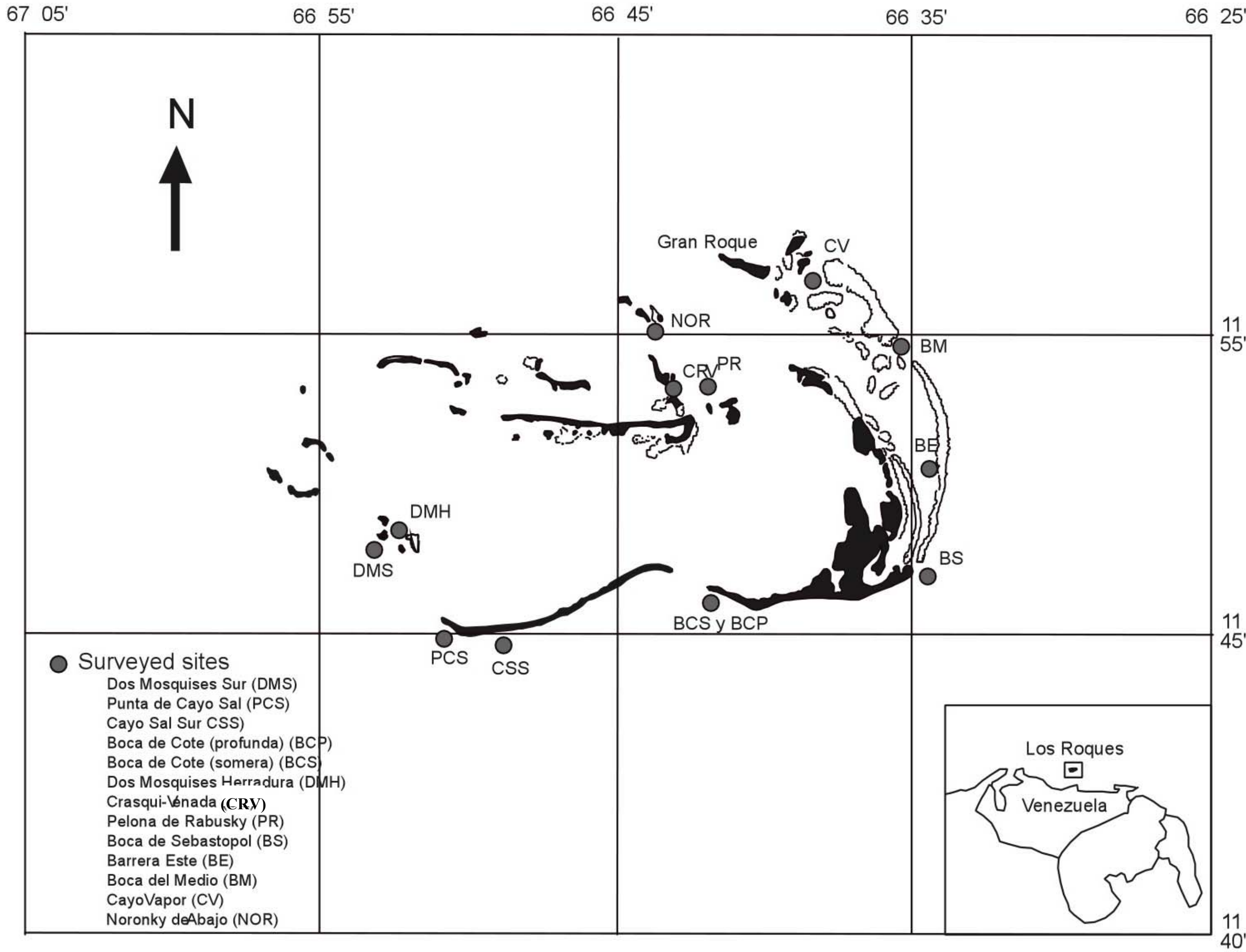

Figure 1. AGRRA survey sites in the Archipiélago de Los Roques National Park, Venezuela.

RAPID ASSESSMENT OF CORAL REEFS IN THE ARCHIPIÉLAGO DE LOS ROQUES NATIONAL PARK, VENEZUELA (PART 2: FISHES)

BY

JUAN M. POSADA,[1,2] ESTRELLA VILLAMIZAR,[2,3] and DANIELA ALVARADO[1]

ABSTRACT

The reef fish community in Archipiélago de Los Roques National Park was evaluated by using the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol in 13 sites during October, 1999. *Scarus croicensis* was a dominant herbivore in eight sites. The density of key herbivores (scarids ≥5 cm and acanthurids) was higher in the shallower (<8 m) reefs than at depths of 8-12 m; commercially important carnivores (lutjanids, select serranids) were relatively scarce in the shallow eastern sites. There was a significant inverse relationship between total fish density and live stony coral cover. The 11-20 cm size class dominated the length frequency distributions of the key herbivores and carnivores. The Los Roques fish community appears to be in good condition overall and least disturbed anthropogenically in the southern barrier reef.

INTRODUCTION

The Archipiélago de Los Roques National Park, established in 1972, is one of the oldest national marine parks in the Caribbean and is Venezuela's most important insular reef complex. Located 150 km north of the central Venezuelan coast, from 11° 44´-11° 58´N latitude and from 66°32-66°57´W longitude (Fig. 1), it covers an area of approximately 800 km^2. The 42 cays and 200 sand banks collectively form an irregular oval which is delimited to the east and south by narrow barrier reefs (approximately 20 and 30 km long, respectively) that partially enclose a shallow lagoon with a mean depth of 4 m. The lagoonal floor is predominantly bare sand or mud with important expanses of seagrass and/or macroalgal beds and numerous patch reefs.

