. Fishing pressure is considerably greater on GC than around LC. Five spawning aggregations of Nassau grouper (*Epinephelus striatus*) have been heavily harvested (during the 2002 spawning season, all but one had been depleted). Five hundred local residents are licensed to snorkel with spearguns. Fish pots (Antillean Z-traps) probably represent the biggest threat to the fish communities of both islands (personal observations).

An extensive marine park system was established in the Cayman Islands in 1986. Reefs in marine park and replenishment zone areas are protected from fish traps, spearguns, anchoring, and line fishing, although line fishing from shore and beyond the drop-off (shelf edge) is allowed. The Cayman Islands' Department of the Environment maintains a system of 257 permanent mooring buoys throughout the three islands.

The benthos of the Cayman Islands has been well studied, including descriptions of the coral communities, reef status, and analysis of spatial patterns (Roberts, 1988; Logan, 1994; Roberts, 1994). In contrast, apart from descriptions of Nassau grouper spawning aggregations (Colin et al., 1987; Tucker et al., 1993), there are few scientific descriptions of its reef fishes. However, Burgess et al.'s (1994) taxonomic review of collection expeditions contained an annotated list of 381 species known to occur in the Cayman Islands, including the endemic y-lined blenny (*Starksia y-lineata*) described by Gilbert (1965).

Since 1994, fish sighting and relative abundance data have been collected around the Cayman Islands as part of the Reef Environmental Education Foundation (REEF) Fish Survey Project, an ongoing volunteer monitoring effort. REEF volunteers use the Roving Diver Technique (RDT) (Schmitt and Sullivan, 1996) and the survey data are maintained in a publicly-accessible database. By the end of 2001, the REEF database contained over 40,000 surveys from over 2,000 sites, including approximately 2,200 surveys from the Cayman Islands.

This paper describes the fish assemblages of the Cayman Islands using the 1999 AGRRA data for GC and LC, along with REEF data from the two islands collected between 1994 and 2001. An updated species list and comparisons between islands and among sites are provided. The relationship between herbivorous fishes and macroalgal abundance is also investigated.

METHODS

In June 1999, AGRRA fish and benthos surveys were simultaneously conducted at 15 sites on GC and 18 sites on LC (Fig. 1, Table 1). Sites were chosen by a mixed representative/strategic strategy: 12 were on the windward sides of the islands and 21 were on their leeward sides (the southwest side of GC was underrepresented). Six sites on LC and three on GC were located within marine park or replenishment zone areas. The benthic component is reported by Manfrino et al. (this volume). To assess the fishes, the AGRRA protocol Version 2.1 was used (Appendix One, this volume). At each site, a team of three (occasionally two) divers conducted at least 10 2 m x 30 m belt transects. Counts of serranids (groupers) were restricted to species of *Epinephelus* and *Mycteroperca*; scarids (parrotfishes) and haemulids (grunts) less than 5 cm in length were not tallied. Each diver also conducted a 45-60 minute RDT survey at each site. All fieldwork was undertaken between 9:00 a.m. and 3:00 p.m. Field identifications were based on Humann (1994), Stokes (1980), and Robins et al. (1986).

The fish transect data were entered into a custom AGRRA Excel spreadsheet. REEF provided the RDT data in ASCII format. Using the transects as replicates, the average density (#/100 m^2) and size (cm) of each species and family were calculated for each site. Analyses were done at the regional (GC versus LC) and site levels, incorporating reef location (windward, leeward) and benthic parameters when appropriate. The average density and size of each species and family were compared between regions using a t-test after testing the data for normality. Due to confounding factors such as differences in use (e.g., recreation, harvest) and hydrographic features, comparisons between protected (marine park) and unprotected sites were not attempted. The site data were used in a hierarchical cluster analysis using Pearson's similarity index. The similarity matrix was generated using log-transformed density values for each species documented in at least three (10%) of the sites; the other 22 rare species were eliminated (per Grossman et al., 1982). A two-dimensional multidimensional scaling (MDS) ordination plot was also generated using the similarity matrix.

The transect data were also used to investigate interactions between the fish assemblages and the benthic community. This preliminary investigation was focused on herbivore/algae interactions. A regression was calculated on the densities of parrotfish and surgeonfish against percent absolute macroalgal abundance in quadrats (hereafter macroalgal abundance) and height at each site. Other coral factors (percent live coral cover, average colony height, percent diseased colonies) and environmental (windward/leeward) parameters were also plotted against each fish family. All values were transformed prior to regression (transformations were log+1 for fish density and algal height and arcsine of the square root for proportions).

The RDT survey data provided species lists, frequency of occurrence, and relative abundance estimates. Percent sighting frequency (%SF) for each species was the percentage of all dives in which the species was recorded. An estimate of abundance was calculated as: abundance score = D x %SF, where the density score (D) for each species was a weighted average index based on the frequency of observations in different abundance categories. Density score was calculated as:

$D= ((n_S x1)+(n_F x2)+(n_M x3)+(n_A x4)) / (n_S + n_F + n_M + n_A)$, where n_S, n_F, n_M, and n_A represented the number of times each abundance category (Single, Few, Many,

Abundant) was assigned for a given species. The RDT data were pooled and compared by island using the Wilcoxon Sign Rank test. Only species that were seen in at least 10% of the RDT AGRRA surveys were included in the analysis (103 species), reducing the effect of rare species (Grossman et al., 1982). SYSTAT 7.0 was used for all the analyses.

All expert-level REEF data from GC and LC, including the RDT data collected during the AGRRA expedition, were used to compile a species list of reef fishes for the Cayman Islands (REEF, 2001).

RESULTS

A total of 341 transects (142 - GC; 199 - LC) and 79 RDT surveys (32- GC and 47- LC) documenting 173 species were conducted at 33 reefs (Table 1). The RDT survey data were added to the existing REEF database. The total number of species recorded by REEF experts on the Cayman Islands between 1994 and 2001 was 275 (Appendix A, this paper). When compared with Burgess et al.'s (1994) ichthyofaunal list, the REEF survey data added 58 new species records for a total of 423 reef fishes documented on the Cayman Islands (five freshwater species, 10 deepwater (>300 m) species, and a misidentification (*Stegastes mellis*) listed by Burgess et al. (1994) were not included in this tally). The 25 most common species, according to %SF in the REEF database, are noted in Table 2.

