RAPID ASSESSMENT OF THE CORALLINE AND ICHTHYOLOGICAL COMMUNITIES OF THE CORAL REEFS OF THE PRIMEIRAS AND SEGUNDAS ARCHIPELAGO (NAMPULA AND ZAMBEZIA PROVINCES)

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SUMMARY

The archipelago of the Primeiras and Segundas, in the North of Mozambique, comprises an almost continuous chain of coralline islands that are fringed by reefs. A rapid and preliminary study employing visual techniques for both ichthyological and benthonic communities was conducted in the shallow (<15m) reefs of the islands' eastern coast. A total of 194 fish species representing 42 families was identified. Cumulatively, 43 genera of stony coral and 15 genera of soft coral were also identified in the area.

The average coral cover was 62.2% (± 2.0, standard deviation), having varied between 52.4 ± 5.3 % (on Fogo Island) and 71.2 ± 3.8 % in Epidendron, composed primarily of stony coral. Ramified corals of the *Acropora*, *Pocillopora*, *Seriatopora* and *Porites* genera were the dominant elements of the benthic fauna of the southernmost islands (Fogo and Epidendron), while the massive (*Porites*, Favids, *Lobophyllia corymbosa* and *Diploastrea heliopora*) and sub-massive (*Porites*, *Goniopora djiboutiensis* and *Acropora palifera*) ones were conspicuous in reefs situated more towards the north (Puga-Puga and Mafamede). The survey area presented the following average values for fish density, biomass and diversity: 35 specimens/154 m^2, 380 g/154 m^2 and 11 species /154m^2, with Acanthuridae (surgeon fishes), Scaridae (parrot fishes) and Chaetodontidae (butterfly fish) representing the most important families. Signs of over-fishing are evident, especially on the Primeiras Islands where, in general, one does not encounter specimens that are of commercial value or larger (a size category smaller than 10 cm was predominant, comprising more than 85% of the specimens observed). All said, the conclusions support the idea that the Primeiras and Segundas Islands reefs are among the most remarkable in Mozambique, both as regards biodiversity and state of conservation. This was the second quantitative study of the area, but the first to measure the coverage size. Proposals are offered for a program to monitor the coralline communities, relevant indicators and methodology. The need is stressed for implementation of a formal system of ecosystem protection and the following immediate administrative measures: (i) restrictions on underwater fishing and pelagic species; (ii) prohibitions against dropping anchor above the reefs and use of destructive fishing techniques (including trawls, poisons and explosives); (iii) adoption of good practices by tour guides, especially as regards activities that directly affect coral reefs, such as diving and use of vessels; and (iv) a better control over the local community's collection of invertebrates (clams, starfish, etc.).

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INTRODUCTION

Corals are animals of the coelenterate group, such as the anemones, medusas or jellyfish, the majority of which form colonies. Typically, corals have tentacles that contain nematocysts. The most researched corals are those that form reefs, typically the stony, herma-typic variety. Though members of the animal kingdom, herma-typic corals posses symbiotic algae (Zooxanthellae) in their tissues that form an association in which nutrients and the products of the photosynthetic activity of algae are shared. As a result of their growth and their metabolism, corals deposit an aragonite (calcium-carbonate) skeleton which, after accumulating of the course of thousands of years, forms reefs (Veron, 1993; Sorokin, 1995).

Some stony corals contain symbiotic algae and are denominated non-hermatypic as they do not build reefs. Another large corals group, one that possesses symbiotic algae but does not deposit solid skeletons, is that of soft corals. The structure and consistency of soft corals is leathery and, for structural support, they produce miniscule calcareous structures, or sclerites. Soft coral colonies do not become reefs but turn to sediment when dead (Veron, 1993; Sorokin, 1995).

The formation of reefs – and indeed corals themselves – requires very specific conditions of warm, flowing, limpid waters of normal salinity (approximately 35%). Water limpidity is essential for the photosynthesis of the symbiotic algae. In East Africa, the true coral reefs are found along the equatorial zone. In Mozambique in particular, corals develop over a rocky base of cemented dunes formed by events induced by the lowering of average sea level during the Pleistocene, between 100,000 to 18,000 Ma. At approximately 6,500 Ma, the sea level rose again, transforming the cemented dunes to reefs colonized by various levels of coral (Ramsay, 1994; 1996). Independent of their geologic origins, Mozambique's reefs play an essential ecological and socioeconomic role owing to their biodiversity and productivity.