The archipelago's location makes it especially favorable for reef development for three reasons: 1) physical environmental stability is high because it is not subject to the direct impact of hurricanes; 2) anthropogenic disturbances are low because it is remote from the continental coast; and 3) water transparency is usually clear because it is remote

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Pp. 530-543 in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496.

from any significant runoff. As a consequence, the archipelago has as unusually diverse and luxuriant coral fauna (e.g., Méndez Baamonde, 1978; Cróquer and Villamizar, 1998; García, 2001).

The archipelago sustains an important finfish and shellfish fishery (i.e., 90% of the Venezuelan spiny lobster production) and tourist activities have increased during the last 10 years. In order to manage the rational use of its commercial and natural resources, the park area has been divided into several special-use zones, e.g., full protection ("no take"), recreation, scientific interest, while commercial and recreational fishing are allowed in the rest of the archipelago. The island of Gran Roque is the most densely populated region of the archipelago (approximately 750 inhabitants) and tourism activities are mostly concentrated there or at the nearest surrounding cays. Fishing activities are restricted to hook-and-line (hand and long lines) all year round and fish traps (spiny lobster season, Nov. 1 to Apr. 31). Skin diving is allowed only for the capture of spiny lobsters, and spearfishing is prohibited throughout the entire archipelago. Fish nets were totally banned in 1994.

Studies of the fish in the archipelago have been focused on the evaluation of the biological characteristics of several species, most of which are commercially important (e.g., Hauschild, 1984; Posada et al., 1988; Ortaz et al., 1996). A smaller but still valuable effort has been devoted to creating a complete fish inventory (e.g., Cervigón and Alcalá, 1997).

The purpose of the present study was to characterize the key elements of the fish community of the archipelago according to the protocol established by the AGRRA program (http://coral.aoml.noaa.gov/agra). The results will provide a baseline of the current status of the fish community which is essential for its proper management. In addition, the results are a valuable basis for regional comparisons and for evaluating subsequent changes in the park after future repeat assessments.

METHODS

The selection of representative assessment sites in reefs where corals are abundant was based on the two senior authors' previous knowledge of the area along with advice from Patricia Kramer. Eight of the sites were in shallow water (1-7 m) and five were in depths of 8-12 meters (Table 1). Four sites were located in the fore reef of the southern barrier [Punta de Cayo Sal (PCS), Cayo Sal Sur (CSS), Boca de Cote Somero (BCS) and Boca de Cote Profundo (BCP)], while strong winds and currents forced us to restrict the four surveys of the eastern barrier [Boca de Sebastopol (BS), Barrera Este (BE), Boca del Medio (BM) and Cayo Vapor (CV)] to back-reef habitats (Fig. 1). Also surveyed were four fringing reefs surrounding small cays [Dos Mosquises Sur (DMS), Dos Mosquises Herradura (DMH), Crasquí-La Venada (CRV) and Pelona de Rabusquí (PR)] and one patch reef [Noronqui de Abajo (NOR)]. For a more detailed description of the sites and their benthos, see Villamizar et al. (this volume).

The field methodology closely followed the AGRRA Version 2.2 fish protocol (see Appendix One, this volume). All surveys were conducted by two trained observers (Posada and Alvarado). A total of 10 30 m x 2 m belt transects were swum in all reefs but one (PCS), for which there were nine transects (Table 1). Counts of serranids were restricted to species of *Epinephelus* and *Mycteroperca*; scarids and haemulids less than 5 cm in length were not tallied. The surveys were conducted between 1000 and 1500 hours except for late afternoon assessments in the two westernmost reefs (DMS and DMH).

Consistency training was conducted for a day with natural populations prior to beginning the surveys to ensure agreement on fish sightings, identification, counts, and length estimation. Field identification of fishes was based on Humann (1994). Benthos surveys were conducted at the same time (see Villamizar et al., this volume) but were spaced sufficiently far away to avoid uncontrolled perturbations of fish behavior.

Data analysis followed the AGRRA protocol. All Spearman correlation analyses were performed at a significance level of $p \leqslant 0.05$. Statistical analyses were made using nonparametric tests due to non-normality of the data, even after transformation. Macroalgal index (% macroalgal relative abundance x macroalgal height in cm) was used as a proxy for macroalgal biomass (see Villamizar et al., this volume).

A multidimensional scaling analysis (MDS), based on the Bray-Curtis similarity index (Clarke 1993), was carried out to compare the archipelago's fish community structure on the basis of the relative abundance of the AGRRA fishes. Additional comparisons were made between our fish abundance data and that provided for Los Roques in the Reef Environmental Education Foundation (REEF)'s expert database on September 29, 1999.

RESULTS

A total of 129 belt transects at 13 sites in the archipelago were made during October 4-10, 1999 (Table 1). Fifty-nine of the 70 species in our database of AGRRA fishes were observed during the belt-transect surveys, 11 of which were found at all sites: *Acanthurus bahianus*, *A. coeruleus*, *Haemulon flavolineatum, H. sciurus*, *Microspathodon chrysurus, Ocyurus chrysurus*, *Scarus croicensis, S. taeniopterus*, *S. vetula*, *Sparisoma aurofrenatum,* and *S. viride.* Two of the western reefs were most numerous in terms of AGRRA species (PCS and DMH with 36 each), while the fewest species were found in shallow reefs close to Gran Roque (NOR, BM and CV with 20, 22 and 23 species, respectively). Curiously, the reefs with the largest numbers of AGRRA species had relatively low fish densities (67.6 and 91.2 individuals/100 m^2, respectively) and vice versa (Table 1).

