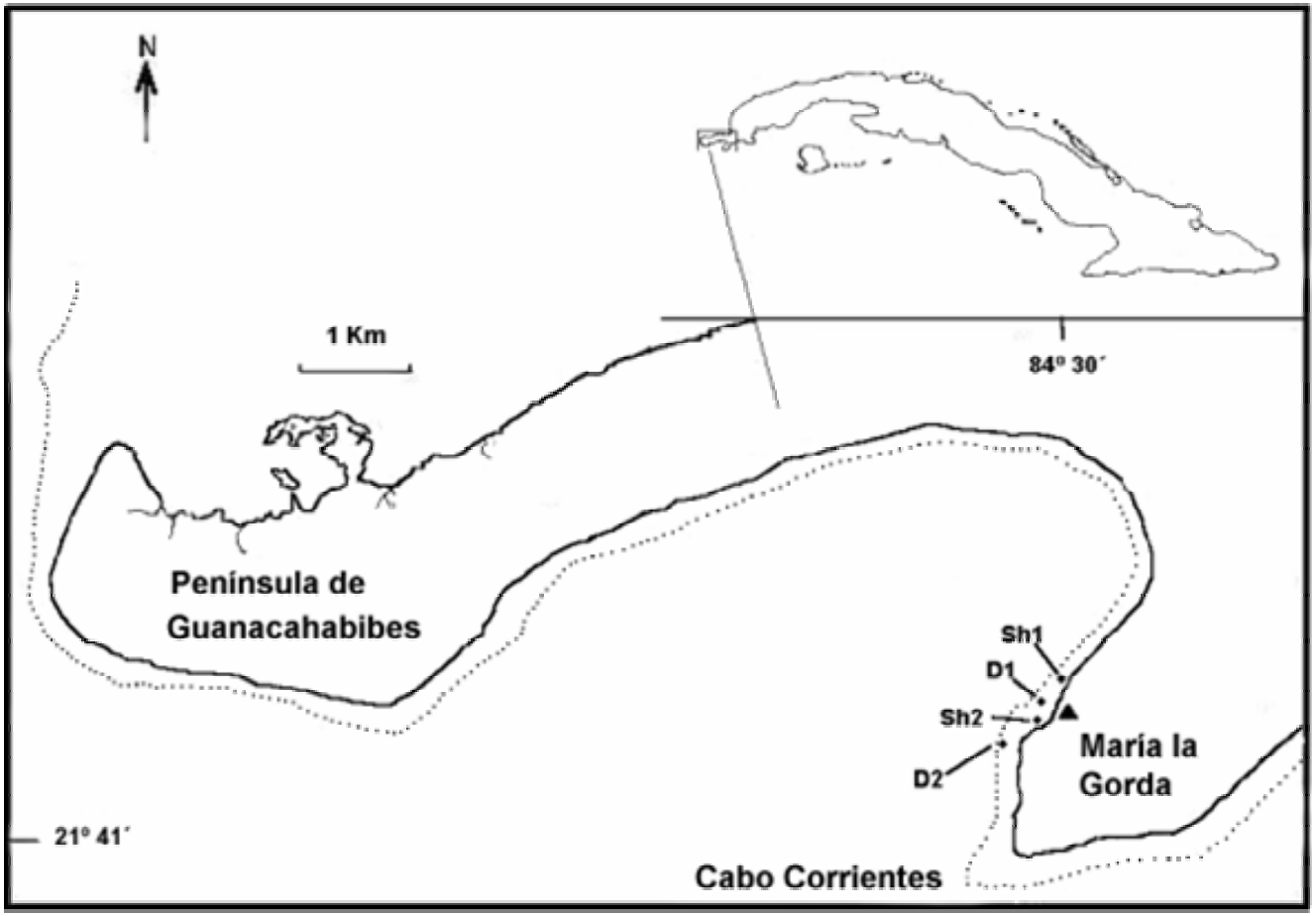

Figure 1. AGRRA survey sites in María la Gorda, Cuba. See Table 1 for site codes.

RAPID ASSESSMENT OF CORAL COMMUNITIES OF MARÍA LA GORDA, SOUTHEAST ENSENADA DE CORRIENTES, CUBA (PART 2: REEF FISHES)

BY

RODOLFO CLARO[1] and KAREL CANTELAR RAMOS[1]

ABSTRACT

An assessment of fish community structure was carried out in the fringing reef at María la Gorda in the Guanacahabibes Biosphere Reserve, following the Atlantic and Gulf Rapid Reef Assessment protocols. Quantitative "all species" surveys were also taken for comparison with existing information elsewhere. Unexpectedly for a no-take reserve, fish density and biomass were very low in comparison with other Cuban reefs. In the two shallower (5-8 m) reefs, parrotfishes and grunts were numerically dominant, and grunts were dominant in terms of biomass, but most were small-sized species. A balistid *(Melichthys niger)* dominated one of the deeper (9-10 m) reefs. Groupers and most snappers were uncommon at all depths. The scarcity of medium- and large-sized fishes is a consequence of illegal fishing in the reserve. Reduced predation by piscivores may also have caused the proliferation of damselfishes, some of which are killing corals and may be facilitating the spread of coral diseases.