Coral reefs rank among the planet's most productive ecosystems; surely, they are the most diverse marine ecosystems and as such are often compared with the world's humid tropical forests. Millions who live in tropical regions rely upon the reefs' nutritional, socio-cultural, pharmaceutical and recreational resources (Spalding *et al*., 2001). The reefs play a crucial role as reproductive zones, providing shelter and food for young species. Coral reefs are equally critical to the protection of coastlines, particularly as regards erosion and the effects of cyclones and storms.

As a result of their high productivity, coral reefs encompass the greatest portion of the fisheries areas along the coasts of developing tropical countries, where the majority of the coastal population depend upon fishing as the main source or to supplement their animal protein consumption. The production potential in terms of fish catch was estimated at several tons per km^2 per year.

The reefs that fringe the Primeiras and Segundas Islands are known as the most developed in Mozambique (Salm, 1983; Schleyer and Celliers, 2000). Few studies, however, have been

conducted in this area and a general ignorance prevails concerning the reefs' nature, size and state of conservation. Quantitative research was carried out only on Caldeira Island (Schleyer and Celliers, 2000) as part of the Environmental Impact Study of the Thopuitho heavy-sands extraction project. The referenced study confirmed the presence of a high diversity of corals and other benthic organisms characteristic of reefs, along with the occurrence of equally-diverse ichthyofauna. Very little information, however, was offered with respect to the other islands.

The Primeiras and Segundas and the adjacent coastal region are rich in biodiversity and are in the category of regionally-important eco-regions (Horrill, 2001), but few quantitative studies of the area have been conducted. By way of example is the recent discovery of the *Icuria dunensis* tree genus that occurs in almost mono-specific forests of the continental zone (Fourier & Lubke, 2000).

This work presents the conclusions of a rapid quantitative and preliminary assessment carried out on five islands of the Primeiras and Segundas archipelago. The field work, conducted over a period of ten days in October and November of 2006, had the following objectives in mind:

- Describe the coralline and ichthyological communities of select representative areas of the Primeiras and Segundas Archipelago;
- Identify potential natural and anthropogenic factors that can threaten the future and integrity of the reefs;
- Contribute to the establishment of a monitoring system for the region's coralline and ichthyological communities.

More specifically, the following objectives were outlined:

- Describe the coralline cover and diversity of the reefs and potential threats to their conservation;
- Describe the reef-associated biota, including macro-algae, seagrasses, invertebrates (zoanthidea , gastropods, equinoderms, etc.) in terms of abundance and commercial value;

- Describe the reef fish community in terms of its diversity, abundance, biomass and size structure, particularly those having commercial value;

- Evaluate and quantify potential threats to reef conservation, including pollution, spiny starfish and coral bleaching

METHODOLOGY

Benthic Communities

The coralline communities and other benthic organisms were studied by divers using Scuba equipment and high resolution digital cameras (Nikon Coolpix 4800, 4 megapixel), according to the method developed by Celliers & Schleyer (in prep). Photo-squares measuring approximately 0.3 m^2 were taken at regular intervals of approximately two minutes along transects parallel to the reefs. Approximately 40 photo-squares were obtained for each transect. The transects were approximately 10 m apart. Two distinct reef zones were considered: a deeper zone or "reef slope" of between 5 to 10 meters, and a shallower one, or "back reef", of between 1 to 4 meters. Three transects were placed in each of the zones and a last one was placed perpendicularly over the two zones ("cross reef").

Before each dive, geographic coordinates for the point of entry were annotated employing the Garmin *eTrex* GPS system. Depth, current, wind, temperature and visibility parameters were gathered as part of each diving routine. The presence of *Acanthaster planci* (spiny starfish), coral bleaching and signs of destructive fishing were likewise annotated as part of the diving routine.

The JPEG images from the field were later analyzed in a laboratory. Employing a precise interpretative technique with CPCe software, the biotic categories and substratum were analyzed through eight points distributed randomly in each of the photographs. Organisms found under each of the eight points were identified and classified according to categories suggested by English *et al*. (1994), based upon the growth method. The organisms, furthermore, though submitted for analysis according to their genera, were identified to the lowest possible taxonomic level.

The coralline benthic organisms present differing levels of susceptibility to the physical stress caused by recreational scuba divers. The potential for damage to the coralline communities of the surveyed areas was quantified using the percentage of coral cover and a consideration of the susceptibility of each species or genus within a simple qualitative system: resistant, susceptible and very susceptible (Table 1).

Table 1. Susceptibility to damage of the various sub-categories of corals found at the surveyed reefs (1= resistant; 2= susceptible and 3= very susceptible).