In general, the community structure of the AGRRA fishes was dominated by herbivorous species (scarids, acanthurids and damselfishes). *Sparisoma viride* was present in 125 of the belt transects conducted during the current study (97%), followed by *Acanthurus coeruleus* (88%), *Mycrospathodon chrysurus* (83%), *Scarus vetula* (81%) and *S. croicensis* (81%). Carnivores were well represented by the zooplankton feeder, *Ocyurus chrysurus*, which was observed in 71% of the transects; the only large-sized serranid present in the surveys was *Mycteroperca bonaci.*

When the data for all sites were pooled, the average density by family was highest for scarids (41.0 individuals/100 m^2) and acanthurids (22.5 individuals/100 m^2) and lowest for balistids and pomacanthids (each 0.8 individuals/100 m^2) and serranids (0.9 individuals/100 m^2) (Table 2). Scarids clearly predominated at both depths (Fig. 2).

Pp. 530-543 in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys, Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496.

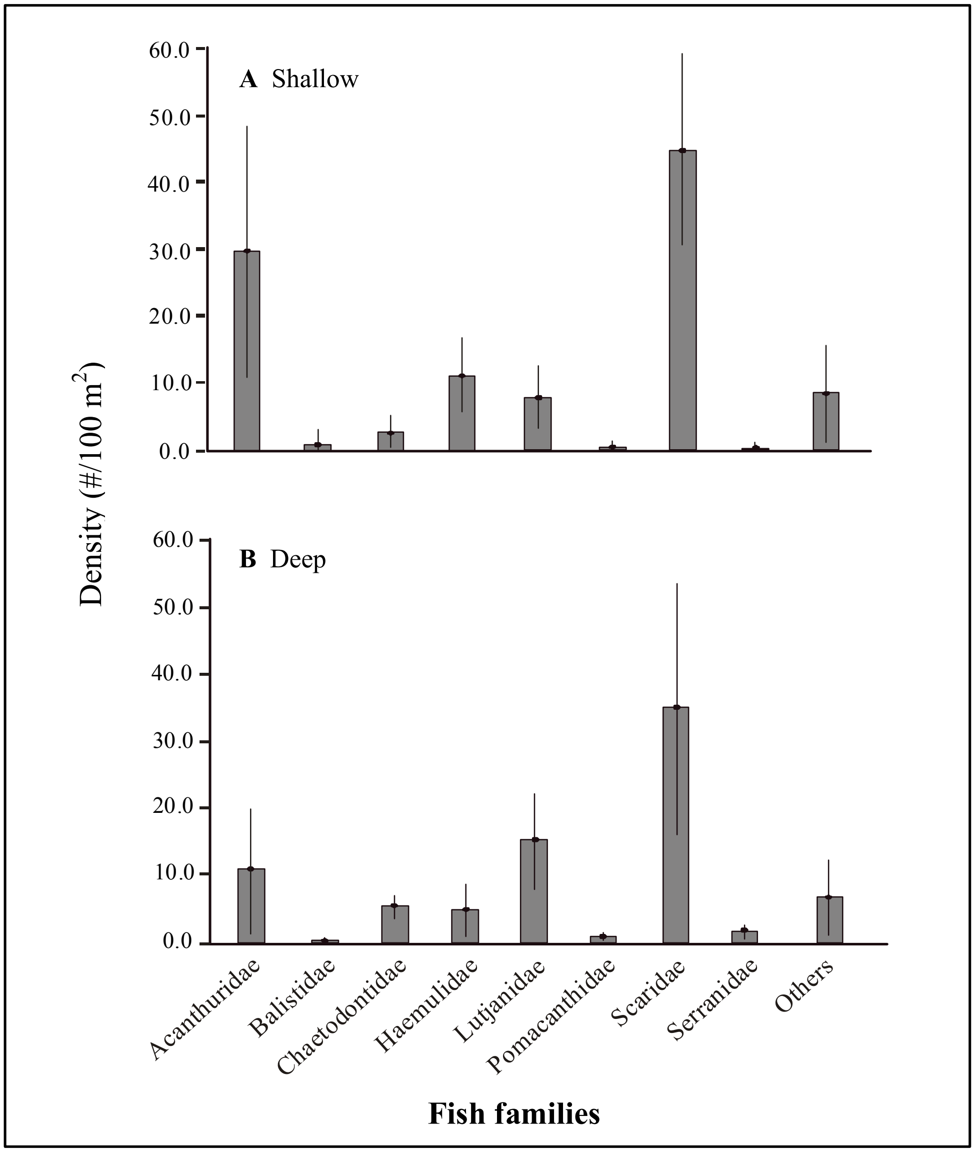

Figure 2. Mean fish density (# individuals/100 m^2 ± sd) for AGRRA fishes by depth in **(A)** shallow and **(B)** deeper sites in Los Roques, Venezuela. Others = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Microspathodon chrysurus,* and *Spyraena barracuda.*

However, both the relative abundance and the density of the scarids and acanthurids decreased with depth while the opposite trend was seen in the carnivorous serranids and lutjanids (Fig. 3). Overall, the densities of the AGRRA fishes (especially the herbivores) were highest in the reefs (many of which were shallow) located in or near the eastern barrier. Average fish densities were lower at the deeper reefs in the southern barrier where carnivorous lutjanids and serranids were more common.