INTRODUCTION

The leeward fringing coral reef at María la Gorda, a small resort in the Península de Guanahacabibes Biosphere Reserve in western Cuba, is considered one of the nation's most beautiful and best conserved. The only tourist facility, which has 29 rooms and belongs to a scuba diving resort, is located near the southeastern tip of Ensenada de Corrientes (Fig.1). Not far from this resort is a small settlement with 22 houses, a frontier guard-post, a visitor's center for the reserve, and a meteorological radar station. There are fewer than 200 inhabitants (including tourists) during the high tourism season (about six months of the year). The Reserve has been a no-take area for fishing since 1996 by a Resolution of the Ministry of Fishing Industry. Hence its coral reefs would be expected to have a relatively intact fish population. However, there is no existing quantitative information regarding the fish communities in this area.

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Reef lobes of irregular shapes, but elongated parallel to the bay's coastline, rise 1-2 m above a gently sloping sandy terrace between depths of 5 and 15 m. Live stony coral cover and the density of "large" (≥25 cm diameter) colonies were both considered moderate in July 1999, slightly higher at 5-6 m in two shallow lobes (5-6 m) than in two deeper lobes (8-11 m), and dominated by *Montastraea annularis, M. franksi, Siderastrea siderea and M. faveolata* (Alcolado et al., this volume). Nevertheless, the preferred dive sites for tourists are on the higher relief, structurally more complex, and biologically more diverse reefs that are located at depths of 20-30 m along the outer margin of the terrace.

The topography on the reef lobes is very irregular, potentially providing plenty of shelter for fishes and mobile invertebrates. Fishermen who have worked for many years in the area and local villagers emphasized that, until about 20 years ago, the fringing reef supported numerous, large- and medium- sized predatory fishes such as snappers (lutjanids), groupers (serranids), and large-sized parrotfishes (scarids).

The María la Gorda area was traditionally fished by commercial fishermen using such artisanal fishing gear as fish traps and hooks and lines. Eventually, non-commercial fishers began to use spearguns. Illegal speargun and hook-and-line fishing increased during the early 1990s due to the economic crisis in the country. Small-scale commercial fishing currently occurs outside the reserve, where a few tourists are probably also allowed to fish. The latter is not significant, but due to the small size of the reserve, resident fishes can be harvested close to its boundaries during their local migrations. Illegal subsistence fishing, practiced by local residents and outsiders, continues within and outside the reserve, due to a low level of enforcement of the regulations.

Located approximately eight km southwest of the reserve's boundary, at a depth of 25-40 m in Cabo Corrientes, is a well-known spawning site for mutton snapper (*Lutjanus analis*) in June, cubera (*L. cyanopterus*) and dog snapper (*L. jocu*) in July-August, Nassau grouper (*Epinephelus striatus*) in December-January, plus black grouper (*Mycteroperca bonaci*) and yellowfin grouper (*M. venenosa*) in January-March. These aggregations are fished mainly with hooks and lines and fish traps (Claro and Lindeman, in press).

The objective of this paper is to contribute to the assessment of reef condition at María la Gorda by examining the status of the fish community and its relationship to impacts.

METHODS

The reef at María la Gorda was strategically chosen on the basis of its reputation among divers. Four fish surveys were carried out at two depths (5-8 m and 9-13 m) on representative fore-reef lobes in July 1999 (Table 1). Fishes were visually censused using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) Version 2.2 protocols (see Appendix One, this volume), modified as described below. Quantitative data for the AGRRA fishes in each reef were collected along six belt transects, each 50-m long x 2 m wide, provided quantitative data for the AGGRA fishes in each reef. The transect tape was

set on the substratum by the diver, and the counts started five minutes later. Counts of serranids were restricted to species of *Epinephelus* and *Mycteroperca*; scarids and haemulids (grunts) less than 5 cm in length were not tallied. All surveys were made between 10:00 and 17:00 hours by two divers. For identifications, we used Humann's (1994) guide to reef fishes.

Leatherjackets were classified according to Eschmeyer's (1998) revision, in which *Balistes* and *Melichthys* are in the Balistidae, while *Aluterus* and *Cantherhines* are assigned to the Monacanthidae. Biomass estimates of the AGRRA fishes were made using the length-weight relationships given by Garcia-Arteaga et al. (1997) for Cuban fishes. A ranking index (% sighting frequency x % abundance) was calculated for the 25 most abundant of these fishes (data summed over all sites). Species diversity (H'), richness (R_1), and evenness (J) indices for all fish species were estimated on the basis of two qualitative, 30-minute roving diver surveys in each reef.

We made six additional "all species" belt transects (each 50 m long x 2 m wide) to count and estimate sizes of all fishes in three of the reefs, to compare with similar surveys made at 15 m depth in 16 sites of the Archipelago los Canarreos (SW Cuba) in 1988-1989. Even though the data are not fully comparable statistically, due to the small sample size at María la Gorda, the comparison may serve as a primary reference for assessing current conditions in Maria la Gorda's population of reef fishes.

