Chapter 3

The Status of Target Reef Fishes

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SUMMARY

- This report deals with the larger fishes targeted by reef fisheries of the Abrolhos Bank, including species of families Scaridae (parrotfishes), Serranidae (groupers), Carangidae (jacks), Lutjanidae (snappers) and Haemulidae (grunts).

- During the RAP survey, Scaridae was the most abundant target fish family, constituting 30 to 57% of all fishes observed. Serranids varied from 0.20 to 3% of total target fishes. Other families showed high variation among the reefs assessed.

- The most abundant scarids on most reefs were *Sparisoma axillare, Scarus trispinosus* and *Sparisoma amplum*. The most abundant serranid, lutjanid, and carangid on most reefs were *Mycteroperca bonaci*, *Ocyurus chrysurus* and *Carangoides crysos*, respectively. *Anisotremus virginicus* and *Haemulon plumieri* were the most abundant haemulids on all reefs.

- Densities of serranids, carangids and scarids were higher in sites within the National Marine Park (RAP Sites 25, 26, 29, 30, 33, 34, 35), although values were significantly different only for the first two groups.

- Reefs inside the National Marine Park contained greater numbers of large-sized scarids and serranids than in other reefs. The greatest proportion of large-sized carangids was found at Itacolomis reefs (RAP Sites 14 to 18), the National Marine Park reefs (RAP Sites 25, 26, 29, 30, 33, 34, and 35), and in Paredes reefs (RAP Sites 19, 20, 21, 23, 36, 37, and 45). For haemulids, the greatest abundance of large-sized fish was found at Timbebas reefs, within the National Marine Park (RAP Sites 38, 39, 40, and 42), Popa Verde (RAP Sites 3, 4, 5, 7, 8), and Itacolomis reefs (RAP Sites 14 to 18). Lutjanidae was the only group that displayed a similar size-distribution regardless of location.

- Data gathered on fish abundance and size indicates that the most protected portion of the National Marine Park shows positive signs of protection, at least for some families. Likewise, data for Popa Verde (RAP Sites 3, 4, 5, 7, and 8) and Timbebas reefs (RAP Sites 38, 39, 40, and 42), the latter within the National Marine Park, also indicate relatively high abundance and large size of fishes for some families.

- Hook-and-line is the most common fishing method employed on the Abrolhos Bank. In general, however, interpretation and comparison of data on reef fishing is difficult due to the lack of basic data concerning type of gear, catches, and fishing effort for each reef. Fisheries at the Abrolhos Bank are not restricted to reef fishes, but also include pelagic and certain benthic species that are difficult to assess by means of visual census.

INTRODUCTION

Abrolhos is a region characterized by a relatively high diversity of corals and fishes (Leão 1982; Pitombo *et al*. 1988; Villaça and Pitombo 1997; Ferreira and Gonçalves 1999). Its reefs also support important fisheries, not only for the subsistence needs of local residents but also for supplying larger markets in adjacent municipalities. Due to urban development, tourism and other activities (Coutinho *et al*. 1993; Leão 1996; Ferreira and Gonçalves 1999), Abrolhos' unique marine environments became increasingly threatened over the last two decades (Werner *et al*. 2000). As a consequence, there has been a reduction in fish landings, and a decrease in the size and types of exploited fishes (pers. obs.), a trend that is also reported in many other reef fisheries around the world (Russ and Alcala 1989; Pauly & Chritensen 1998). Fishing pressure, in particular, also can affect the complex interactions occurring in reef systems, causing the so-called cascading effect to different trophic levels (Pennings 1997; Steneck and Carlton 2001). In Abrolhos and other tropical regions, the scarcity of top predators may explain the exploitation of large herbivorous fishes, especially scarids, as food (Ferreira and Gonçalves 1999; also see Roberts 1995, Jennings and Kaizer 1998). Overfishing in the Abrolhos region is also indicated by initial reports based solely on intense macroalgae growth in coastal reefs (Coutinho *et al.* 1993; Ferreira and Gonçalves 1999). Consequently, there is a vital need for a deeper analysis of reef fish stocks, which is critical for sustainable management of target fisheries and reef conservation. The basic aim of this report is to provide baseline information on the abundance and size of commercially important reef fishes of the Abrolhos Bank

METHODS

Fish Abundance and Size

Relative fish abundance was estimated through a stationary visual census technique (*sensu* Bohnsack and Bannerot 1986), replicated for each site and explained in detail by Moura and Francini-Filho (*this volume*). Fishes were classified into five 10-cm size classes. At sites with low visibility, quantitative estimates were not carried out, and only species lists were made (see Moura and Francini-Filho *this volume*). The fish families assessed as part of the RAP survey were those that contain the larger reef fishes, which are the ones most heavily exploited: Scaridae, Serranidae, Carangidae, Lutjanidae and Haemulidae. Other important fish families exploited in the region include Carcharhinidae, Sphyraenidae, Coryphaenidae and Scombridae. However, these were excluded from the study because they often occur in environments that are not propitious to visual census techniques. During the RAP survey, we selected coastal and offshore reefs possessing different morphologies, as well as protected and unprotected reefs. Despite forming part of the Abrolhos National Marine Park, the Timbebas reefs have never received much protection, and so, for the purposes of these analyses, were considered as unprotected coastal reefs.