Categories	Susceptibility	Genera
Stony ramified coral	3	*Acropora*, *Pocillopora*, *Seriatopora*, *Stylophora*, *Porites rus*
Stony finger coral	3	*Acropora*
Stony tabular coral	3	*Acropora*, *Turbinaria*
Stony encrusting coral	1	*Echinopora*, *Montipora*
Stony foleaceous coral	3	*Pachyseris*, *Merulina*, *Pavona*
Stony massive coral	1	*Favia*, *Favites*, *Platygyra*, *Diploastrea*, *Porites, Lobohyllia*
Stony sub-massive coral	2	*Porites*, *Acropora pallifera*, *Goniopora*
Fire coral	2	*Millepora*
Stony fungiid coral	1	*Fungia*
Soft coral	1	*Sarcophytum, Lobophytum, Sinularia, Cladiella, Xenídeos, Neftídeos*

Ichthyological Communities

The method employed in this study was based upon the "point count" (PC) technique described by Bohnsack & Bannerot (1986). The fish within a 7m (or less depending on visibility) radius and 5 m above the substrata were counted. The observer would initiate the count after a few minutes, once the fish settled into normal behavior. Each PC took approximately three minutes to be implemented and would be randomly placed 15 to 20 meters from the next. Table 2 indicates the number of PC's implemented in each reef. The sizes of commercially-significant fish species were estimated according to 10 cm size categories, utilized to estimate biomass employing weight-dimension relationships (Froese & Pauly, 2007).

Owing to the elevated number and diversity of fish species found in these reefs, only the previously-identified species were counted (Appendix I). The species selection was based upon various criteria, including:

- Species sought by fishermen in tropical coral reefs (e.g., groupers –Serranidae family);
- Indicative species (indicative of the general health of the reef, e.g., butterfly fish of the Chaetodontidae family); and
- Visually obvious species representative of the largest trophic categories.

To obtain a general idea of fish species diversity, all species observed during each dive were recorded on Perspex plaques by the observer and his diving partner.

FINDINGS

Sampling Effort

The work team's logistical and safety conditions in great measure conditioned the sampling effort and coverage. All told, six islands were visited: Fogo, Coroa and Epidendron in the Primeiras and Ndjovo Archipelago and Puga-Puga and Mafamede in the Segundas Archipelago (Figure 1). Table 2 presents a summary of the sampling effort that was conducted. A total of 34 photo transects and 1421 photo squares were sampled covering a reef area of approximately 454.7 m^2 . Subsequent visits by the first author and reviews of published articles (Celliers & Schleyer, 2000 and Schleyer, 1999, for example) corroborated this information.

Table 2. Sampling coordinates and effort in each reef visited.

Site	Latitude	Longitude	Transects	Photo-squares	PC
Primeiras Islands					
Fogo	S17º 13.890'	E038º 52.267'	6	239	4
Coroa	S1 7º 11.323'	E038º 56.283'	*	*	*
Epidendron	S17º 05.082'	E039º 07.722'	7	273	7
Segundas Islands					
Ndjovo	S16º 33.880'	E039º 48.563'	7	332	7
Puga Puga	S16º 26.546'	E039º 56.886'	7	282	7
Mafamede	S16º 21.340'	E040º 01.250'	7	295	7
Total			**34**	**1421**	**32**

* = quantitative sampling not conducted. PC =Point Count

Description of Coralline and Ichthyological Communities

General Description

Each of the islands is fringed with reefs, at times completely encircling them so as to form an atoll (as in the case of Silva Island; Schleyer, 1999) or a semi-circle. The Silva, Coroa, Mafamede and Puga-Puga Islands, all relatively small (<2 ha), are covered by little or no vegetation. The Islands of Casuarina, Fogo, Epidendron and Ndjovo are somewhat larger and contain more developed vegetation, including large trees.

The lakes surrounded by rocky atolls are shallow, containing sediment, coal shards and seagrass beds. In the lakes' southwest zone facing the open sea, colonies of massive coral (chiefly *Porites* and favids) occur sporadically. The average coral coverage was 62.2% (± 2.0, standard deviation), having varied between 52.4 ± 5.3 % (on Fogo Island) and 71.2 ± 3.8 % on Epidendron, where stony corals predominate. On some of the islands that were visited (Caldeira, Ndjovo, Puga-Puga), anemones (*Heteractis magnifica*) and macroalgae (*Halimeda*, *Sargassum* and *Padina*) are common. Reef development and an abundance of corals are generally found in the more protected areas on the islands, particularly those facing the continent where one finds greater coralline coverage and diversity. The reef's highest points become exposed at low tide to the pounding of waves and current. The extent of the maximum high tide around the islands is approximately 4.5 m.