RESULTS

Fish Diversity

A total of 88 fish species (Table 2) were found during the eight roving diver censuses (mean = 58/reef, sd= 6). Relative to the two shallow reefs, estimates of species diversity and evenness in the two deeper reefs were slightly lower, while species richness estimates were slightly higher. The most frequently sighted and abundant of these species were the blue chromis *(Chromis cyanea)*, bluehead wrasse *(Thalassoma bifasciatum),* and bicolor damselfish *(Stegastes partitus)* (Table 3).

In the "all species" belt transects, there were 42-54 species per reef (for a total of 71 species). Between 25 and 29 of the AGRRA species were seen in the AGRRA belt transects in each reef (total =45). Highest in the AGRRA hierarchy index were French grunt *(Haemulon flavolineatum*), striped parrotfish *(Scarus iserti, =S. croicensis,* see Eschmeyer, 1998) and blue tang *(Acanthurus coeruleus)* (Table 4).

Fish Density

The total density of the AGRRA fishes (Table 5) was nearly identical in the two shallower reefs (~30.3 and 31.2 individuals/100 m^2) but more variable in the two deeper reefs (~20.3 and 37.5 individuals/100 m^2). Herbivorous fishes, primarily small-sized parrotfishes, comprised over half (~52%) of the total numerical count while grunts constituted the second most abundant family overall (Fig. 2). Striped parrotfish dominated in one of the shallow reefs (Sh-1), whereas French grunts were predominant in

the other (Sh-2). A large group of black durgeon *(Melichthys niger)* and blue tang (*Acanthurus coeruleus*) predominated in one of the deeper reefs (D-1), where yellowtail snapper (*Ocyurus chrysurus*) were also moderately common. The second deeper reef (D-2) had the fewest fishes overall and lacked dominance by any species. Surgeonfishes (acanthurids) were slightly more abundant in the two deeper reefs than in the shallower reefs. Densities of snappers, angelfishes (pomacanthids), butterflyfishes (chaeotodontids), and select groupers (*Epinephelus* and *Mycteroperca*) each totaled <6 individuals/100 m^2 for the four reefs. However, a larger number of snappers *(O. chrysurus* and *Lutjanus apodus)* were observed close to the edge of the reef (and outside the area covered by the belt transects) during the roving diver censuses at one of the deeper reefs (D-1).

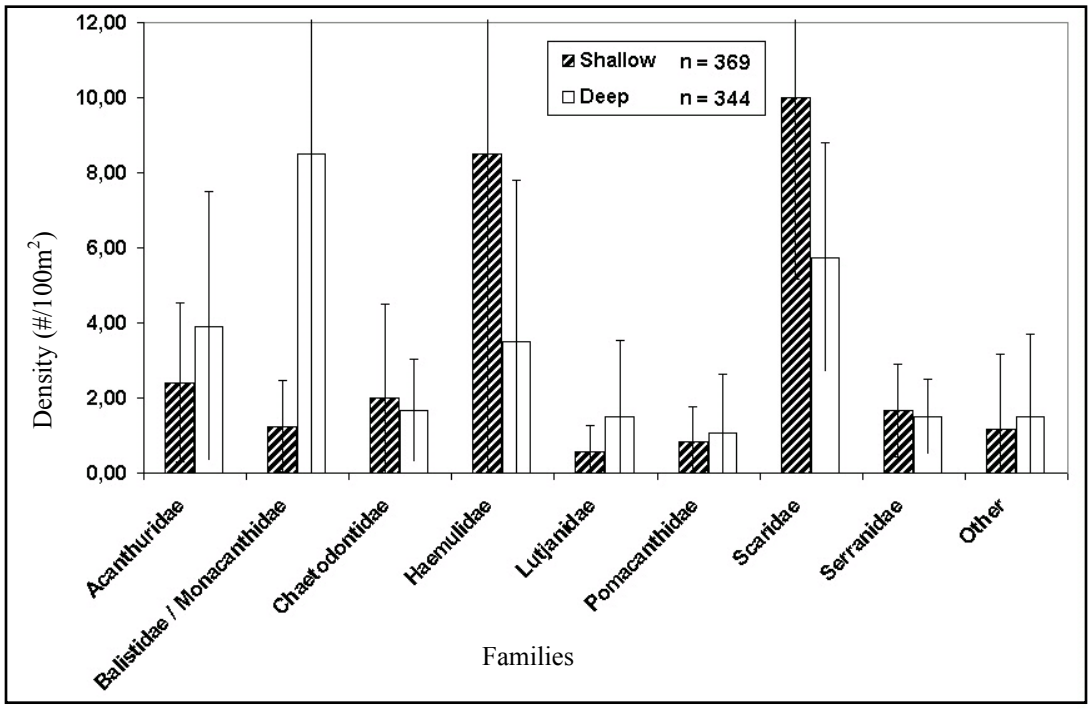

Figure 2. Mean fish density (no. individuals/100 m^2 ± sd) for AGRRA fishes in María la Gorda, Cuba. Other = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Microspathodon chrysurus, Sphyraena barracuda.*