Statistical Analysis

In order to achieve a more robust statistical analysis, data from reefs in the same complex or having similar levels of protection were pooled as shown in Table 1. This procedure was necessary because few replicates were performed at most RAP sites. In order to avoid problems associated with grouping dissimilar sites (with respect to habitat characteristics), some sites were eliminated from the analyses after preliminary screening. For comparisons of fish family abundance among sites, a one-way ANOVA was performed, followed by a *post hoc* Student-Newman-Keuls test (SNK) for multiple comparisons of means (Zar 1999). When necessary, data were square root transformed (X+1) to stabilize variances (Underwood 1997). Size class distributions of fish families among sites were compared using a Kolmogorov-Smirnov two-sample test (Zar 1999).

RESULTS

Fish Abundance

Scarids were the most abundant group and serranids the least abundant, except at PV (Fig. 1). Densities of serranids, carangids, and scarids were higher inside NMPR, but only the values for serranids and carangids were significantly different (Table 2). Lutjanids were most abundant at PV, with similar values for TI, NMPR and PA, and lower values for SR and IT (Table 2). Haemulids were denser at PA (marginally significant), but other reefs had similar numbers. A comparison of mean density and percent abundance for the six groups of sites is presented in Table 3. The most abundant scarids included *Sparisoma axillare, Scarus trispinosus* and *Sparisoma amplum*. *Mycteroperca bonaci* and *Ocyurus chrysurus* were by far the most abundant serranids and lutjanids, respectively. Other members of these families were either found in low numbers or were absent, with the exception of *Lutjanus synagris*, which was relatively abundant at NMPR. *Carangoides*

Table 1. Groups of sites used in the statistical analysis and their corresponding acronyms, RAP Site numbers, and sample size.

GROUPS OF SITES	RAP SITES
Southern Reefs (SR)	1, 2, 6
Popa Verde Reefs (PV)	3, 4, 5, 7, 8
Itacolomis Reefs (IT)	14, 15, 16, 17 18
Paredes Reefs (PA)	19, 20, 21, 23, 36, 37, 45
National Marine Park Reefs (NMPR)	25, 26, 29, 30, 33, 34, 35
Timbebas Reefs (TI)	38, 39, 40, 42

Table 2. Results of ANOVA comparisons of fish family abundance among reefs and SNK comparisons. Legends for RAP site codes in Table 1.

Family	F	df	p	SNK comparisons
Scaridae	2.36	5	< 0.05	SR < PV = PA = IT = TI = NMPR
Serranidae	4.73	5	< 0.001	IT = TI = PA = PV = SR < NMPR
Carangidae	1.98	5	< 0.05	PV = IT = TI = PA = SR < NMPR
Lutjanidae	7.29	5	< 0.001	IT = SR < PA = NMPR = TI < PV
Haemulidae	3.53	5	< 0.01	SR = PV = NMPR = IT = TI < PA

Table 3. Mean (± 1 SE) density (individuals x 50m^{-2}) and percent relative abundance (in bold font) of target reef fishes. Corresponding RAP site codes in Table 1.

	Southern Reefs	Popa Verde Reefs	Itacolomis Reefs	Paredes Reefs	Natnl Park Reefs	Timbebas Reefs
Scaridae						
Scarus trispinosus	0.40 (0.22) **3.05**	0.68 (0.13) **4.49**	1.25 (0.40) **8.24**	2.12 (0.43) **10.79**	1.72 (0.28) **7.39**	3.02 (0.51) **15.25**
S. zelindae	1.20 (0.85) **9.16**	1.60 (0.32) **10.60**	0.12 (0.09) **0.79**	0.58 (0.28) **2.95**	1.38 (0.46) **5.93**	1.72 (0.25) **8.09**
Sparisoma axillare	3.40 (1.26) **26**	0.60 (0.12) **3.96**	6.04 (1.08) **39.84**	3.87 (0.65) **15.69**	3.29 (1.70) **14.14**	2.40 (0.64) **12.13**
S. amplum	--	--	0.16 (0.09) **1.05**	--	0.03 (0.02) **0.12**	0.22 (0.10) **1.11**
S. frondosum	--	2.68 (0.53) **17.7**	1.21 (0.50) **7.98**	0.20 (0.09) **1.01**	3.96 (0.58) **17.02**	1.90 (0.39) **9.61**
Serranidae						
Mycteroperca bonaci	0.40 (0.16) **3.05**	0.16 (0.03) **1.06**	0.07 (0.05) **0.46**	0.21 (0.11) **1.06**	0.98 (0.29) **4.21**	0.04 (0.02) **0.20**
Epinephelus itajara	--	0.04 (0.008) **0.26**	--	--	--	--
E. morio	--	0.16 (0.03) **1.06**	--	--	--	--
Carangidae						
Carangoides crysos	3.00 (2.30) **22.9**	--	0.13 (0.06) **0.85**	0.82 (0.50) **4.97**	2.00 (0.22) **8.59**	--
C. bartholomaei	--	--	--	--	0.93 (0.19) **3.99**	0.09 (0.06) **0.45**
C. ruber	--	--	--	--	0.16 (0.08) **0.68**	--
Caranx latus	--	--	--	--	1.51 (0.22) **6.49**	--
Lutjanidae						
Lutjanus jocu	0.40 (0.30) **3.05**	1.16 (0.18) **7.66**	0.06 (0.04) **0.39**	1.57 (0.66) **7.89**	0.03 (0.02) **0.13**	--
O. chrysurus	3.00 (0.44) **22.90**	5.40 (1.07) **35.60**	2.10 (0.04) **13.85**	4.87 (0.60) **24.28**	1.70 (0.14) **7.31**	5.90 (0.54) **29.81**
L. synagris	--	--	--	--	--	2.54 (0.78) **10.92**

continued

Table 3. (continued) Mean (± 1 SE) density (individuals x 50m^{-2}) and percent relative abundance (in bold font) of target reef fishes. Corresponding RAP site codes in Table 1.