Scarus croicensis was the numerical dominant in seven reefs, with a relative abundance that ranged between 11.0% (DMH) and 37.2% (DMS). *Acanthurus coeruleus* predominated at three shallow reefs (BCS, BE and NOR), with relative abundances of 19.1, 15.6 and 15.3%, respectively. *Microspathodon chrysurus* and *Acanthurus bahianus* showed the highest relative abundance in two sites (20.9% in BS and 22.4% in CV). In the only reef without a dominant herbivore (CSS), a lutjanid, *Ocyurus chrysurus*, had the highest relative abundance (18.4%).

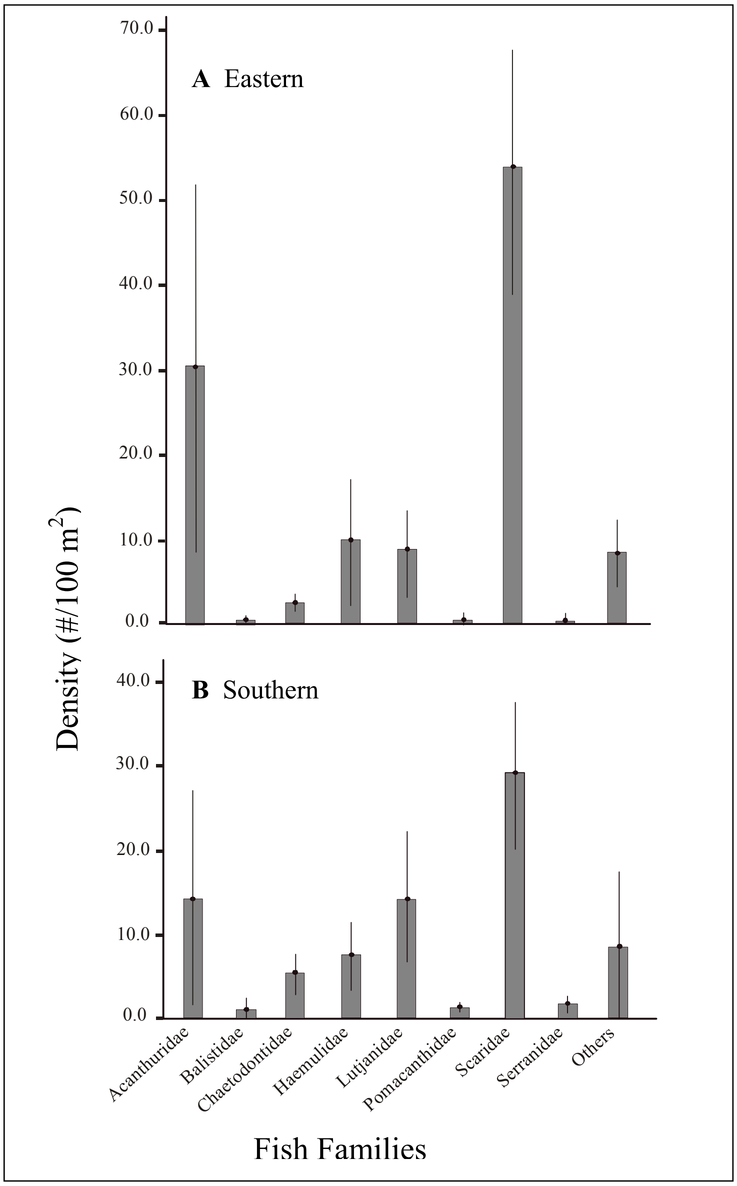

Figure 3. Mean fish density (# individuals/100 m^2 ± sd) for AGRRA fishes by geographic location in **(A)** eastern and **(B)** southern sites in Los Roques, Venezuela. Others = *Bodianus rufus, Caranx ruber, Lachnolaimus maximus, Microspathodon chrysurus* and *Spyraena barracuda.*

In the multidimensional ordination plot (Fig. 4), the fish communities in five (CV, BE, BCS, NOR and BS) of the shallow reefs clustered fairly well together and were separated from most (four/five) of the deeper reefs (CSS, PCS, BCP and DMS). Two of the deeper reefs (CSS and PCS), both located in the southern barrier, also appeared to form a separate subcluster.

An inverse, but significant correlation was observed between the total density of all the AGRRA fishes and coral reef complexity as represented by the percentage of live