The mean density of fishes in the "all species" belt transects was nearly 20 times greater than that of the selected species in the AGRRA fish transects (541 versus ~30 individuals/100 m^2). Damselfishes (pomacentrids) were the most abundant family with a mean density of 126 individuals/100 m^2, and most (>93%) of these were bicolor damselfish (Table 6). At approximately 36 individuals/100 m^2, the average density of herbivores (all parrotfishes and surgeonfishes, *Microspathodon chrysurus*) was almost 20 times greater than the average density of carnivores (all snappers, *Epinephelus, Mycteroperca*), of which there were only 2.6 individuals/100 m^2.

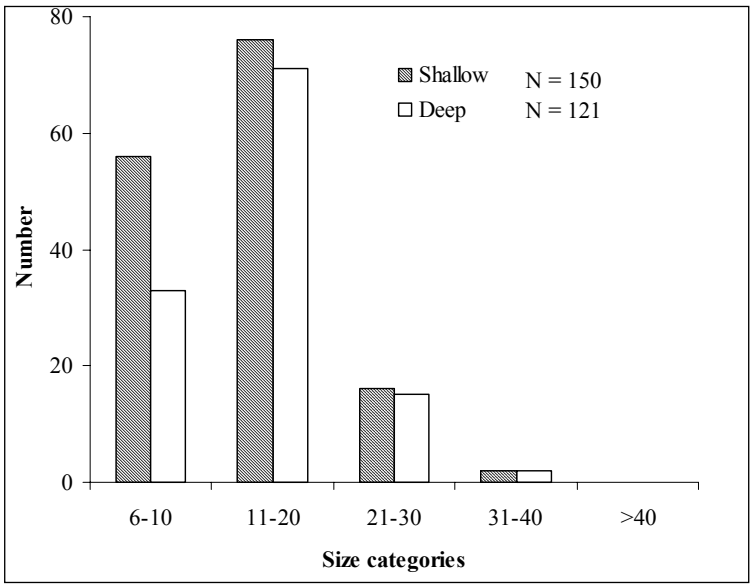

Figure 3. Size frequency distribution (in cm) of herbivores (acanthurids, scarids ≥5 cm, *Microspathodon chrysurus*) in María la Gorda, Cuba.

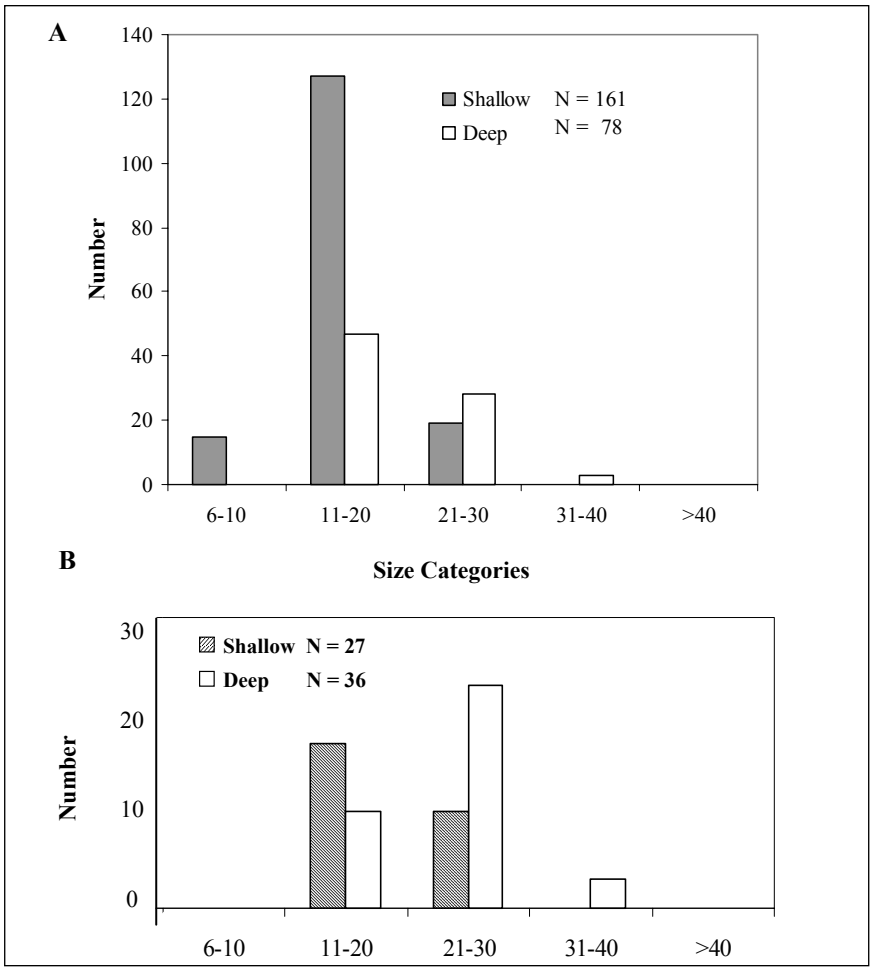

Figure 4. Size frequency distribution in cm of carnivores, as (**A**) all lutjanids and haemulids ≥5 cm, select serranids and (**B**) all lutjanids and select serranids, in María la Gorda, Cuba.