	Southern Reefs	Popa Verde Reefs	Itacolomis Reefs	Paredes Reefs	Natnl Park Reefs	Timbebas Reefs
L. griseus	--	--	--	0.60 (0.32) **3.05**	--	--
Haemulidae						
Haemulon plumieri	0.20 (0.13) **1.53**	0.28 (0.05) **1.85**	2.40 (0.04) **15.83**	3.17 (1.01) **16.13**	0.16 (0.08) **0.68**	0.18 (0.08) **0.91**
H. parra	0.70 (0.42) **15.34**	--	0.40 (0.21) **2.63**	0.07 (0.01) **0.35**	--	--
Anisotremus virginicus	0.40 (0.26) **3.05**	2.32 (0.46) **15.30**	1.16 (0.48) **7.65**	1.57 (0.33) **7.99**	2.87 (1.07) **12.34**	4.32 (0.31) **28.83**
A. surinamensis		0.04 (0.008) **0.26**	0.06 (0.04) **0.39**			

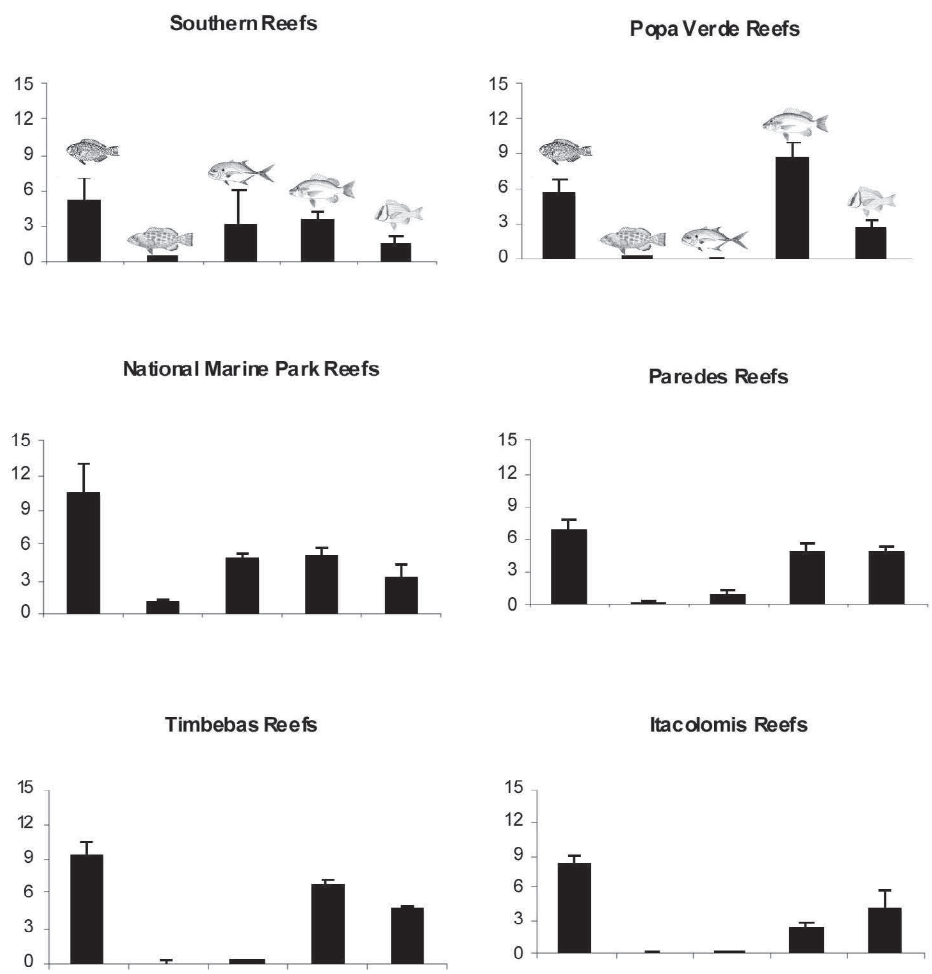

Figure 1. Comparison of fish abundance (mean ± SE) among different reefs. Corresponding RAP site codes in Table 1.

crysos was the most abundant carangid, and the most abundant haemulids were *Anisotremus virginicus* and *Haemulon plumieri*. At the family level, scarids and serranids showed smaller abundance variation between sites. Scarid abundance varied from 30 to 57 % of the total fishes surveyed, while serranid abundance varied between 0.2 to 3 %. Carangids, lutjanids and haemulids exhibited considerable density variation between reef areas (Table 2).