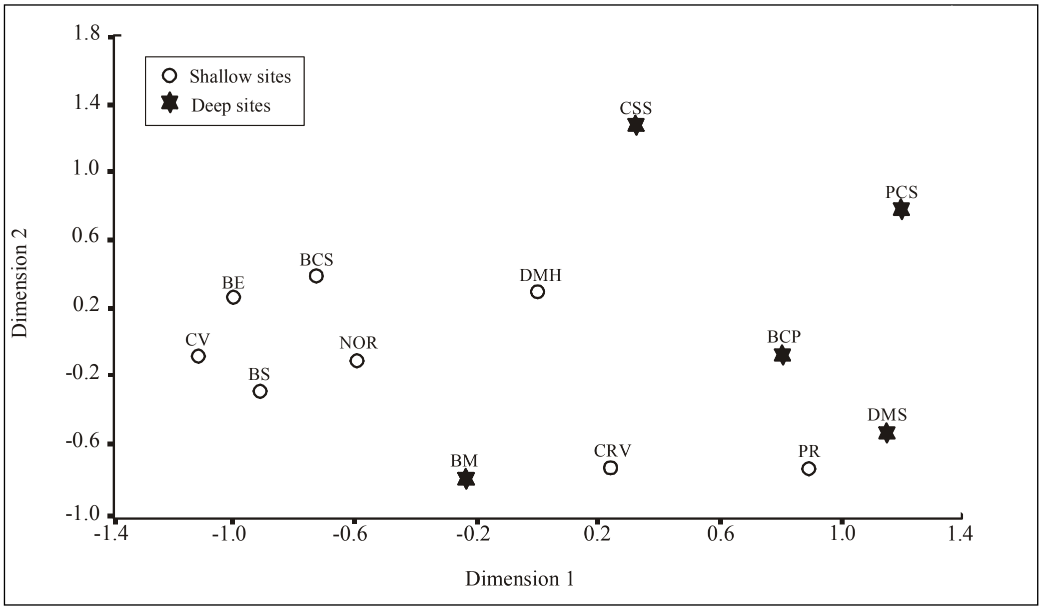

Figure 4. Multidimensional ordination plot of AGRRA fish transect data in Los Roques, Venezuela.

stony coral cover (r = -0.33; p = 0.30). However, there was no relationship between total AGRRA fish density and the diameter (r = 0.54; p = 0.05) or height (r = 0.29; p = 0.37) of the "large" (≥25 cm diameter) stony corals nor between the ratio of these two parameters of reef rugosity (r = 0.36; p = 0.24). Nor was there any relationship between the total density of the key AGRRA herbivores and macroalgal index (r = 0.33; p = 0.30).

Significant correlations were found between the density of individual fish families and several coral reef parameters. There was a clear inverse relationship between the density of acanthurids and total live stony coral cover (r = -0.61; p = 0.026) as well as the number of species (r = -0.84; p = 0.01) and density (as number/10 m) (r = –0.69; p = 0.009) of the large stony corals. Lutjanid density was significantly correlated with the number of large coral species (r = 0.69; p = 0.01) while the density of serranids was significantly correlated with large coral density (r = 0.893; p < 0.0001) and total live stony coral cover (r = 0.80; p = 0.0009).

Size frequency distributions of the AGRRA carnivores *(Epinephelus, Mycteroperca* and all lutjanids) and herbivores (scarids ≥5 cm, acanthurids, *Microspathodon chrysurus*) are shown in Figure 5. The size class that was 11-20 cm in total length (TL) dominated the length frequency distribution when all species of AGRRA fishes in all sites were grouped. Similar results were observed when subsets of the data were examined by depth stratum or reef type.

DISCUSSION

The list of species included in our AGRRA database appears to be adequate for a rapid characterization of the key elements of the Los Roques reef fish community (Table 4). For example, nearly 50% of the 59 species observed in the present belt-transect study were included in the 50 most common species listed in the REEF geographic report for Los Roques in September, 1999.

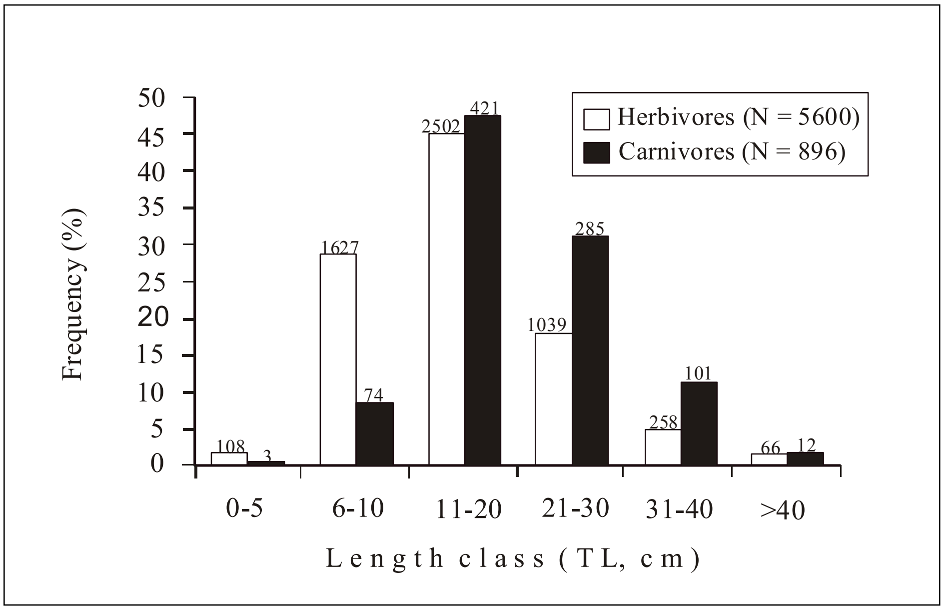

Figure 5. Size frequency distribution of herbivores (acanthurids, scarids ≥5 cm, *Microspathodon chrysurus*) and carnivores (all lutjanids, select serranids) in Los Roques, Venezuela.

Cervigón and Alcalá (1997) listed an accumulated total of 307 fish species for the Los Roques archipelago, similar to the 306 species reported from 547 Bonaire expert REEF surveys and clearly above the 270 species found in 777 Key Largo expert REEF fish counts (http://www.reef.org). The high fish diversity found recently by REEF surveys at Los Roques archipelago (217 species, expert data), despite the relatively low effort invested (106 surveys), is an unequivocal sign of an intact fish community.