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Fish Size

Most of the key herbivores (acanthurids, scarids ≥5 cm, *Microspathodon chrysurus)* were less than 20 cm in total length (Fig. 3). Large-sized parrotfishes (such as *Scarus guacamaia* and *S. coelestinus*) were absent from the AGGRA belt transects, and most of the surgeonfishes were also small-sized. Regardless of whether or not grunts are included with the key AGRRA carnivores, most predatory fishes were in the 11-20 cm size class in the two shallower reefs and somewhat larger (21-30 cm) in the two deeper reefs (Fig. 4A,B).

Fish Biomass

The total biomass of the AGRRA fishes (Table 7) ranged from 2,312 g/100 m^2 (in D-2, which also had the fewest fishes) to 7,502 g/100 m^2 (in D-1, where it was elevated by the presence of the yellowtail snapper and black durgeon). Despite their similar densities, the two shallower reefs differed somewhat in biomass due to their differing species composition, the French grunts in Sh-2 being slightly larger than the striped parrotfish in Sh-1. The key herbivores overall constituted 29% of the total fish biomass. The biomass of grunts was greater in shallow water, whereas the biomass of black durgeon, surgeonfishes and, to a lesser extent, the AGRRA-listed groupers *(Epinephelus, Mycteroperca,* were higher in the deeper reefs (Fig. 5).

In the "all-species" surveys, the total fish biomass equaled 8,620g/100 m^2, of which 3,256 and 499 g/100 m^2 respectively, were comprised of the herbivores (many of which were small-sized scarids) and carnivores (Table 6).

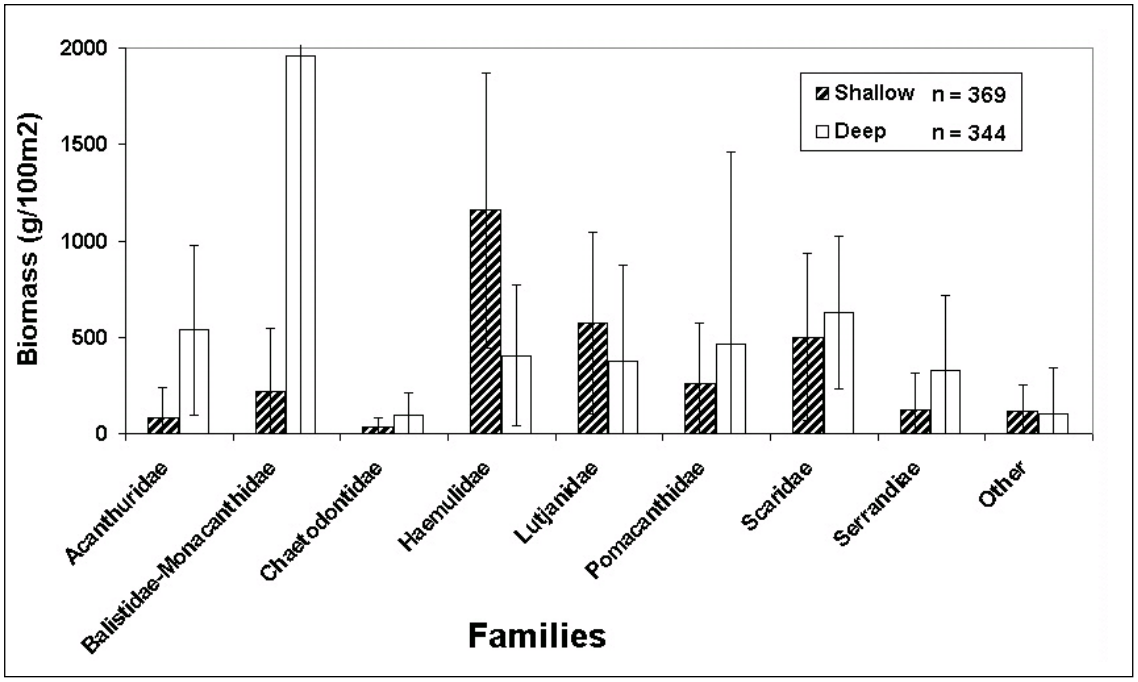

Figure 5. Mean fish biomass (grams/100m^2 ± sd) for AGRRA fishes in María la Gorda, Cuba. Other = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Microspathodon chrysurus, Sphyraena barracuda.*

Macroalgae

The macroalgal index (data from Alcolado et al., this volume) had a significant (r^2 = 0.52, p =0.95) inverse relationship with herbivore density, but showed no relationship with total herbivore biomass (Fig. 6).