Fish Size

There were more large-sized scarids and serranids at NMPR than at other reefs, followed by PV and TI, for both families (Figs. 2 and 3). Large carangids were best represented at IT, followed by NMPR and PA (Fig. 4). Lutjanids exhibited a similar size-distribution at all reefs, with SR having the highest proportion of smallest sizes (Fig. 5). The greatest proportion of large haemulids was found at TI, followed by PV and IT (Fig. 6). A comparison of size-class distribution between reefs is presented in Table 4. As the sample size for some families was small (*e.g.*, Serranidae), it was not always possible to detect significant differences in size distribution between reef areas.

DISCUSSION

The Abrolhos Marine National Park was established in 1983, but effective conservation policy was not implemented until the mid 1990's. Therefore, the region has been protected for less than 10 years prior to the present study. The fish

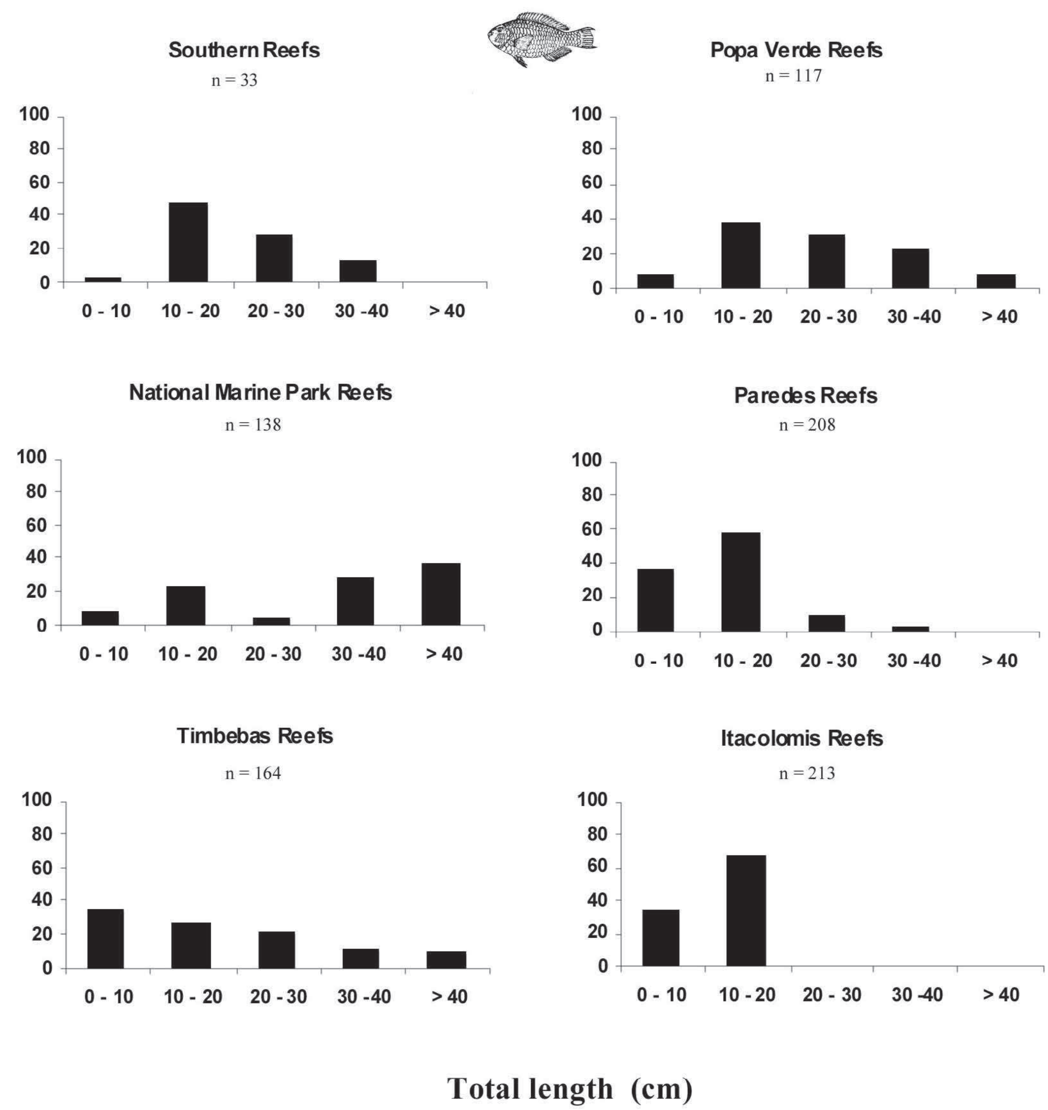

Figure 2. Size class frequency distribution of scarids among different reefs. Corresponding RAP site codes in Table 1.

abundance and size data obtained during this study indicate that fish populations, for at least a few families (particularly the Serranidae and Carangidae), have benefited from this protection. Although more large-size scarids were recorded within the National Park boundaries, large individuals were also noted on other reefs, such as PV and TI. Large-size lutjanids were detected only on PV, but relatively high densities of smaller size-classes also were observed at TI (unprotected) and NMPR (protected). However, the analysis of lutjanid size-distribution data and the effects of protection were somewhat obscured by the universal abundance of *Ocyurus chrysurus*, which was common in a wide size range in both protected and non-protected sites.