As regards ichthyofauna, the study area presented, respectively, the following average values in terms of density, biomass and diversity: 35 specimens/1 54 m^2, 380 g/1 54 m_2 and 11 species /154m^2 (Appendix II). Of the 10 families that were studied, four demonstrated superior importance in terms of both specimen and species numbers: surgeonfish (Acanthuridae), butterfly fish (Chaetodontidae), parrotfish (Scaridae) and snappers (Lutjanidae). As regards biomass, the surgeonfish and parrotfish were clearly the most notable. The most represented trophic group in terms of density, biomass and diversity was the herbivore, followed by carnivores and omnivores.

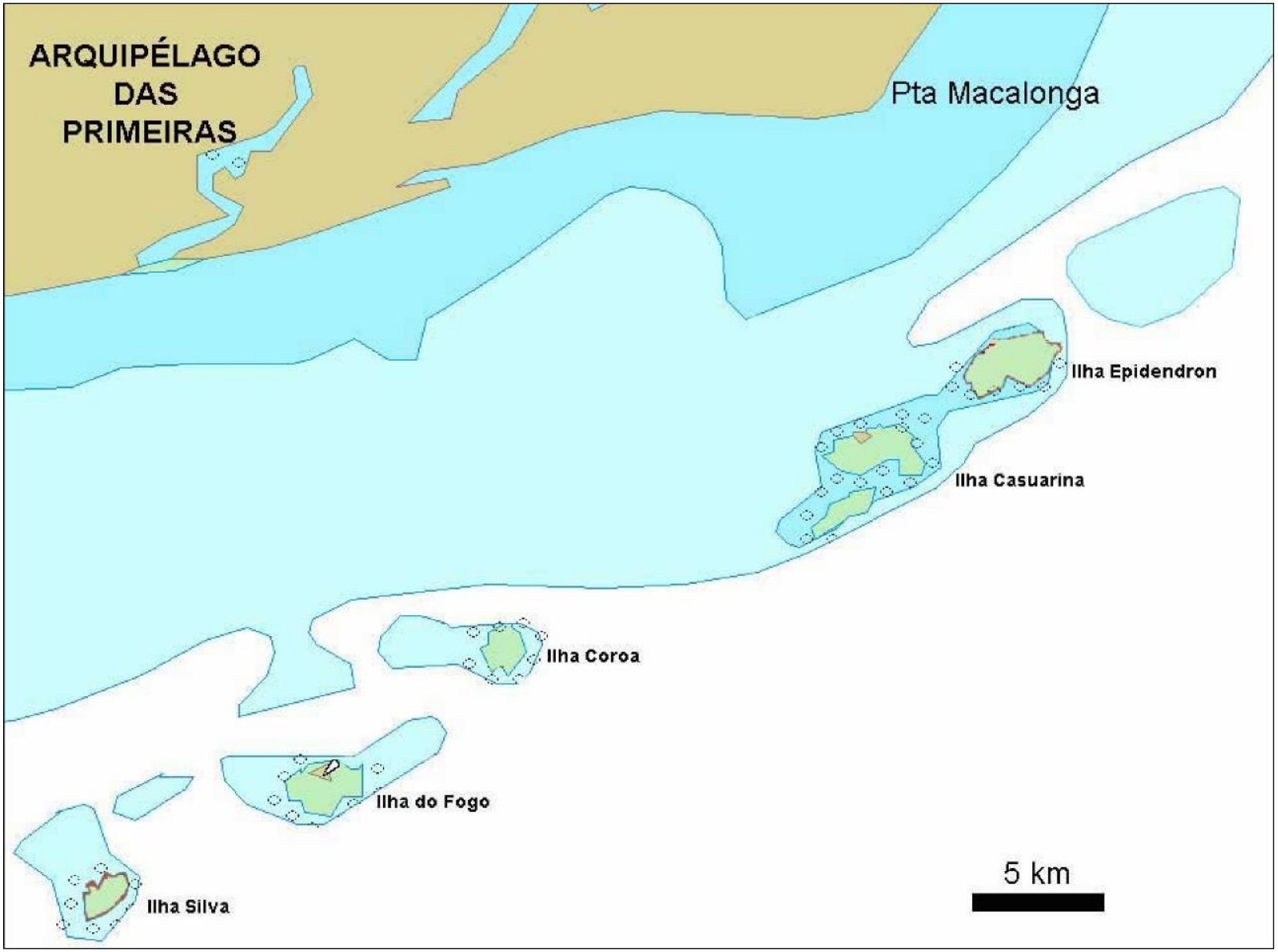

Figure 1. Site of the reefs that were studied within the Primeiras Archipelago. Green areas surrounding the islands are the bordering reefs (atolls).