Parrotfish (Scaridae) was the most abundant family recorded during the belt transects (Fig. 2). Average density of snapper (Lutjanidae) on LC was approximately twice that of GC reefs. Size frequency distributions of carnivores (select grouper genera and all snappers) and herbivores [parrotfish ≥5 cm, surgeonfish (Acanthuridae), and the

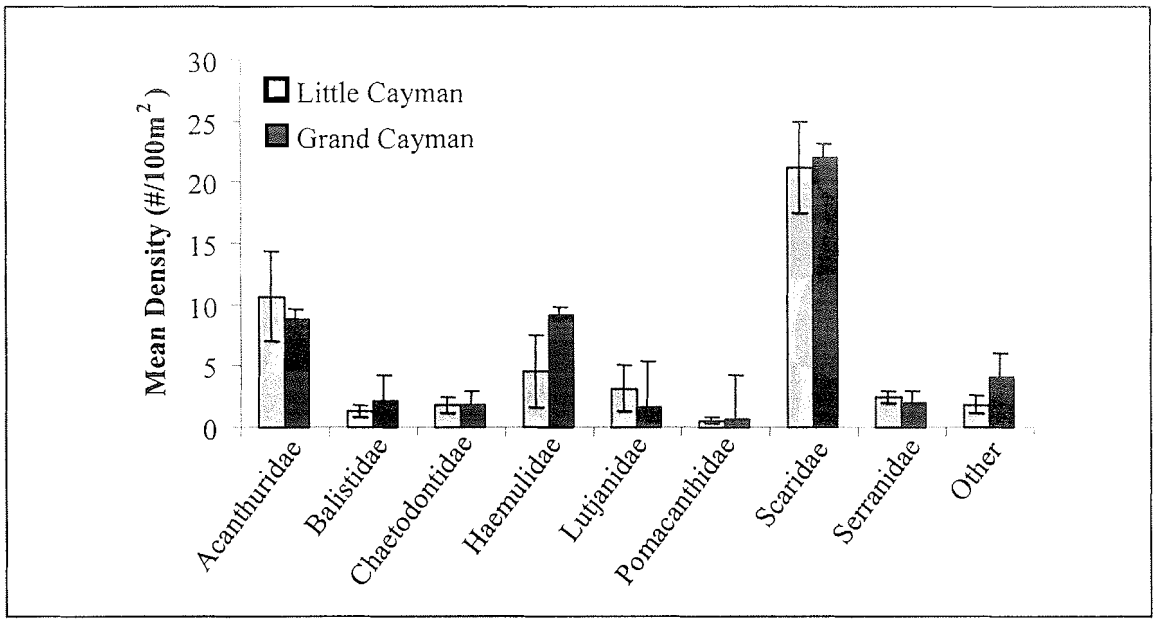

Figure 2. Mean fish density (no. individuals/100 m^2 ± sd) for AGRRA fishes in Grand Cayman and Little Cayman. Other = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Microspathodon chrysurus, Sphyraena barracuda.*

yellowtail damselfish *Microspathodon chrysurus*] are shown in Figure 3. Approximately 75% of the carnivores were less than 30 cm in length, and 85% of the herbivores were less than 20 cm in length. T-tests on these data showed that the average density and size for most species and families did not differ between islands. However, many species were reported in RDT surveys with greater than average abundance on the LC reefs (Wilcoxon Sign Rank $p<0.0005$). In particular, the sighting frequencies of six species of large groupers were considerably greater in LC (Table 3; Wilcoxon Sign Rank $p<0.05$). Exceptions included yellowtail snapper (*Ocyurus chrysurus*) and sergeant major (*Abudefduf saxatilis*), two species that become abundant when fed regularly by divers. Fish feeding is much more commonplace on GC reefs (Burgess et al., 1994; personal observations).

Site comparisons at the assemblage level showed no clear, intra-island groupings. However, two distinct clusters were obvious in the MDS plot (Fig. 4A) and, to a lesser extent, in the cluster diagram (Fig. 4B). The only environmental characteristics significantly related to fish density were reef location (windward/leeward) and macroalgal abundance. The windward (high-wave exposure) or leeward/protected windward (low wave-exposure) location of the sites was an important factor in the MDS cluster for all but two of the sites (LC02 and GC30). Leeward sites also had significantly higher macroalgal abundance than windward sites (45% versus 31%, respectively: F-test $p<0.001$; multiple $R = 0.560$).

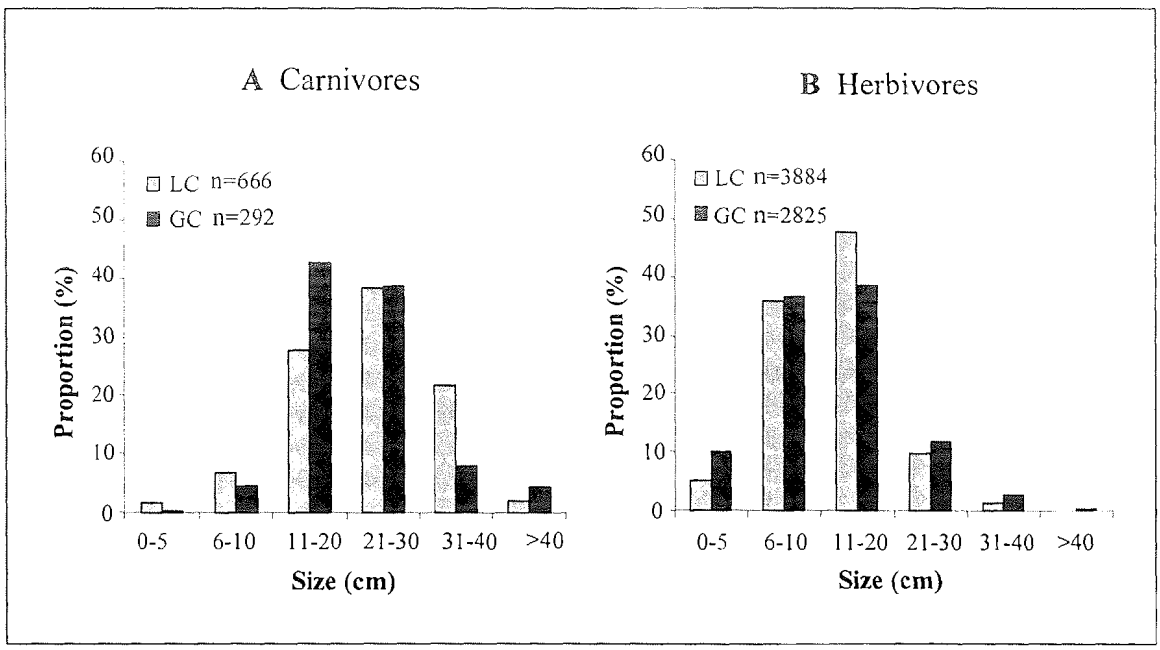

Figure 3. Size frequency distribution of (**A**) carnivores (all lutjanids, select serranids) and (**B**) herbivores (acanthurids, scarids ≥ 5 cm, *Microspathodon chrysurus*) in GC (Grand Cayman) and LC (Little Cayman). Total number of individuals counted (n) is given.