As high variation in abundance among the surveyed sites may be due to habitat differences, some sites were eliminated after preliminary analyses. This problem was particularly noticeable for PA, which occupies a comparatively large area characterized by different habitats and a high variability in species diversity and abundance. PV, in contrast, consists mainly of relatively sparse "chapeirões" in deeper (15–30 m) water. Probably because of the deeper setting of the reefs and their steep morphology, this area is less vulnerable to fishing. Consequently, it appears to sustain fish populations in relatively "good health", as indicated by the high abundance of lutjanids. Moreover, it was the only reef where the jewfish (*Epinephelus itajara*) was observed. TI, although included in the National Park, has never been policed and, like other coastal reefs, suffers from the effects of fishing, both by local people and tourists. Nevertheless, it contains relatively high densities of scarids, lutjanids and haemulids. Differences in fisheries exploitation among reef areas appear to be corre-

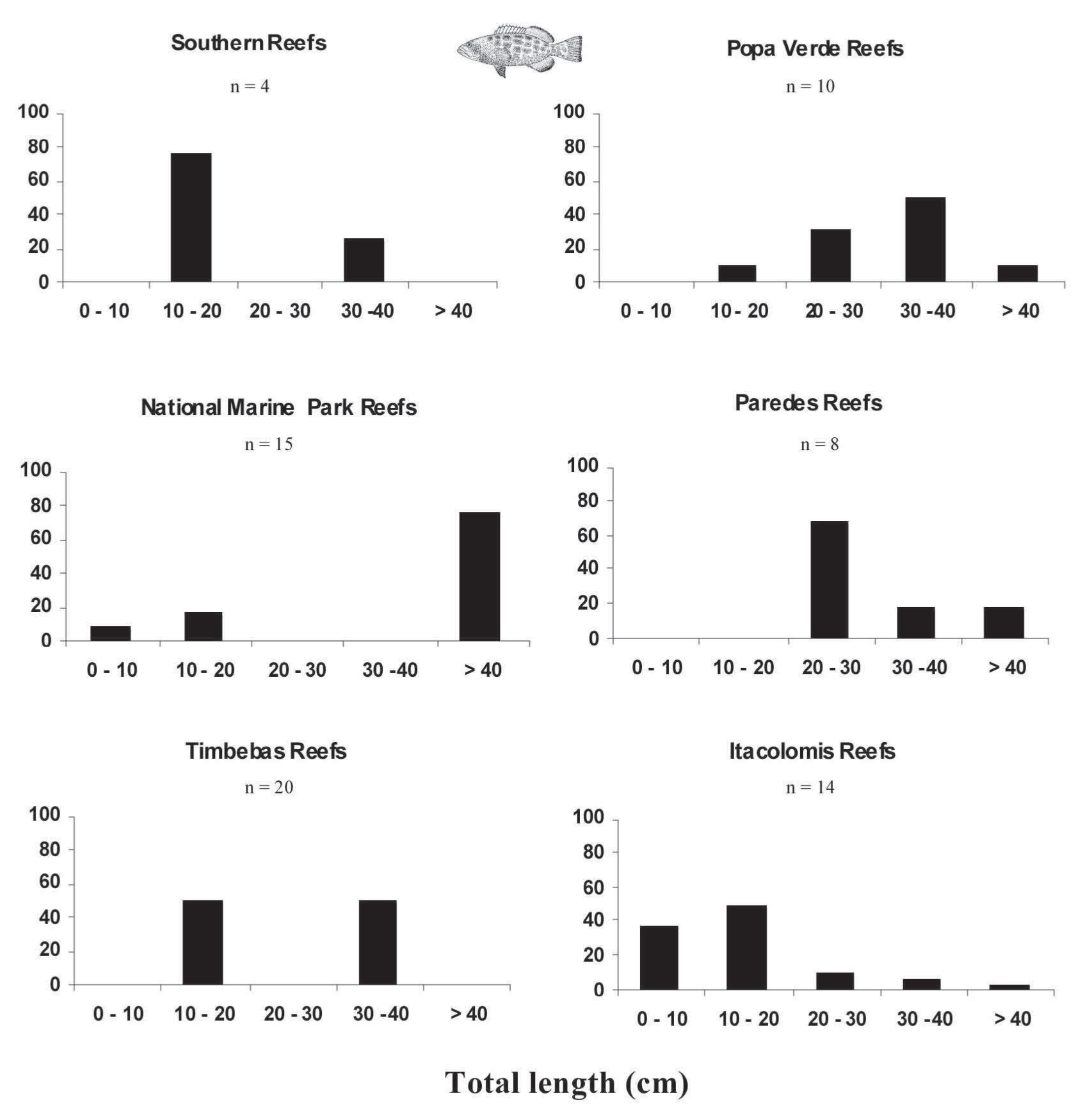

Figure 3. Size class frequency distribution of serranids among different reefs. Corresponding RAP site codes in Table 1.

lated with both ecological conditions and proximity to humans.

Hook-and-line is the main fishing gear employed on Abrolhos reefs. Spearfishing, on the other hand, is a comparatively new technique, and its use is limited to a few local and visiting recreational fishermen (pers. obs.). Nevertheless, spearfishing may seriously impact local fish populations, just as much as the conventional hook-and-line gear. It is well known that certain families, such as the Serranidae, are easily impacted by spear fishing and other selective fishing techniques (Colin 1992; Roberts 1995; Sadovy and Colin 1995; Jennings and Kaiser 1998). All the top predators studied during the RAP survey are subjected to both hook-and-line and spearfishing methods. However, scarids are targeted by spearfishing and netting, this latter technique applied on certain bank reefs (*e.g.*, Lixa Reefs, Rap Site 36). Haemulids are taken mainly by hook-and-line, but also by spearfishing. Therefore, unlike many other tropical areas where a variety of fishing methods are employed, reef fisheries in Abrolhos are restricted to relatively few methods, of which hook-and-line is by far the most common. There is no recent use of highly destructive fishing techniques such as explosives or cyanide. Nevertheless, it is difficult to assess the real impact of fishing activities in Abrolhos, due to the lack of basic data concerning type of gear, catches, and fishing effort.