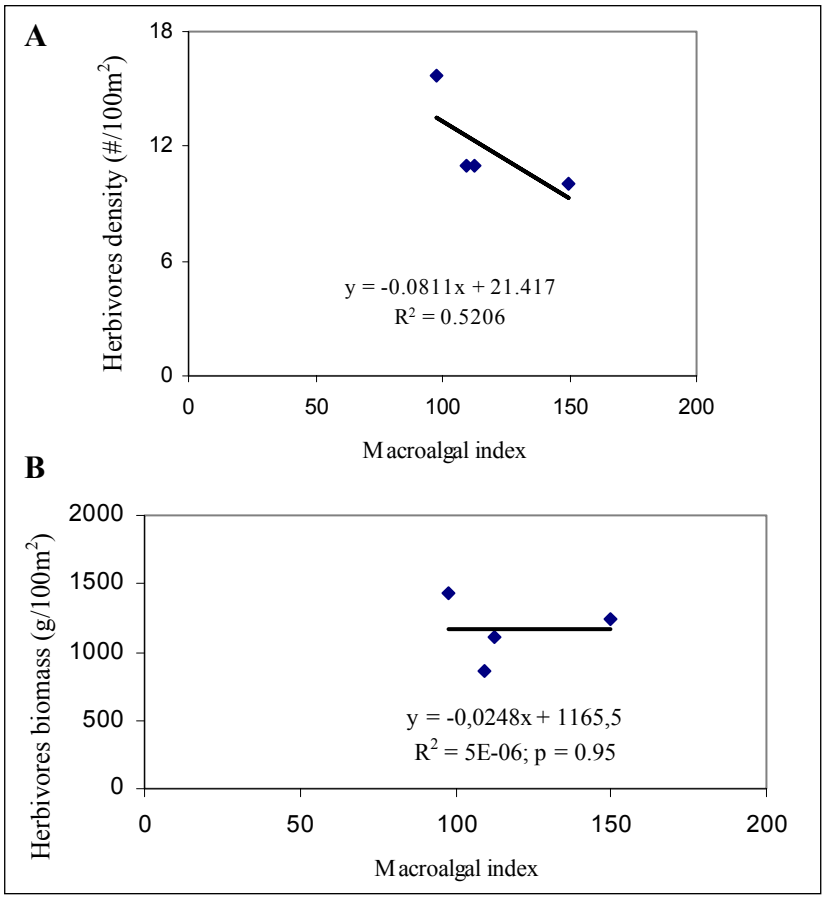

Figure 6. Regression plots between mean macroalgal index and (**A**) mean herbivore density (no. individuals/100m^2), (**B**) mean herbivore biomass (grams/100m^2), by site in María la Gorda, Cuba.

DISCUSSION

Relatively high values for the species diversity indices were found during the qualitative fish surveys at María la Gorda (Table 2). Moreover, the total number of species recorded in the "all species" transects (42 to 54, n = 6 sites) was slightly higher than the value in the Archipiélago los Canarreos (mean = 42, sd = 5, n = 21 sites) recorded in 1988-1989 (Instituto de Oceanología database). The most frequently sighted and abundant of these species (blue chromis, bicolor damselfish, and bluehead wrasse) are common dominants in many other Cuban coral reefs (Claro and García-Arteaga, 1994; Claro et al., 1998; Claro and Parenti, 2001).

Small-sized species of parrotfishes and grunts dominated the AGRRA fishes in belt transects at the two shallower reefs. Total fish biomass in María la Gorda was low

compared to other Cuban reefs. For example, corresponding biomass values for the "all species" census were approximately 30% lower than those at comparable depths in the Archipiélago los Canarreos and Archipiélago Sabana-Camagüey in 1988-1989, and less than 50% of that recorded for the Archipiélago Jardines de la Reina in 1997 (Claro and Parenti, 2001).

Herbivore biomass was 37% lower in María la Gorda than that found in 1996 in the marine reserve at the Archipiélago Jardines de la Reina, where larger-sized species are more abundant (Sierra et al., 2001). Nevertheless, the densities and biomass of herbivorous fishes in María la Gorda were higher than those recorded at the Archipiélago los Canarreos (Table 6) and at the Archipiélago Sabana-Camagüey in 1989-1990, and even exceeded corresponding values for Martinique, Guadeloupe, and Key West, Florida (Claro and Parenti, 2001).

The mean biomass of carnivorous fishes (selected groupers and snappers) was very low; values were about eight times higher in the 1988-1989 "all species" surveys at Archipiélago los Canarreos (Table 6). Particularly notable was the scarcity of snappers, which are usually common in Cuban reefs (Claro and García-Arteaga, 1994; Claro et al., 1998). For example, average snapper biomass at the Archipiélago los Canarreos in 1988-1989 was thirteen times higher than that found in 1999 off María la Gorda. The slightly higher abundance and size of carnivores in one of its deeper reefs (D-1) may result in part from the higher relief and topographic complexity at its edge, where snappers and black durgeon tend to aggregate.