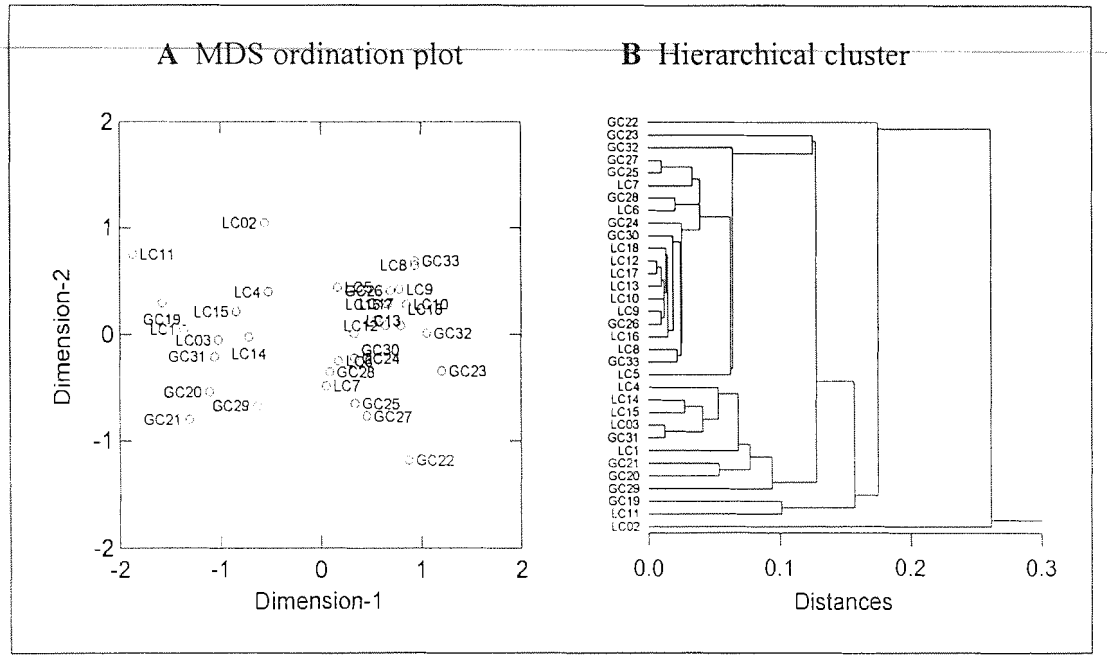

Figure 4. (**A**) MDS ordination plot (left cluster is windward) and (**B**) hierarchical cluster analysis of AGRRA reef fish transect data in GC (Grand Cayman) and LC (Little Cayman).

Surgeonfish density showed an inverse relationship with macroalgal abundance ($p<0.01$; r2 = 0.209), whereas parrotfish density was positively related to macroalgal abundance ($p<0.01$; r2 = 0.215) (Fig. 5). Adding macroalgal height to a multiple regression significantly improved the relationships with macroalgal abundance for parrotfish ($p<0.001$; $r^2 = 0.413$) and surgeonfish ($p=0.001$; $r^2 = 0.367$) densities. A strong inverse relationship between parrotfish and surgeonfish densities was also found ($p<0.001$; $r^2 = 0.384$).

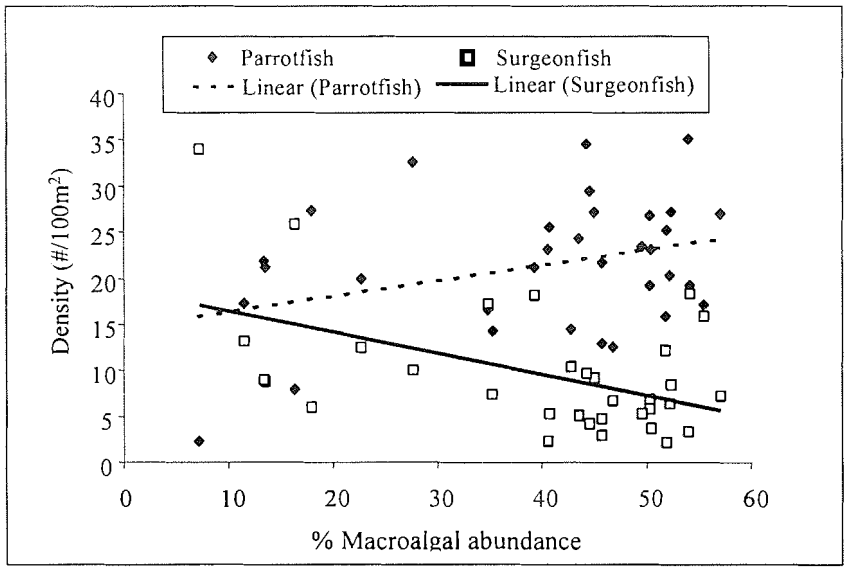

Figure 5. Regression plot between mean parrotfish density (♦) and mean surgeonfish density (□) (no. individuals/100m^2) and mean absolute macroalgal abundance by site in the Cayman Islands.

DISCUSSION

The reefs of the Cayman Islands support relatively diverse and abundant fish assemblages. This richness is probably a result of several factors including high local habitat diversity, a significant (34%) area of coastal reserves, and a reef system that is generally in fair condition (Manfrino et al., this volume). However, significant differences were revealed between GC and LC, most likely a result of the greater anthropogenic impacts on GC reefs. Higher harvest pressure on GC was reflected in the lower density and size of large groupers, parrotfishes and snappers (Table 4) and lower sighting frequencies of large groupers (Table 3). Analyses of RDT data indicated that regardless of commercial importance, the average abundance of most fish species was higher on LC, hence other factors, such as coastal development and water pollution, may also adversely impact fish communities on GC.

The site-level transect density data correlated most strongly with relative wave exposure (Fig. 4A,B). Macroalgae were significantly less abundant overall on windward (high-wave exposure) sites than on leeward and protected windward (low-wave exposure) sites, where parrotfish were the most abundant fishes in the transects. It is clear, however, that macroalgal abundance does not by itself adequately explain site-level assemblage composition, given that LC sites had only slight differences between wave-exposed and non wave-exposed sites (Manfrino et al., this volume). The correlation between fish communities at sites with similar wave exposure highlights the effect of physical parameters on fish assemblage structure, and should be taken into consideration in future analyses of fish data for the Cayman Islands.

In a simple system, one might expect the presence and density of herbivorous species to be negatively correlated with algal abundance and height. In other words, a site with many herbivorous fish would have relatively low algal abundance due to grazing. Our analysis at the site level indicates that this expectation holds true for surgeonfish. However, the inverse is evident in parrotfish. This implies either or both of the following: 1) there is a direct or indirect interaction between parrotfish and surgeonfish, or, more generally 2) the dynamic spatial and temporal characteristics of reef fish confound simple relationships between resource availability and fish abundance. Recent work on stoplight parrotfish (*Sparisoma viride*) indicates that whereas there are few, if any, direct interactions between surgeonfish and parrotfish, the use of space on the reef by individual fish is complex (territorial behavior, depth partitioning based on social grouping), and varies as a function of social status and intraspecific interactions (van Rooij et al., 1996a; van Rooij et al., 1996b). Clearly, more research is needed to understand the use of space by reef fish if accurate conclusions are to be drawn from relationships between fish abundance and benthic conditions.

One of the crucial tasks that scientists face in implementing a "reef health scale" using AGRRA data is to determine exactly what indicators within the collected data track health. An additional challenge lies in assessing how to evaluate and analyze the broad and complementary set of information collected on fishes, stony corals, and algae. Results from this paper and others in this volume will provide valuable insight on these issues. Due to the inherently complex nature of coral reef communities, the manner in which AGRRA data will dictate a scale of reef condition is most certainly also complex. The negative relationship between surgeonfish and parrotfish at the site level is a good

example of how community complexity may confound seemingly logical indicators of reef health such as herbivore biomass. Given our results, it is possible that Cayman Island reefs with similar herbivore biomass constituted by predominately different taxa may reflect dramatic differences in benthic conditions. The disparity between grouper abundance between the transect and RDT data and the dramatic increase in species reported in the Cayman Islands that resulted from the RDT surveys (18% based on the published list by Burgess et al., 1994) highlights the importance of using the two complementary visual fish-survey methods.