Herbivores that were widespread in the AGRRA surveys *(S. viride, A. coeruleus, M. chrysurus, S. vetula, S. croicensis)* have previously been reported as common and highly abundant in both coastal and insular Venezuelan reef systems (Cervigón, 1993, 1994), while *Ocyurus chrysurus* represents the major finfish target in a fishery that, at Los Roques, is oriented towards spiny lobsters (Posada and Brunetti, 1988). Scarids and acanthurids are lightly harvested since the prohibitions against trapping, spearing, and netting of reef fishes are enforced by local authorities. In consequence, the archipelago may be considered to be a nearly unfished reef fish population.

The predominance of herbivorous species in 12 of the 13 Los Roques assessment sites can be associated with good water quality (high transparency) which facilitates benthic algal photosynthetic activities. However, abundance of herbivorous fishes declines, as expected, with depth (Choat, 1991) as the abundance of carnivores increases. That one reef (CSS) was dominated by a carnivore (*Ocyurus chrysurus*) is likely due to its proximity to the reef edge and the strong currents, full of transient zooplankton, of the southern barrier.

A large number of fish species is often related to a complex coral reef topography (Roberts and Ormond 1987). However, contradictory results were observed between fish density and different measurements of reef complexity examined at Los Roques. While significant inverse relationships were observed between total AGRRA fish density and the percentage of live stony coral cover (which is not directly related to topography), there were no relationships with other indicators of reef rugosity (i.e., diameter or height

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of the large corals, or the ratio of these two parameters). Probably none of these simple parameters are adequate indicators of optimum fish habitat and/or other processes (food availability, water quality, wave action, recruitment, community interactions; Williams, 1991) are simultaneously influencing fish abundance.

In our assessments, total fish density varied between 70.8 and 124 individuals/100 m^2. These values are below those for quantitative fish surveys reported by Alvarado (2000) at Morrocoy National Park (101-287 individuals/100 m^2), a protected coral reef located in Venezuela's central coastal zone. However, because Alvarado (2000) modified the AGRRA protocol to include all species of the Pomacentridae and Labridae, the difference between these two estimates is not considered significant. Further comparisons between these two national parks could be enlightening since the two areas differ in the degree to which each is exposed to perturbations. In contrast to Los Roques, Morrocoy National Park is located in a region highly influenced by river runoff and by a greater influence of anthropogenic activities and intense fishing pressure. In addition, its coral reefs were affected in 1996 by an as-yet-undetermined mass mortality event which, in some areas, has decreased the percentage of live stony coral cover from 40% to 1% and increased the proportion of macroalgae from 11% to 55% (Losada and Klein, unpublished manuscript).

Overall fish densities for the Scaridae, Acanthuridae, and Serranidae were very similar in Los Roques (Table 2) and Morrocoy (39.0, 22.0 and 1.0 individual/100 m^2, respectively; Alvarado, 2000). However, lutjanids were significantly more abundant in Los Roques than in Morrocoy (10.7 individuals versus 3 individuals/100 m^2, respectively). The low proportion of carnivorous species in the Morrocoy National Park fish community can be attributed to more intense fishing pressure and its smaller area.

Fish community structure was also dominated by herbivorous fishes in the Morrocoy National Park. However, whereas *Scarus croicensis* dominated in all eight of Alvarado's (2000) survey sites at Morrocoy, dominance in the Los Roques archipelago was distributed among several species (*Scarus croicensis*, *Acanthurus bahianus* and *A. coeruleus*) and families (Scaridae, Acanthuridae). In Kenya, the predominance of just one species of scarid has been linked by McClanahan (1994) to areas not protected from fishing activities.

While the 11-20 cm TL size class dominated the size frequency distributions in most of the fish families surveyed at both Los Roques and Morrocoy National Parks (Alvarado, 2000), there was a slight tendency for proportionately higher numbers of individuals to occur in the smaller (6-10 cm TL) size class in Morrocoy. Size classes above 20 cm TL were better represented in the Los Roques data, particularly for commercial species of carnivores. Differences in size structure between these two populations can be attributed to fishing pressure as it is well known that the larger individuals in a population tend to be targeted by most fishing techniques used to capture coral reef species (Russ, 1991).

In general terms, the reef fish communities in the Archipiélago de Los Roques National Park appear to be in a healthy state (highly diverse community, an abundance of individuals, some large-sized species, a good balance between herbivores and carnivores, etc.) in close concurrence with the good conditions of most of the coral reef sites visited during the present study (see García, 2001; Villamizar et al., this volume). Overall, the key elements of the fish community were more balanced in the deeper southern barrier and southwestern fringing reefs. Fewer commercially important carnivorous fishes were found close to Gran Roque and the eastern barrier. The cause(s) of this disparity could be related to natural differences associated with geographic location or depth, or could possibly be the result of anthropogenic impacts from the islands. It is recommended that special attention be given to these northeastern and eastern areas in any future studies.

Thanks to its effective protection by the Instituto Nacional de Parques (INPARQUES), the Los Roques archipelago provides one of the few opportunities in the wider Caribbean to examine a minimally disturbed fish community. This feature is of crucial importance since it provides a baseline standard against which population parameters may be measured in areas that are fished. According to H. Choat and R. Robertson (personal communication), there are few reef systems in the Caribbean with comparable high abundances of large herbivorous and carnivorous fishes. Hence, the Los Roques fish populations should be periodically monitored (at least biannually) in order to become aware of any declines. Research would also be needed to determine the factor(s) that are potentially responsible for these changes and to respond with a contingency plan. Rapid assessments, as provided by the AGRRA protocols, are very useful in countries where economic support for long-term monitoring studies is limited.