Fishing in coral reef and other marginal habitats are not restricted to the species included in this report. Studies that have monitored local fish landings in the region indicate that pelagic fishes of families Coryphaenidae and Scombridae are a seasonally important component of the catches (Costa *et al.*, 2003). Moreover, hook-and-line fishing is not confined to shallow reef environments, but employed to a depth of at least 180 m. Monitoring data (Costa *et al.*, 2003) indicates that catches from deeper areas is composed of relatively few species, including *Mycteroperca bonaci, Lutjanus jocu* and *O. chrysurus*, as well as other species not recorded during the RAP survey. According to local fishermen, catches of typical reef fish species, including *Balistes vetula* (Balistidae), *Sphyraena barracuda* (Sphyraenidae) and some reef sharks, have declined in recent years. This sort of anecdotal information, however, may be useful for future research in the region.

There is an increasing interest in the role of marine protected areas in helping to restore fisheries in places that have suffered a decline in fisheries productivity (Demartini 1993; Polunin and Roberts 1993; Bohnsack 1996; Russ 2001). Regardless of the level of protection, the potential of an area to sustain acceptable levels of fishing is highly dependent on having a sufficiently large area that includes a variety of habitats that are critical to the various life-history stages of the target organisms (Dugan and Davis 1993). The Abrolhos National Marine Park encompasses a reef area of 913 km^2, including areas of the Abrolhos Archipelago where habitat and fish diversity is high (Moura and Francini-Filho *this report*). However, the estimated area of the entire Abrolhos Bank is approximately 6,000 km^2 (Leão 1996), raising the question of how large the protected area coverage should be in order to sustain fishing on adjacent reefs. Coastal reefs sometimes include specific habitats that are not represented within the existing protected areas boundaries. The Timbebas Reef would certainly fulfill some of these needs, but

Table 4. Results of the Kolmogorov-Smirnov two-sample tests (*p* values) for comparisons of percent distribution of size classes of target fish families. Corresponding RAP site codes in Table 1.

	Scaridae	Serranidae	Carangidae	Lutjanidae	Haemulidae
SR vs. PV	NS	NS	***	***	NS
SR vs. NMPR	NS	NS	***	***	*
SR vs. TIM	**	NS	***	***	NS
SR vs. PA	**	NS	NS	***	NS
SR vs. IT	**	NS	***	***	***
PV vs. IT	***	***	***	NS	NS
PV vs. PA	***	NS	***	NS	NS
PV vs. NMPR	NS	NS	***	NS	NS
PV vs. TIM	***	NS	NS	NS	NS
IT vs. PA	NS	***	NS	NS	*
IT vs. NMPR	***	NS	NS	NS	NS
IT vs. TIM	***	*	**	NS	NS
PA vs. NMPR	***	NS	NS	NS	**
PA vs. TIM	***	NS	*	NS	*
NMPR vs. TIM	*	NS	**	NS	NS

NS = not significant, * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

would require effective law enforcement and environmental education programs for the local community. This would effectively transform the Timbebas Reef from a “paper park” to a functioning fully-protected area. The Paredes Reefs is also a good candidate area for coral reef conservation in Abrolhos, being the largest reef complex in Brazil, and containing a relatively high habitat diversity. Another aspect that deserves urgent attention is the gap in our knowledge of the interactions between reefs and coastal systems, such as estuaries and mangroves. These coastal systems have close associations to coral reefs in the Caribbean and other tropical regions (Nagelkerken 2000), but remain almost completely unstudied in the Abrolhos region.

It is crucial to implement monitoring programs as soon as possible. The goal should be to collect comprehensive data pertaining to catch size and composition, as well as catch per unit effort. Only through such a program, to be implemented among Abrolhos fishing villages, can a thorough understanding of fishing pressure be obtained. At the same time, more visual census studies should be initiated, in both protected and unprotected reefs, like those reported herein. This is particularly important for groups such as scarids that are poorly represented in typical fish landings. Scarids are important for controlling algal abundance and growth, thus playing an important role in coral-dominated reef systems (*e.g.*, Choat 1991), and also serving as indicators of reef “health”. The future of the Abrolhos reefs heavily depends on our ability to produce basic data that will guide and facilitate effective management.