Because certain fish species dominate the top of coral reef food webs, a baseline of fish community composition and richness provides a useful tool for future assessment of reef health, given that a change in reef communities at lower trophic levels will most likely result in changes in the reef fish community composition (Choat, 1991; Jones et al., 1991). Additionally, because fish tend to be the most charismatic group of reef community members, changes in their community are most likely to be noticed and documented.

ACKNOWLEDGMENTS

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Table 1. Site information for AGRRA fish surveys in Little Cayman and Grand Cayman Islands.

Name[1]	Site	Protection[2]	Location[3]	Reef Type[4]	Latitude ° ' N	Longitude ° ' W	Survey date	Depth (m)	% live stony coral cover (mean ± sd)[5]	30m fish transects (#)	RDT surveys (#)[6]	RDT fish species (#)
Little Cayman												
Jigsaw Puzzle	LC02	open	lee	High S&G	19 39.983'	80 06.390'	6-Jun-99	10.5	27.0 ± 9.5	11	4	96
Mixing Bowl	LC05	park	lee	Shelf edge	19 41.096'	80 04.700'	8-Jun-99	12.4	29.0 ± 12.0	12	2	105
Black Tip Tunnels	LC06	replen	lee	S&G	19 42.847'	79 57.470'	9-Jun-99	12.4	15.5 ± 7.5	12	2	74
Penguin's Leap	LC07	open	lee	Hardpan	19 42.551'	80 00.487'	9-Jun-99	16.1	16.5 ± 8.0	12	2	64
Meadows	LC08	park	lee	Patch	19 41.510'	80 04.130'	10-Jun-99	18.4	37.0 ± 11.5	14	3	88
Nancy's Cup of Tea	LC09	park	lee	Shelf edge	19 41.639'	80 04.137'	10-Jun-99	12.5	21.5 ± 14.0	14	3	87
Joy's Joy	LC10	park	lee	Shelf edge	19 40.690'	80 05.575'	10-Jun-99	12.1	19.0 ± 6.5	14	3	82
Paul's Anchor	LC12	park	lee	Shelf edge	19 41.661'	80 04.181'	13-Jun-99	12.9	17.0 ± 12.0	9	3	73
Rock Bottom Wall	LC13	open	lee	S&G	19 42.057'	80 03.421'	13-Jun-99	12.6	22.5 ± 10.5	10	2	70
	LC16	open	lee	S&G	19 39.702'	80 06.728'	15-Jun-99	14	25.5 ± 5.5	10	3	76
	LC17	open	lee	S&G	19 42.470'	80 00.495'	15-Jun-99	8.8	22.5 ± 4.5	10	3	71
	LC18	replen	pro wind	Hardpan	19 42.996'	79 58.921'	15-Jun-99	10.8	15.0 ± 5.5	10	3	62
Grundy's Gardens	LC01	park	wind	S&G	19 39.421'	80 05.321'	6-Jun-99	9.4	37.5 ± 11.5	10	3	80
Disneyland	LC03	replen	wind	S&G	19 49.831'	80 01.374'	7-Jun-99	9.9	25.5 ± 6.5	11	2	73
Charles Bay	LC04	open	wind	S&G	19 41.628'	79 58.459'	7-Jun-99	10.7	17.5 ± 6.5	11	2	76
Main Channel East	LC11	open	wind	Fringing	19 39.412'	80 04.368'	11-Jun-99	2.8	16.0 ± 5.5	9	1	30
Lucas's Ledge	LC14	replen	wind	S&G	19 40.155'	80 02.595'	14-Jun-99	13.6	24.5 ± 6.0	10	3	68
	LC15	replen	wind	S&G	19 40.628'	80 01.562'	14-Jun-99	10.9	26.5 ± 8.5	10	3	65
Grand Cayman												
Hepp's Mini Wall	GC28	park	lee	Patch/S&G	19 23.126'	81 24.992'	20-Jun-99	11.5	22.0 ± 5.5	5	1	35
Cemetery Reef	GC32	park	lee	Patch/S&G	19 21.917'	81 23.726'	22-Jun-99	9	17.5 ± 4.9	9	2	74
Sunset House	GC33	park	lee	Patch/S&G	19 17.172'	81 23.463'	22-Jun-99	9.1	22.5 ± 12.0	12	3	74
Isabel's Reef	GC22	open	pro wind	High S&G	19 21.460'	81 08.145'	18-Jun-99	10.6	24.5 ± 7.5	10	2	52
Babylon	GC23	replen	pro wind	S&G	19 21.200'	81 09.842'	18-Jun-99	9.5	18.0 ± 3.5	10	2	51
Delila's Delight	GC24	open	pro wind	S&G	19 21.518'	81 14.801'	19-Jun-99	7.1	23.0 ± 13.0	10	2	56
Queen's Throne	GC25	replen	pro wind	Hardpan	19 22.818'	81 17.493'	19-Jun-99	12.1	14.5 ± 3.0	10	2	61
	GC26	replen	pro wind	S&G	19 21.202'	81 11.746'	19-Jun-99	13.9	12.5 ± 4.0	10	2	49
Bear's Paw	GC27	replen	pro wind	S&G	19 23.854'	81 21.617'	20-Jun-99	10.7	15.5 ± 3.5	5	1	46
	GC19	open	wind	High S&G	19 19.058'	81 04.484'	17-Jun-99	6.7	23.0 ± 9.5	10	2	38
	GC20	open	wind	High S&G	19 20.002'	81 04.596'	17-Jun-99	8.9	18.0 ± 4.5	10	2	49

Table 1, Continued

Name	Site[1]	Protection[2]	Location[3]	Reef Type[4]	Latitude °N	Longitude °W	Survey date	Depth (m)	% live stony coral cover (mean ± sd)[5]	30m fish transects (#)	RDT surveys (#)[6]	RDT fish species (#)
Snapper Hole	GC21	open	wind	High S&G	19 20.634'	81 04.676'	18-Jun-99	10.1	24.0 ± 10.5	10	3	72
Breakers	GC30	open	wind	S&G	19 17.507'	81 12.069'	21-Jun-99	12.5	22.5 ± 4.5	10	2	59
Playing Fields	GC31	open	wind	High S&G	19 17.565'	81 06.318'	21-Jun-99	7.5	17.5 ± 4.5	10	3	71

[1]Site name given if it corresponds to a known Cayman Island Department of Environment buoy.
[2]Park = Marine Park Area; open = no protection; replen = Replenishment Zone Area
[3]lee = leeward; wind = windward; pro wind = protected windward
[4]Reef types follow Manfrino et al. (this volume), S&G = spur and groove, High S&G = high profile spur and groove.
[5]Cover values from benthic AGRRA transects (Manfrino et al., this volume)
[6]RDT = Roving Diver Technique

Table 2. Twenty-five most frequently sighted fish species on the Cayman Islands. Data (Sighting Frequency and Density Score) were compiled from the REEF database, using expert sightings from 1994 through 2001 (N=670 RDT Surveys).