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Table 1. Site information for AGRRA fish surveys in the Archipiélago de Los Roques National Park, Venezuela.

Site name	Site code	Reef type	Latitude (° ' N)	Longitude (° ' W)	Survey date	Depth (m)	≥10 cm stony corals (#/10 m)[1]	% live stony coral cover (mean ± sd)[1]	Macroalgal index[1]	30 m fish transects (#)	AGRRA fish species (#)
Shallow sites											
Noronqui de Abajo	NOR	Patches (NE)	11 55.805	66 44.629	Oct. 10 99	1	8	21.5 ± 9.5	10	10	20
Barrera Este	BE	Barrier (East)	11 47.540	66 53.714	Oct. 8 99	1	12	18.5 ± 8.0	N[2]	10	28
Boca de Sebastopol	BS	Barrier (East)	11 46.711	66 34.827	Oct. 8 99	7	8	7.5 ± 6.5	0.5	10	32
Cayo Vapor	CV	Barrier (East)	11 57.257	66 37.360	Oct. 9 99	1	9	9.0 ± 7.0	5	10	23
Crasqui – La Venada	CRV	Fringing (CE)	11 52.868	66 53.714	Oct. 7 99	5	11	8.0 ± 9.0	<0.5	10	27
Pelona de Rabusqui	PR	Fringing (CE)	11 52.934	66 41.342	Oct. 7 99	6	12	25.5 ± 12.0	<0.5	10	28
Boca de Cote Somero	BCS	Barrier (South)	11 45.982	66 42.346	Oct. 6 99	1	11	7.5 ± 5.0	70	10	32
Dos Mosquises Herradura	DMH	Fringing (SW)	11 48.014	66 53.051	Oct. 6 99	1	15	27.5 ± 14.0	1	10	36
Deep sites											
Boca del Medio	BM	Barrier (East)	11 54.638	66 35.547	Oct. 9 99	8	7	19.0 ± 6.5	<0.5	10	22
Boca de Cote Profundo	BCP	Barrier (South)	11 45.982	66 42.346	Oct. 6 99	9	15	36.5 ± 34.5	2.5	10	27
Cayo Sal Sur	CSS	Barrier (South)	11 44.134	66 50.858	Oct. 5 99	8	17	30.5 ± 17.0	N	10	29
Punta Cayo Sal	PCS	Barrier (South)	11 44.529	66 51.463	Oct. 5 99	12	13	54.0 ± 9.5	<0.5	9	36
Dos Mosquises Sur	DMS	Fringing (East)	11 47.540	66 53.714	Oct. 5 99	8	15	60.0 ± 18.5	N	10	34

[1]From Villamizar et al. (this volume).
[2]N = no macroalgae present at this site.

Table 2. Mean density (± standard deviation) of AGRRA fishes, by depth in the Archipiélago de Los Roques National Park, Venezuela.

Sites	Density (#/100 m^2)									
	Key herbivores			Key carnivores						
	Acanthuridae	Scaridae (≥5cm)	*Microspathodon chrysurus*	Haemulidae (≥5cm)	Lutjanidae	Serranidae[1]	Chaetodontidae	Pomacanthidae	Balistidae	**Total AGRRA**
All shallow	29.7 ± 18.65	45.0 ± 14.34	7.6 ± 7.19	11.3 ± 5.59	7.9 ± 4.61	0.4 ± 0.45	2.8 ± 2.28	0.5 ± 0.61	0.9 ± 1.59	**857.2**
All deep	11.0 ± 9.50	34.8 ± 19.33	5.9 ± 5.01	5.0 ± 4.10	15.3 ± 7.42	1.8 ± 1.25	5.4 ± 2.02	1.3 ± 0.66	0.5 ± 0.35	**408.5**
All sites	**22.5 ± 17.96**	**41.0 ± 16.47**	**6.8 ± 16.47**	**8.9 ± 5.82**	**10.7 ± 6.69**	**0.9 ± 1.05**	**3.4 ± 2.47**	**0.8 ± 0.71**	**0.8 ± 1.25**	**1265.7**

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

Table 3.
Density of AGRRA fishes (mean ± standard deviation), by site in the Archipiélago de Los Roques National Park, Venezuela.