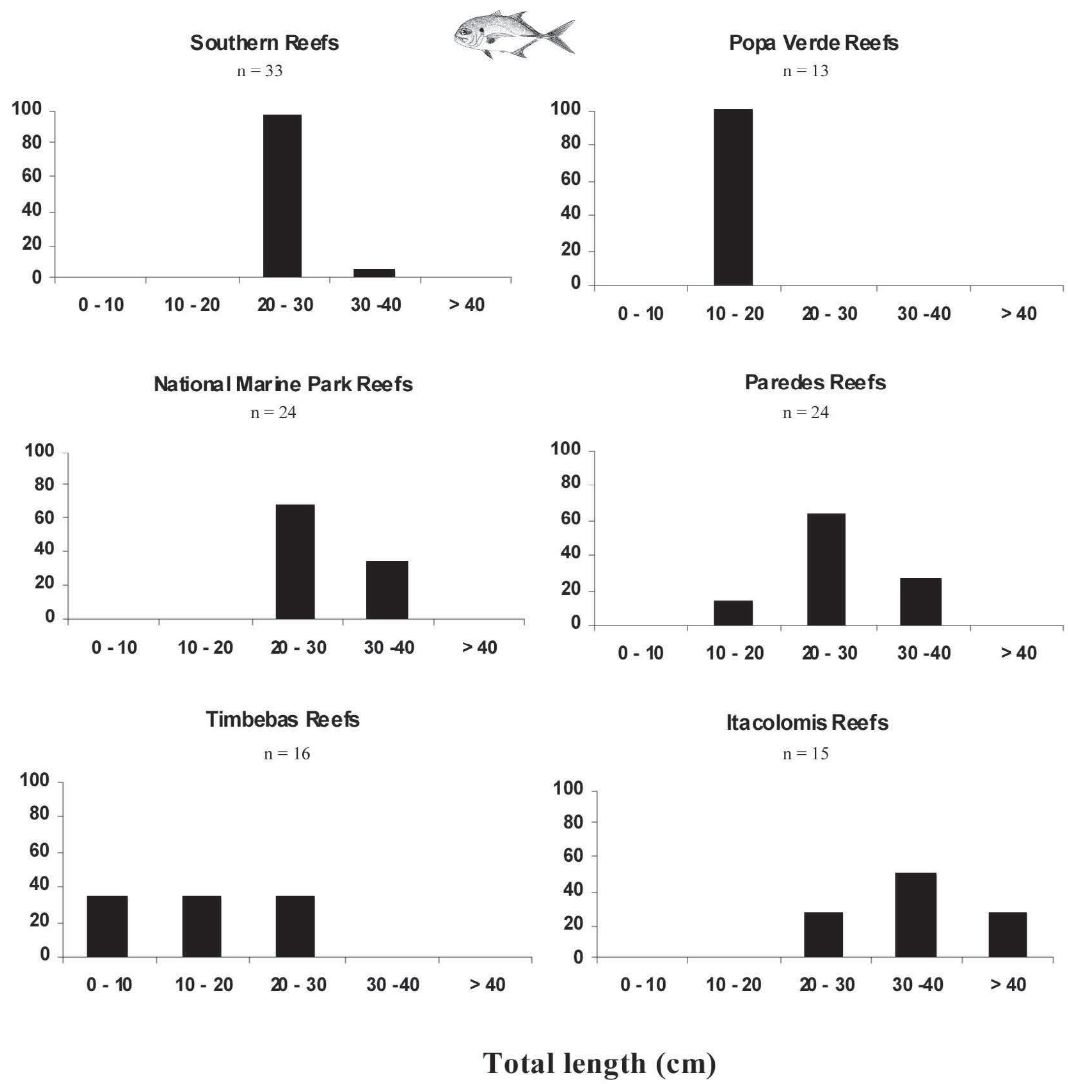

Figure 4. Size class frequency distribution of carangids among different reefs. Corresponding RAP site codes in Table 1.

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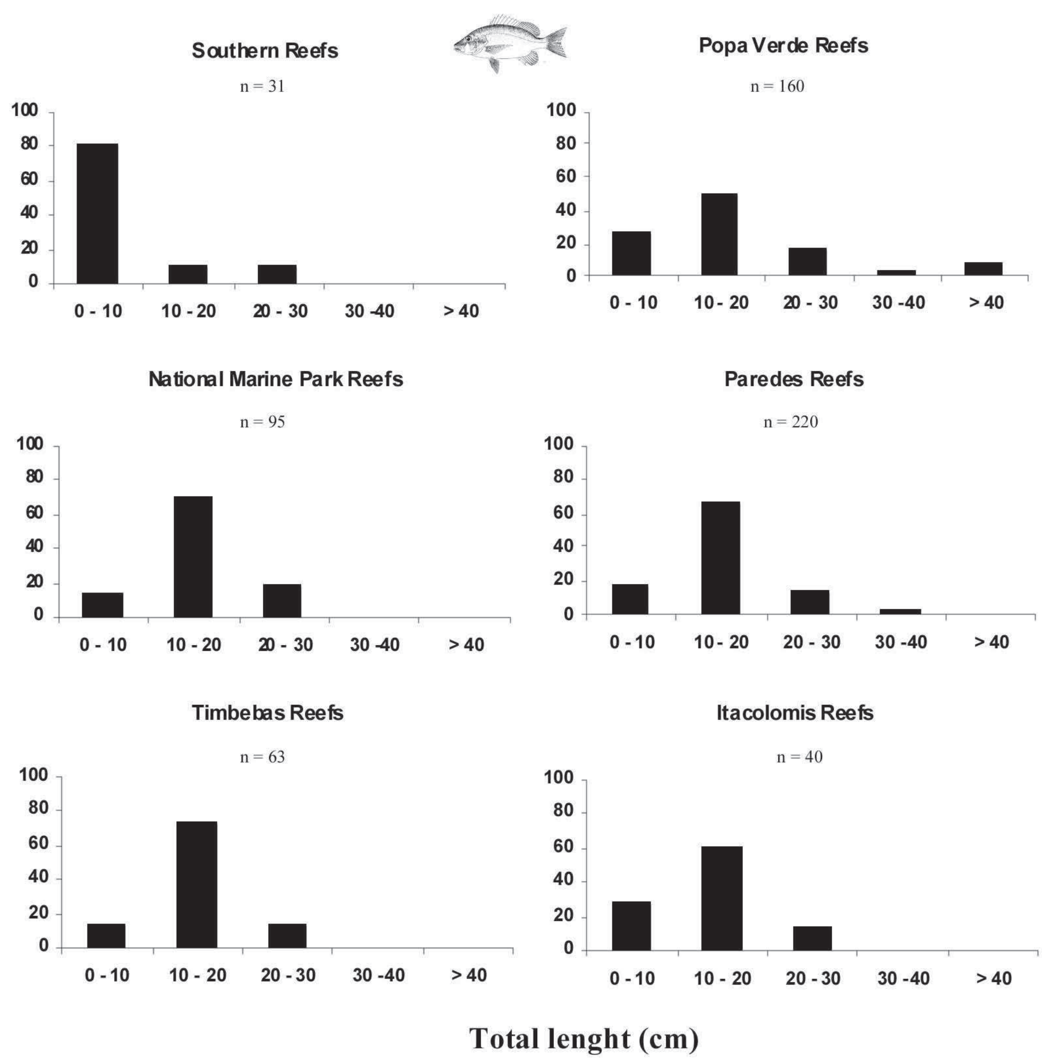