Scientific name	Common name	Sighting frequency (%)	Density score[1]
Acanthurus coeruleus	Blue Tang	98	2.8
Thalassoma bifasciatum	Bluehead	97	3.3
Chromis cyanea	Blue Chromis	97	3.8
Stegastes partitus	Bicolor Damselfish	96	3.6
Sparisoma viride	Stoplight Parrotfish	96	2.7
Caranx ruber	Bar Jack	95	2.3
Chromis multilineata	Brown Chromis	95	3.4
Gramma loreto	Fairy Basslet	94	3.6
Chaetodon capistratus	Foureye Butterflyfish	94	2.1
Sparisoma aurofrenatum	Redband Parrotfish	93	2.7
Halichoeres garnoti	Yellowhead Wrasse	92	2.7
Canthigaster rostrata	Sharpnose Puffer	92	2.1
Epinephelus cruentatus	Graysby	92	2.1
Lutjanus apodus	Schoolmaster	91	2.4
Ocyurus chrysurus	Yellowtail Snapper	89	2.5
Haemulon flavolineatum	French Grunt	89	2.3
Scarus croicensis	Striped Parrotfish	89	2.4
Scarus taeniopterus	Princess Parrotfish	88	2.5
Clepticus parrae	Creole Wrasse	87	3.7
Melichthys niger	Black Durgon	87	2.8
Mulloidichthys martinicus	Yellow Goatfish	84	2.4
Holacanthus tricolor	Rock Beauty	84	1.9
Stegastes diencaeus	Longfin Damselfish	82	2.3
Epinephelus fulvus	Coney	81	2.1
Stegastes planifrons	Threespot Damselfish	80	2.2

[1]See Methods for definition of Density score.

Table 3. Mean percent sighting frequency of select groupers during AGRRA roving diver surveys in LC and GC, Cayman Islands.

Scientific name	Common name	Sighting frequency (%)	
		LC	GC
Mycteroperca bonaci	Black Grouper	7%	3%
Epinephelus striatus	Nassau Grouper	69%	9%
Epinephelus guttatus	Red Hind	44%	21%
Mycteroperca tigris	Tiger Grouper	50%	12%
Mycteroperca venenosa	Yellowfin Grouper	22%	0%
Mycteroperca interstitialis	Yellowmouth Grouper	6%	3%

Table 4. Density and length (mean ± standard deviation) of AGRRA fishes, and macroalgal index values for LC and GC, Cayman Islands.

Island	Herbivores		Carnivores			Macroalgal index[2]
	Acanthuridae	Scaridae (≥5 cm)	Haemulidae (≥5 cm)	Lutjanidae	Serranidae[1]	
LC density (#/100m^2)	10.67 ± 7.22	21.20 ± 7.56	4.59 ± 5.98	3.17 ± 3.61	2.38 ± 0.96	105
LC length (cm)	11.85 ± 2.08	15.87 ± 2.67	19.45 ± 2.58	27.78 ± 3.42	19.11 ± 3.02	
GC density (#/100m^2)	8.35 ± 6.66	22.13 ± 7.04	8.72 ± 10.04	1.86 ± 2.04	2.00 ± 0.67	32
GC length (cm)	12.02 ± 1.60	15.33 ± 2.19	19.21 ± 1.36	28.58 ± 7.29	18.95 ± 1.92	

[1]*Epinephelus* spp. and *Mycteroperca* spp.
[2]Macroalgal index = absolute macroalgal abundance x canopy height.

Appendix A. Cayman Islands Species List. Data compiled from the REEF database, using expert sightings from 1994 through 2001. A total of 670 expert surveys (32- Cayman Brac; 258- Little Cayman; 380- Grand Cayman) reported 276 species. For each species, percent sighting frequency (%SF) and density score (DEN) are given. Fifty-eight species previously unreported from the Cayman Islands are listed and indicated by an asterisk (*).

Scientific Name	Common Name	SF%	DEN	Scientific Name	Common Name	SF%	DEN
Acanthuridae	**Surgonfishes**			**Belonidae**	**Needlefishes**		
Acanthurus bahianus	Ocean Surgeonfish	84%	2.3	**Playbelone argalus*	Keeltail Needlefish	0.1%	2.0
Acanthurus chirurgus	Doctorfish	39%	2.0	*Tylosurus crocodilus*	Houndfish	3%	1.6
Acanthurus coeruleus	Blue Tang	98%	2.9	**Blenniidae**	**Blennies (Combtooth)**		
Apogonidae	**Cardinalfishes**			*Entomacrodus nigricans*	Pearl Blenny	0.3%	1.0
**Apogon affinis*	Bigtooth Cardinalfish	0.1%	2.0	*Ophioblennius atlanticus*	Redlip Blenny	32%	1.9
**Apogon aurolineatus*	Bridle Cardinalfish	0.4%	1.6	**Parablennius marmoreus*	Seaweed Blenny	1%	1.3
Apogon binotatus	Barred Cardinalfish	17%	2.0	**Bothidae**	**Flounders (Lefteye)**		
Apogon lachneri	Whitestar Cardinalfish	17%	2.0	*Bothus ocellatus*	Eyed Flounder	0.3%	1.0
Apogon maculatus	Flamefish	14%	1.7	*Bothus lunatus*	Peacock Flounder	12%	1.2
**Apogon pillionatus*	Broadsaddle Cardinalfish	SO[1]		**Callionymidae**	**Dragonets**		
Apogon planifrons	Pale Cardinalfish	1%	1.8	*Paradiplogrammus bairdi*	Lancer Dragonet	3%	1.3
Apogon pseudomaculatus	Twospot Cardinalfish	2%	1.6	**Carangidae**	**Jacks**		
Apogon quadrisquamatus	Sawcheek Cardinalfish	1%	1.8	*Alectis ciliaris*	African Pompano	SO[1]	
Apogon townsendi	Belted Cardinalfish	26%	2.2	*Caranx bartholomaei*	Yellow Jack	3%	1.6
Astrapogon puncticulatus	Blackfin Cardinalfish	0.4%	2.0	*Caranx crysos*	Blue Runner	1%	1.4
Phaeoptyx pigmentaria	Dusky Cardinalfish	3%	2.3	*Caranx hippos*	Crevalle Jack	2%	1.9
**Phaeoptyx xenus*	Sponge Cardinalfish	11%	1.6	*Caranx latus*	Horse-Eye Jack	33%	2.3
Aulostomidae	**Trumpetfishes**			*Caranx lugubris*	Black Jack	8%	1.4
Aulostomus maculatus	Trumpetfish	69%	1.7	*Caranx ruber*	Bar Jack	95%	2.3
Balistidae	**Leatherjackets**			*Elagatis bipinnulata*	Rainbow Runner	0.4%	1.3
Aluterus scriptus	Scrawled Filefish	9%	1.1	*Scomberomorus regalis*	Cero	18%	1.3
Balistes vetula	Queen Triggerfish	34%	1.3	*Trachinotus falcatus*	Permit	3%	1.2
Cantherhines macrocerus	Whitespotted Filefish	22%	1.4	*Trachinotus goodei*	Palometa	0.3%	2.0
Cantherhines pullus	Orangespotted Filefish	13%	1.3	**Carcharhinidae**	**Sharks (Requeim)**		
Canthidermis sufflamen	Ocean Triggerfish	11%	1.3	**Carcharhinus limbatus*	Blacktip Shark	0.3%	1.5
Melichthys niger	Black Durgon	87%	2.8	**Carcharhinus perezi*	Reef Shark	2%	1.1
Monacanthus tuckeri	Slender Filefish	8%	1.4	**Chaenopsidae**	**Blennies (Tube)**		
				Acanthemblemaria aspera	Roughhead Blenny	11%	1.5