Medium- to large-sized species of fishes were uncommonly scarce off María la Gorda. Habitat conditions (live stony coral cover, topographic relief and complexity, water quality, etc.) in 1999 seemed excellent and capable of supporting much higher fish densities. Anecdotal information and qualitative information (personal observations of the senior author) during the 1970s and 1980s indicate that Maria La Gorda's fish populations, especially the snappers and groupers, are drastically reduced. Indeed, this area, along with Cabo San Antonio at the westernmost edge of the Biosphere Reserve, had been well known for its abundance of large fishes.

Management objectives for the Biosphere Reserve are intended to protect its natural resources, to attract tourists, and to serve as reproductive replenishment reserves for downcurrent reefs; yet it is clear that fishing regulations here are poorly enforced. Large-sized fishes are vulnerable even to very low harvesting levels (Watson et al., 1997). Furthermore, fish that are subjected to spearfishing are likely to swim away from divers, which further diminishes the reserve's touristic value.

Removing large predators alters a reef's trophic balance, potentially allowing small territorial fishes and invertebrate predators of scleractinians, such as the snail, *Coralliophila abbreviata,* and the bristle worm, *Hermodice carunculata*, to proliferate. Indeed, along with blue chromis, loreto (*Gramma loreto*), and bluehead wrasse, the density of damselfishes at María la Gorda was eightfold greater than had been found in the Archipelago los Canarreos in 1988-1989, and the bicolor damselfish was 13 times more abundant (Claro, unpublished data; Table 5 for damselfishes). Individuals of the three-spot damselfish (*Stegastes planifrons*) were conspicuously destroying live corals in order to construct algal gardens with which to defend their territory and attract females. Fishing the larger-sized herbivorous parrotfishes can also have unintended consequences

when macroalgae and turf algae increase in abundance, as may have happened at María la Gorda (Alcolado et al., this volume).

For all of these reasons, it is very important that the regulation prohibiting fishing at María la Gorda be strictly and effectively enforced. We also recommend increasing the no-take area protected from commercial fishing, educating the professional dive guides about the ecological and economic value of intact residential fish populations, and periodic monitoring of the local fish communities. Furthermore, the commercial and sport fishing that is carried out nearby at Cabo Corrientes during the fish spawning aggregations should be completely suspended. Establishing a carefully self-regulated "catch and release" fishery for certain non-reef fishes (tarpon, bonefish) should be considered as an alternative source of revenue for displaced fishers.

ACKNOWLEDGMENTS

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Table 1. Site information for AGRRA fish surveys in María la Gorda, Cuba.

Site name	Site code	Reef type	Lat.itude (° ′)	Longitude (° ′)	Survey date	Depth (m)	(#/10 m)[1]	% live stony coral cover (mean ± sd)[1]	Macroalgal index[1]	AGRRA 50 m fish transects (#)
Yemayá	Sh-1	Fringing lobe	21 50.059	84 29.390	July 8, 1999	5-6	10.5	23.5 ± 4.5	97	6
Acuario	Sh-2	Fringing lobe	21 47.644	84 30.733	July 7 1999	5-8	8. 5	20.5 ± 5.5	110	6
Jardín de las Gorgonias	D-1	Fringing spur	21 48.566	84 30.823	July 9 1999	9-10	7. 5	17.0 ± 4.0	150	6
La Cadena Misteriosa	-D-2	Fringing spur	21 47.270	84 31.094	July 6 1999	12-13	7. 5	15.5 ± 3.0	113	6

[1] from Alcolado et al. (this volume).

Table 2. Species numbers in the surveys in María la Gorda, Cuba; species indices based on roving diver surveys.

Site code	Species number			Species indices		
	Belt transects		Roving diver	Diversity	Richness	Evenness
	AGRRA	"All species"	surveys	(H')	(R_1)	(J)
Sh-1	26	54	57	3.4	4.8	0.6
Sh-2	26	49	51	3.3	4.3	0. 6
D-1	29	42	64	3. 2	4. 9	0. 5
D-2	25	-	61	2. 7	5. 1	0. 4
∑ All sites	**45**	**71**	**88**	**3. 5**	**6. 2**	**0. 5**

Table 3. Twenty-five most frequently sighted fish species during rover diver surveys in María la Gorda, Cuba, with mean density for species in AGRRA belt transects

Species name	Ranking index[2]	Sighting frequency (%)[3]	Density (#/100 m^2)
Chromis cyaneus	*1*	*100*	
Thalassoma bifasciatum	2	100	
Stegastes partitus	3	100	
Chromis multilineatus	4	100	
Gramma loreto	5	100	
Haemulon flavolineatum	6	100	5.46
Scarus iserti (=S. croicensis)[1]	10	100	3.29
Lutjanus apodus	13	100	0.29
Melichthys niger	14	10	4.58
Sparisoma viride	15	100	1.25
Sparisoma aurofrenatum	20	100	0.63
Stegastes planifrons	18	100	
Stegastes adustus (=S. dorsopunicans)[1]	22	100	
Halichoeres bivittatus	23	100	
Serranus tigrinus	24	100	0
Haemulon plumieri	25	100	0.42
Acanthurus coeruleus	16	87	2.46
Sparisoma chrisoptera	28	85	
Halichoeres garnoti	17	85	
Caranx ruber	8	75	
Ocyurus chrysurus	12	75	0.63
Haemulon sciurus	19	75	1.38
Mulloidichthys martinicus	21	75	
Scarus taeniopterus	30	75	0.88
Chaetodon capistratus	27	75	1.42

[1]Species names according to Eschmeyer's (1998) revision.
[2]Ranking index = (% sighting frequency x % abundance.
[3]Sighting frequency = percent of all roving diver surveys in July, 1999 in which the species was recorded.