Site name[1]	Density (#/100 m^2)									
	Key herbivores			Key carnivores						
	Acanthuridae	Scaridae (≥5cm)	*Microspathodon chrysurus*	Haemulidae (≥5cm)	Lutjanidae	Serranidae[2]	Chaetodontidae	Pomacanthidae	Balistidae	**Total AGRRA**
Shallow sites										
NOR	37.5 ± 45.8	51.2 ± 20.8	3.8 ± 3.9	19.7± 24.0	1.5 ± 3.1	0.2 ± 0.5	2.2 ± 2.5	0	0	**116.7**
BE	36.5 ± 17.0	32.0 ± 7.9	6.7 ± 5.0	16.8 ± 29.0	5.7 ± 5.1	0.7 ± 1.2	2.0 ± 1.7	0.2 ± 0.5	0	**100.8**
BS	35.7 ± 12.5	36.2 ± 9.6	24.7 ± 7.32	7.2 ± 10.6	6.8 ± 5.4	0.2 ± 0.5	0.8 ± 1.2	0.8 ± 1.8	4.7 ± 4.1	**118.0**
CV	64.5 ± 30.4	43.7 ± 20.8	5.67 ± 3.1	13.2 ± 22.6	5.7 ± 9.0	0	1.2 ± 1.9	0.2 ± 0.5	0	**134.3**
CRV	13.5 ± 14.6	71.0 ± 26.1	9.5 ± 4.2	3.3 ± 2.4	13.5 ± 11.0	0.3 ± 0.7	2.8 ± 3.5	0.7 ± 0.9	0	**115.7**
PR	2.5 ± 2.1	57.5± 19.7	3.3 ± 2.7	5.8± 5.2	14.5 ± 18.6	1.2 ± 1.6	4.7 ± 2.8	1.8 ± 2.4	0.8 ± 1.2	**94.8**
BCS	22.7 ± 37.3	40.5 ± 18.3	4.7 ± 4.8	11.0 ± 21.4	4.5 ± 4.2	0	1.0 ± 1.4	0	1.3 ± 2.3	**85.5**
DMH	24.3 ± 14.3	27.7 ± 14.4	3.3 ± 2.5	13.3± 9.0	11.0 ± 11.9	1.0 ± 2.6	7.5 ± 6.0	0.7 ± 2.1	0.5 ± 0.8	**91.2**
Deep sites										
BM	27.2 ± 5.4	65.5 ± 19.9	15.0 ± 4.8	0.3 ± 0.7	10.8 ± 8.7	0.3 ± 1.1	2.3 ± 3.7	0.7 ± 1.2	0.8 ± 1.2	**124.2**
BCP	6.0 ± 3.6	33.2 ± 12.1	7.2 ± 5.2	6.2 ± 7.5	12.7 ± 8.6	2.8 ± 2.4	6.5 ± 5.1	1.0 ± 1.2	0.5 ± 1.1	**76.5**
CSS	11.5 ± 10.2	21.0 ± 9.7	0.5± 1.2	6.0± 5.7	24.8 ± 29.8	1.2 ± 1.1	4.3 ± 3.9	1.5 ± 1.7	0.3 ± 0.7	**71.5**
PCS	6.9 ± 4.3	16.1 ± 8.7	1.1 ± 1.2	10.7 ± 14.1	21.1 ± 15.1	1.3 ± 1.1	7.2 ± 4.2	0.9 ± 1.2	0	**67.6**
DMS	3.3 ± 2.2	38.0 ± 15.7	2.8 ± 1.9	1.8 ± 1.8	7.0 ± 4.2	3.3 ± 2.9	6.5 ± 4.5	2.3 ± 1.6	0.8 ± 1.2	**70.8**

[1]Site names corresponding to the site codes are given in Table 1.
[2]*Epinephelus* spp. and *Mycteroperca* spp.

Table 4. Fifty most frequently sighted fish species in September ,1999 (REEF geographic data) for the Archipiélago de Los Roques National Park, Venezuela, with densities (mean ± standard deviation) for species recorded in belt transects (present study).

Scientific name	Sighting frequency (%)[2]	Density (#/100m^2)	Scientific name	Sighting frequency (%)	Density (#/100m^2))
Acanthurus bahianus (*)[1]	97	7.4 ± 8.5	*Chaetodon striatus* (*)	80	0.6 ± 0.5
Sparisoma viride (*)	95	9.0 ± 3.6	*Lactophrys triqueter*	79	
Ocyurus chrysurus (*)	94	5.7 ± 4.6	*Coryphopterus personatus/hyalinus*	78	
Acanthurus coeruleus (*)	94	11.1 ± 8.4	*Epinephelus cruentatus* (*)	77	0.6 ± 1.0
Stegastes partitus	93		*Haemulon sciurus* (*)	77	1.3 ± 1.1
Halichoeres garnoti	93		*Haemulon plumieri* (*)	77	0.2 ± 0.5
Chromis multilineata	92		*Gramma loreto*	76	
Haemulon flavolineatum (*)	92	3.0 ± 2.2	*Scarus taeniopterus* (*)	75	2.8 ± 3.2
Chromis cyanea	92		*Caranx ruber* (*)	74	0.4 ± 0.6
Chaetodon capistratus (*)	92	2.9 ± 2.1	*Abudefduf saxatilis*	73	
Aulostomus maculatus	92		*Acanthurus chrirurgus* (*)	72	3.9 ± 3.7
Thalassoma bifasciatum	91		*Holocentrus rufus*	72	
Holacanthus tricolor (*)	91	0.4 ± 0.5	*Epinephelus fulvus* (*)	71	0.2 ± 0.3
Sparisoma aurofrenatum (*)	89	2.3 ± 1.6	*Scarus croicensis* (*)	70	15.4 ± 12.9
Clepticus parrae	87		*Sphyraena barracuda* (*)	66	0.1 ± 0.2
Mulloidichthys martinicus	87		*Cantherhines macrocerus*	66	0.1 ± 0.2
Serranus tigrinus	86		*Inermia vittata*	64	
Lutjanus apodus (*)	84	1.9 ± 1.8	*Halichoeres maculipinna*	63	
Lutjanus mahogoni (*)	82	1.8 ± 1.8	*Haemulon chrysargyreum*	62	3.8 ± 3.1
Myripristis jacobus	82		*Stegastes planifrons*	62	
Scarus vetula (*)	82	8.1 ± 6.2	*Scarus coeruleus* (*)	59	0.5 ± 1.1
Bodianus rufus (*)	82	0.5 ± 0.5	*Coryphopterus lipernes*	58	
Canthigaster rostrata	82		*Caranx latus*	57	
Coryphopterus glaucofraenum	81		*Scarus coelestinus* (*)	56	0.4 ± 0.6
icrospathodon chrysurus (*)	80	7.0 ± 6.5	*Hypoplectrus puella*	56	

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