Appendix A, Continued

Scientific Name	Common Name	SF%	DEN	Scientific Name	Common Name	SF%	DEN
Chaenopsidae *(cont.)*	**Blennies (Tube)**			**Gerreidae *(cont.)***	**Mojarra**		
**Acanthemblemaria chaplini*	Papillose Blenny	0.1%	1.0	**Eucinostomus gula*	Silver Jenny	0.1%	2.0
Acanthemblemaria maria	Secretary Blenny	16%	1.6	*Eucinostomus jonesi*	Slender Mojarra	0.1%	2.0
Emblemaria pandionis	Sailfin Blenny	14%	1.7	*Gerres cinereus*	Yellowfin Mojarra	11%	1.9
Emblemariopsis sp.	Darkhead Blenny	4%	1.2	**Gobiesocidae**	**Clingfishes**		
Lucayablennius zingaro	Arrow Blenny	19%	1.5	*Arcos rubiginosus*	Red Clingfish	1%	1.4
Chaetondontidae	**Butterflyfishes**			*Gobiesox punctulatus*	Stippled Clingfish	0.1%	1.0
Chaetodon aculeatus	Longsnout Butterflyfish	26%	1.5	**Gobiidae**	**Gobies**		
Chaetodon capistratus	Foureye Butterflyfish	94%	2.1	*Coryphopterus personatus/hyalinus*	Masked/Glass Goby	82%	3.7
Chaetodon ocellatus	Spotfin Butterflyfish	38%	1.7	*Coryphopterus dicrus*	Colon Goby	3%	1.2
Chaetodon sedentarius	Reef Butterflyfish	1%	1.1	*Coryphopterus eidolon*	Pallid Goby	20%	1.6
Chaetodon striatus	Banded Butterflyfish	73%	1.8	*Coryphopterus glaucofraenum*	Bridled Goby	63%	2.3
Cirrhitidae	**Hawkfishes**			*Coryphopterus lipernes*	Peppermint Goby	46%	1.9
Amblycirrhitus pinos	Redspotted Hawkfish	29%	1.3	*Gnatholepis thompsoni*	Goldspot Goby	69%	2.4
Congridae	**Eels (Conger)**			*Gobionellus saepepallens*	Dash Goby	1%	1.4
Heteroconger halis	Brown Garden Eel	22%	3.5	**Gobiosoma chancei*	Shortstripe Goby	3%	1.7
Dactylopteridae	**Flying Gurnards**			*Gobiosoma dilepsis*	Orangesided Goby	28%	1.8
Dactylopterus volitans	Flying Gurnard	0.3%	1.5	*Gobiosoma evelynae*	Sharknose Goby	20%	1.9
Dasyatidae	**Rays (Sting)**			*Gobiosoma genie*	Cleaning Goby	49%	2.4
Dasyatis americana	Southern Stingray	23%	1.3	*Gobiosoma horsti*	Yellowline Goby	45%	1.9
Echeneididae	**Remoras**			*Gobiosoma louisae*	Spotlight Goby	6%	1.7
Echeneis naucrates	Sharksucker	5%	1.1	*Gobiosoma multifasciatum*	Greenbanded Goby	6%	2.0
Elopidae	**Tarpon**			*Gobiosoma pallens*	Semiscaled Goby	4%	1.3
Megalops atlanticus	Tarpon	22%	2.2	**Gobiosoma saucrum*	Leopard Goby	0.3%	1.5
Ephippidae	**Spadefishes**			**Gobiosoma xanthiprora*	Yellowprow Goby	0.1%	2.0
**Chaetodipterus faber*	Atlantic Spadefish	1%	1.2	**Ioglossus helenae*	Hovering Goby	2%	1.4
Exocoetidae	**Flyingfishes/Halfbeeks**			**Microgobius carri*	Seminole Goby	0.1%	1.0
**Hemiramphus balao*	Balao	0.1%	3.0	**Nes longus*	Orangespotted Goby	0.3%	1.5
**Hirundichthys speculiger*	Mirrorwing Flyingfish	SO[1]		*Priolepis hipoliti*	Rusty Goby	3%	1.2
Fistulariidae	**Cornetfishes**			*Risor ruber*	Tusked Goby	1%	1.5
Fistularia tabacaria	Bluespotted Cornetfish	1%	1.5	**Grammatidae**	**Basslets**		
Gerreidae	**Mojarra**			**Gramma linki*	Yellowcheek Basslet	0.1%	1.0
**Eucinostomus melanopterus*	Flagfin Mojarra	0.3%	2.0				

Scientific Name	Common Name	SF%	DEN	Scientific Name	Common Name	SF%	DEN
Grammatidae *(cont.)*	**Basslets**			**Labridae *(cont.)***	**Wrassess**		
Gramma melacara	Blackcap Basslet	34%	3.4	*Doratonotus megalepis*	Dwarf Wrasse	1%	1.0
Lipogramma trilineatum	Threeline Basslet	2%	1.4	*Halichoeres bivittatus*	Slippery Dick	42%	2.2
Haemulidae	**Grunts**			**Halichoeres cyanocephalus*	Yellowcheek Wrasse	2%	1.1
Anisotremus surinamensis	Black Margate	3%	1.5	*Halichoeres garnoti*	Yellowhead Wrasse	93%	2.8
Anisotremus virginicus	Porkfish	1%	1.3	*Halichoeres maculipinna*	Clown Wrasse	43%	2.0
Haemulon album	White Margate	17%	1.5	**Halichoeres pictus*	Rainbow Wrasse	16%	2.0
Haemulon aurolineatum	Tomtate	6%	2.3	**Halichoeres poeyi*	Blackear Wrasse	0.1%	2.0
Haemulon carbonarium	Caesar Grunt	26%	2.3	*Halichoeres radiatus*	Puddingwife	19%	1.4
Haemulon chrysargyreum	Smallmouth Grunt	1%	2.5	**Hemipteronotus martinicensis*	Rosy Razorfish	19%	2.2
Haemulon flavolineatum	French Grunt	89%	2.3	*Hemipteronotus splendens*	Green Razorfish	28%	1.9
**Haemulon macrostomum*	Spanish Grunt	3%	1.7	*Lachnolaimus maximus*	Hogfish	44%	1.3
**Haemulon melanurum*	Cottonwick	1%	1.7	*Thalassoma bifasciatum*	Bluehead	97%	3.3
Haemulon parra	Sailors Choice	18%	2.2	**Labrisomidae**	**Blennies (Scaly)**		
Haemulon plumieri	White Grunt	69%	1.8	*Acanthemblemaria spinosa*	Spinyhead Blenny	4%	1.4
Haemulon sciurus	Bluestriped Grunt	65%	2.0	*Chaenopsis limbaughi*	Yellowface Pikeblenny	1%	1.0
**Haemulon striatum*	Striped Grunt	0.3%	2.0	**Hemiemblemaria simulus*	Wrasse Blenny	1%	1.2
Holocentridae	**Squirrelfishes**			**Labrisomus filamentosus*	Quillfin Blenny	0%	2.0
Holocentrus adscensionis	Squirrelfish	57%	1.9	*Labrisomus gobio*	Palehead Blenny	0.1%	1.0
Holocentrus coruscum	Reef Squirrelfish	3%	1.7	**Labrisomus kalisherae*	Downy Blenny	0.1%	1.0
Holocentrus marianus	Longjaw Squirrelfish	69%	2.0	*Malacoctenus aurolineatus*	Goldline Blenny	2%	1.7
Holocentrus rufus	Longspine Squirrelfish	68%	2.0	*Malacoctenus boehlkei*	Diamond Blenny	25%	1.5
Holocentrus vexillarius	Dusky Squirrelfish	19%	1.9	*Malacoctenus macropus*	Rosy Blenny	7%	1.5
Myripristis jacobus	Blackbar Soldierfish	54%	2.0	*Malacoctenus triangulatus*	Saddled Blenny	75%	2.3
Plectrypops retrospinis	Cardinal Soldierfish	2%	1.2	*Malacoctenus versicolor*	Barfin Blenny	0.1%	1.0
Inermiidae	**Bonnetmouths**			*Starksia nanodes*	Dwarf Blenny	0.1%	2.0
**Emmelichthyops atlanticus*	Bonnetmouth	0.4%	3.0	**Lutjanidae**	**Snappers**		
**Inermia vittata*	Boga	17%	3.0	*Apsilus dentatus*	Black Snapper	0.6%	1.2
Kyphosidae	**Chubs**			*Lutjanus analis*	Mutton Snapper	59%	1.5
Kyphosus sectatrix/incisor	Bermuda/Yellow Chub	78%	2.4	*Lutjanus apodus*	Schoolmaster	91%	2.4
Labridae	**Wrassess**			*Lutjanus buccanella*	Blackfin Snapper	17%	2.0
Bodianus pulchellus	Spotfin Hogfish	1%	1.5	*Lutjanus cyanopterus*	Cubera Snapper	3%	1.2
Bodianus rufus	Spanish Hogfish	74%	1.9	*Lutjanus griseus*	Gray Snapper	4%	1.9
Clepticus parrae	Creole Wrasse	87%	3.7	*Lutjanus jocu*	Dog Snapper	10%	1.3