Figure 5. Size class frequency distribution of lutjanids among different reefs. Corresponding RAP site codes in Table 1.

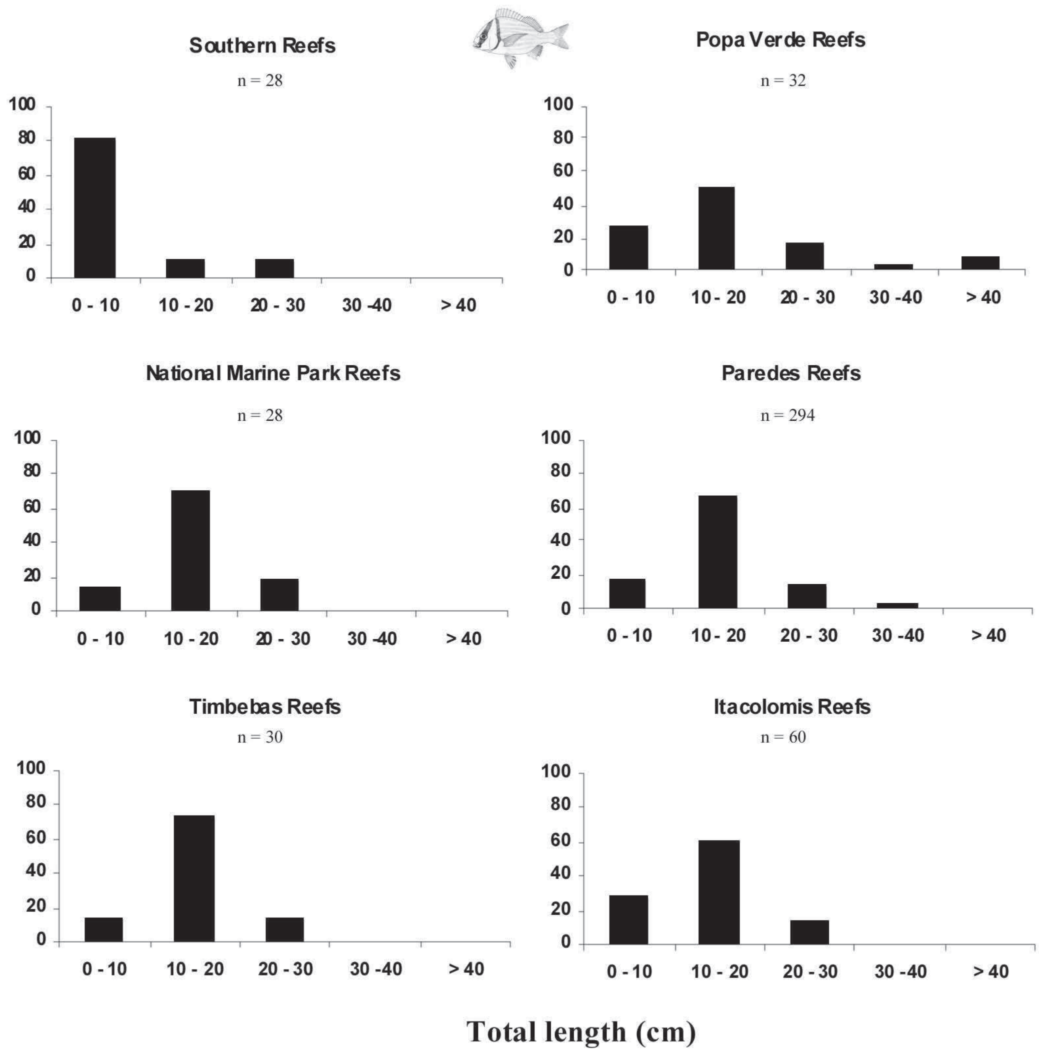

Figure 6. Size class frequency distribution of haemulids among different reefs. Corresponding RAP site codes in Table 1.

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