Table 4. Sighting frequency and density for the twenty-five species highest in the hierarchy index in AGRRA belt transects in María la Gorda, Cuba.

Species name	Hierarchy index[2]	Sighting frequency	Density (#/100 m^2)
Haemulon flavolineatum	1	0.75	5.46
Scarus iserti (=S. croicensis) [1]	2	0.83	3.29
Acanthurus coeruleus	3	0.79	2.46
Chaetodon capistratus	4	0.58	1.42
Sparisoma viride	5	0.75	1.25
Haemulon sciurus	6	0.50	1.38
Melichthys niger	7	0.67	4.58
Scarus taeniopterus	8	0.42	0.88
Cephalopholis cruentata	9	0.67	0.92
Sparisoma chrysopterum	10	0.42	0.88
Sparisoma aurofrenatum	11	0.42	0.63
Microspathodon chrysurus	12	0.33	0.88
Scarus vetula	13	0.38	0.46
Ocyurus chrysurus	14	0.25	0.63
Acanthurus chirurgus	15	0.33	0.50
Cehphalopholis fulva (=Epinephelus fulvus)[1]	16	0.25	0.38
Haemulon plumieri	17	0.25	0.42
Sparisoma atomarium	18	0.25	0.42
Balistes vetula	19	0.29	0.29
Holacanthus ciliaris	20	0.25	0.29
Lutjanus apodus	21	0.21	0.29
Acanthurus bahianus	22	0.17	0.21
Mycteroperca tigris	23	0.17	0.17
Pomacanthus paru	24	0.25	0.56
Bodianus rufus	25	0.17	0.29

[1]Species names according to Eschmeyer's (1998) revision.
[2]Hierarchy index = % sighting frequency x % density.

Table 5. Density of AGRRA fishes, by site in María la Gorda, Cuba.

Site code	Density (#/100 m^2)							
	Herbivores			Carnivores			Others	Total
	Acanthuridae	Scaridae (≥5 cm)	*Microspathodon chrysurus*	Haemulidae (≥5 cm)	Lutjanidae	Serranidae[1]		
Sh-1	2.67	12.33	0.17	9.00	0.17	1.50	5.34	31.83
Sh-2	2.17	7.17	1.67	13.33	0.83	1.83	3.33	30.33
D-1	4.50	5.17	0.33	2.33	2.67	1.33	20.67	37.50
D-2	3.33	6.33	1.33	4.67	0.33	1.67	2.66	20.33
All sites	**3.17**	**7.75**	**0.88**	**7.33**	**1.00**	**1.58**	**7.99**	**29.7 ± 6.9**

[1]*Epinephelus* spp. and *Mycteroperca* spp.

Table 6. Mean density and biomass of "all species" in María la Gorda (this study) and Los Canarreos (in 1988-1989).

Taxon and parameter	Canarreos (1988-1989, n=16 reefs, depth=15 m)	María La Gorda (1999, n=4 reefs, depth=5-13 m)
[1]Herbivore density (#/100 m^2)	22	36
Herbivore biomass (g/100 m^2)	1,800	3,256
[2]Snapper and grouper density (#/100 m^2)	8	2
Snapper and grouper biomass (g/1100 m^2)	3,979	499
Damselfish density (#/100 m^2)	15	126
Bicolor damselfish density (#/100 m^2)	9	118
Total fish density (#/100 m^2)	**197**	**541**
Total fish biomass (g/100 m^2)	**12,432**	**8,620**

[1]Herbivore = all herbivores; [2]Snapper and grouper = all species of lutjanids and serranids.

Table 7. Biomass of AGRRA fishes, by site in María la Gorda, Cuba.

Site code	Biomass (g/100 m^2)							
	Herbivores			Carnivores			Others	Total
	Acanthuridae	Scaridae (≥5 cm)	*Microspathodon chrysurus*	Haemulidae (≥5 cm)	Lutjanidae	Serranidae[1]		
Sh-1	324.4	1105.7	1.9	949.6	46.1	148.9	217.6	2,794
Sh-2	165	677.5	18.6	1,213.1	193.6	202.9	869	3,340
D-1	623.6	693.4	16.5	364.7	691.2	177.4	5025	7502
D-2	450.5	648.5	14.9	447.5	56.8	478.9	215.3	2312
All sites	**413.0**	**643.1**	**16.7**	**675.1**	**313.9**	**386.4**	**2,036.5**	**3,987 ± 2,380**

[1] *Epinephelus* spp. and *Mycteroperca* spp.