Scientific Name	Common Name	SF%	DEN
Lutjanidae *(cont.)*	**Snappers**		
Lutjanus mahogoni	Mahogany Snapper	69%	2.2
Lutjanus synagris	Lane Snapper	2%	1.9
Ocyurus chrysurus	Yellowtail Snapper	89%	2.5
Matacanthidae	**Tilefishes**		
Malacanthus plumieri	Sand Tilefish	74%	2.0
Mobulidae	**Ray (Mantas)**		
Manta birostris	Manta	0.3%	1.0
Mullidae	**Goatfishes**		
Mulloidichthys martinicus	Yellow Goatfish	84%	2.4
Pseudupeneus maculatus	Spotted Goatfish	46%	1.7
Muranidae	**Eels (Moray)**		
Echidna catenata	Chain Moray	0.1%	1.0
Enchelycore carychroa	Chestnut Moray	0.1%	1.0
Gymnothorax funebris	Green Moray	5%	1.0
Gymnothorax miliaris	Goldentail Moray	4%	1.0
Gymnothorax moringa	Spotted Moray	3%	1.2
Gymnothorax vicinus	Purplemouth Moray	0.3%	2.0
Myliobatidae	**Rays (Eagle)**		
Aetobatus narinari	Spotted Eagle Ray	9%	1.1
Ogcocephalidae	**Batfishes**		
Ogcocephalus nasutus	Shortnose Batfish	SO[1]	
Ophichthidae	**Eels (Snake)**		
Myrichthys breviceps	Sharptail Eel	0.3%	1.0
Opistognathidae	**Jawfishes**		
**Opistognathus aurifrons*	Yellowhead Jawfish	42%	2.1
**Opistognathus macrognathus*	Banded Jawfish	0.3%	1.5
**Opistognathus whitehursti*	Dusky Jawfish	0.3%	1.5
Ostraciontidae	**Boxfishes**		
Lactophrys bicaudalis	Spotted Trunkfish	30%	1.1
Lactophrys polygonia	Honeycomb Cowfish	26%	1.2
Lactophrys quadricornis	Scrawled Cowfish	1%	1.6
Lactophrys trigonus	Trunkfish	0.4%	1.3
Lactophrys triqueter	Smooth Trunkfish	23%	1.2
Pempheridae	**Sweepers**		
Pempheris schomburgki	Glassy Sweeper	2%	2.2
Pomacanthidae	**Angelfishes**		
Centropyge argi	Cherubfish	1%	1.2
**Holacanthus bermudensis*	Blue Angelfish	0.1%	1.0
Holacanthus ciliaris	Queen Angelfish	35%	1.4
Holacanthus tricolor	Rock Beauty	84%	1.9
Pomacanthus arcuatus	Gray Angelfish	39%	1.4
Pomacanthus paru	French Angelfish	51%	1.3
Pomacentridae	**Damselfishes**		
Abudefduf saxatilis	Sergeant Major	49%	2.5
Abudefduf taurus	Night Sergeant	0.4%	2.0
Chromis cyanea	Blue Chromis	97%	3.8
**Chromis insolata*	Sunshinefish	18%	2.2
Chromis multilineata	Brown Chromis	95%	3.4
Microspathodon chrysurus	Yellowtail Damselfish	57%	2.0
Stegastes diencaeus	Longfin Damselfish	82%	2.3
Stegastes fuscus	Dusky Damselfish	18%	1.8
Stegastes leucostictus	Beaugregory	35%	1.8
Stegastes partitus	Bicolor Damselfish	96%	3.6
Stegastes planifrons	Threespot Damselfish	80%	2.2
Stegastes variabilis	Cocoa Damselfish	17%	1.5
Priacanthidae	**Bigeyes**		
Priacanthus arenatus	Bigeye	0.4%	1.0
Priacanthus cruentatus	Glasseye Snapper	9%	1.3
Rhincodontidae	**Sharks (Carpet)**		
Ginglymostoma cirratum	Nurse Shark	5%	1.0
Scaridae	**Parrotfishes**		
Cryptotomus roseus	Bluelip Parrotfish	6%	1.9
Scarus coelestinus	Midnight Parrotfish	8%	1.2
Scarus coeruleus	Blue Parrotfish	2%	1.5
Scarus croicensis	Striped Parrotfish	89%	2.4
Scarus guacamaia	Rainbow Parrotfish	15%	1.3
Scarus taeniopterus	Princess Parrotfish	88%	2.5

Scientific Name	Common Name	SF%	DEN	Scientific Name	Common Name	SF%	DEN
Scaridae *(cont.)*	**Parrotfishes**			**Serranidae *(cont.)***	**Sea Basses**		
Scarus vetula	Queen Parrotfish	59%	1.9	**Liopropoma carmabi*	Candy Bass	1%	1.0
**Sparisoma atomarium*	Greenblotch Parrotfish	41%	2.2	*Liopropoma mowbrayi*	Cave Bass	3%	1.3
Sparisoma aurofrenatum	Redband Parrotfish	93%	2.7	*Liopropoma rubre*	Peppermint Bass	19%	1.4
Sparisoma chrysopterum	Redtail Parrotfish	62%	2.0	*Mycteroperca bonaci*	Black Grouper	11%	1.2
Sparisoma radians	Bucktooth Parrotfish	2%	2.2	*Mycteroperca interstitialis*	Yellowmouth Grouper	6%	1.1
Sparisoma rubripinne	Yellowtail Parrotfish	46%	2.0	**Mycteroperca phenax*	Scamp	1%	1.2
Sparisoma viride	Stoplight Parrotfish	96%	2.7	*Mycteroperca tigris*	Tiger Grouper	54%	1.5
Sciaenidae	**Drums**			*Mycteroperca venenosa*	Yellowfin Grouper	18%	1.3
Equetus acuminatus	Highhat	1%	1.5	**Paranthias furcifer*	Creole-fish	1%	2.0
Equetus lanceolatus	Jacknife Fish	0.1%	1.0	*Rypticus saponaceus*	Greater Soapfish	18%	1.2
Equetus punctatus	Spotted Drum	15%	1.2	**Serranus baldwini*	Lantern Bass	11%	1.5
Odontoscion dentex	Reef Croaker	0.4%	1.6	*Serranus tabacarius*	Tobaccofish	53%	1.8
Scorpionidae	**Scorpionfishes**			*Serranus tigrinus*	Harlequin Bass	75%	1.9
Scorpaena plumieri	Spotted Scorpionfish	6%	1.1	**Serranus tortugarum*	Chalk Bass	7%	1.7
Scorpaenodes caribbaeus	Reef Scorpionfish	1%	1.0	**Sparidae**	**Porgies**		
Serranidae	**Sea Basses**			*Calamus bajonado*	Jolthead Porgy	15%	1.2
Epinephelus adscensionis	Rock Hind	2%	1.1	*Calamus calamus*	Saucereye Porgy	27%	1.3
Epinephelus cruentatus	Graysby	92%	2.1	**Calamus pennatula*	Pluma	1%	1.1
Epinephelus fulvus	Coney	81%	2.1	**Sphyraenidae**	**Barracudas**		
Epinephelus guttatus	Red Hind	27%	1.3	*Sphyraena barracuda*	Great Barracuda	49%	1.5
Epinephelus itajara	Goliath Grouper	0.6%	1.2	*Sphyraena picudilla*	Southern Sennet	1%	3.5
**Epinephelus morio*	Red Grouper	0.3%	1.5	**Sphyrnidae**	**Sharks (Hammerhead)**		
Epinephelus striatus	Nassau Grouper	50%	1.5	**Sphyrna lewini*	Scalloped Hammerhead	SO[1]	
Hypoplectrus aberrans	Yellowbelly Hamlet	4%	1.2	**Syngnathidae**	**Pipefishes/Seahorses**		
**Hypoplectrus chlorurus*	Yellowtail Hamlet	0.3%	1.0	**Acentronura dendritica*	Pipehorse	0.4%	1.6
Hypoplectrus gummigutta	Golden Hamlet	0.4%	1.0	**Cosmocampus albirostris*	Whitenose Pipefish	0.1%	1.0
Hypoplectrus guttavarius	Shy Hamlet	21%	1.3	**Hippocampus erectus*	Lined Seahorse	0.4%	1.0
Hypoplectrus indigo	Indigo Hamlet	9%	1.3	**Synodotidae**	**Lizzardfishes**		
Hypoplectrus nigricans	Black Hamlet	14%	1.4	*Synodus intermedius*	Sand Diver	5%	1.1
Hypoplectrus puella	Barred Hamlet	64%	1.8	**Synodus saurus*	Bluestriped Lizardfish	0.3%	1.0
**Hypoplectrus sp.*	Masked Hamlet	2%	1.0	*Synodus synodus*	Red Lizardfish	0.4%	1.0
**Hypoplectrus sp.*	Tan Hamlet	2%	1.0	**Tetradontidae**	**Puffers**		
Hypoplectrus unicolor	Butter Hamlet	19%	1.3	*Canthigaster rostrata*	Sharpnose Puffer	92%	2.1

Scientific Name	Common Name	SF%	DEN	Scientific Name	Common Name	SF%	DEN
Tetradontidae *(cont.)*	**Puffers**			**Tripterygiidae**	**Blennies (Tripplefin)**		
**Chilomycterus antennatus*	Bridled Burrfish	0.3%	1.0	*Enneanectes altivelis*	Lofty Triplefin	2%	1.0
Diodon holocanthus	Balloonfish	4%	1.0	*Enneanectes atrorus*	Blackedge Triplefin	0.1%	1.0
**Diodon hystrix*	Porcupinefish	13%	1.1	*Enneanectes boehlkei*	Roughhead Triplefin	2%	1.4
Sphoeroides spengleri	Bandtail Puffer	5%	1.2	*Enneanectes pectoralis*	Redeye Triplefin	3%	1.1
Torpedinidae	**Rays (Torpedo Electric)**			**Urolophidae**	**Rays (Round)**		
**Narcine brasiliensis*	Lesser Electric Ray	0.1%	2.0	*Urolophus jamaicensis*	Yellow Stingray	6%	1.2

[1]Species Only, those seen during REEF surveys with no abundance estimates.

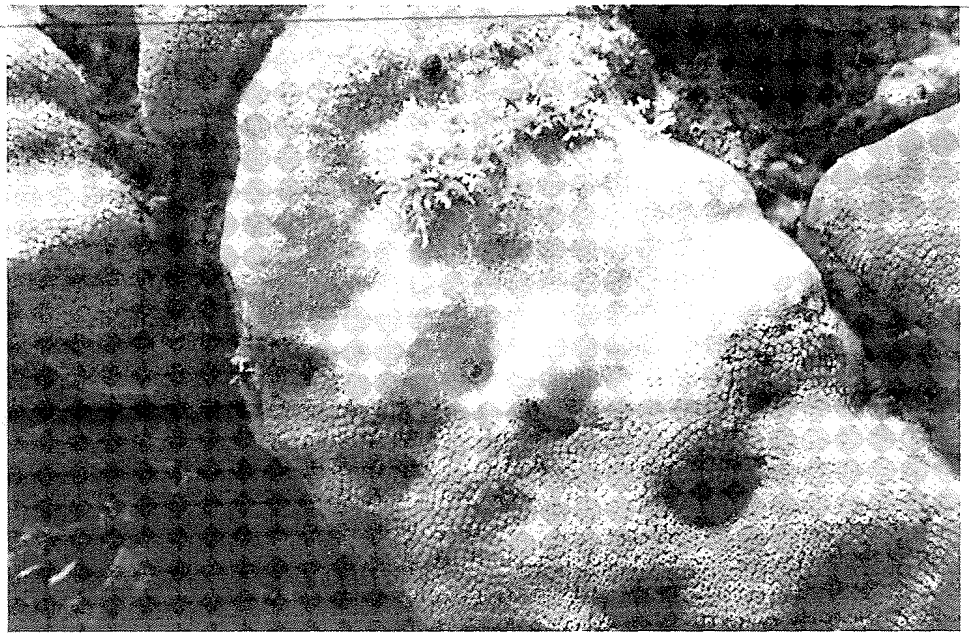

Plate 6A. "Recent mortality," as in this *Montastraea annularis* lobe, is defined as any non-living parts of the coral in which the corallite structures are white and either still intact or covered by a thin layer of algae or fine mud. (Photo Kenneth W. Marks)

Plate 6B. Recent mortality resulting from parrotfish bites, most commonly observed in the *Montastraea annularis* species complex (as shown) and *Colpophyllia natans,* is characterized by partial loss of the skeleton along with the overlying living tissues. (Photo Robert S. Steneck)