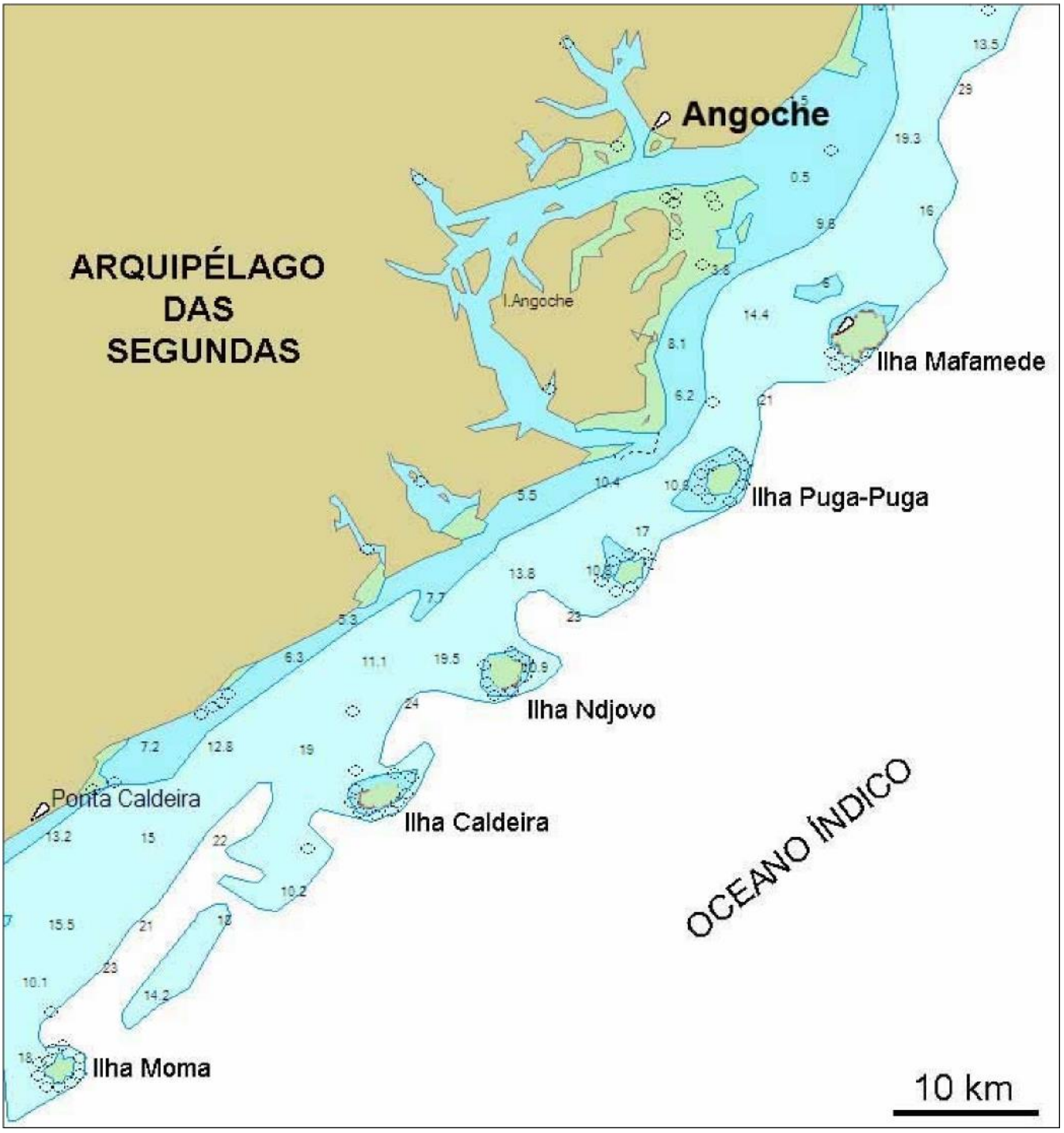

Figure 2. Site of the reefs that were studied within the Segundas Archipelago. Green areas surrounding the islands are the bordering reefs (atolls).

In the present study and on the basis of information compiled from other sources, a total of 15 soft coral genera, 41 stony coral genera and 194 species of reef fish (distributed throughout 42 families) were identified in the zone (Appendices III and IV). Given the preliminary nature of the studies that were conducted, one can view these numbers as high and expect them to increase with the completion of future studies, particularly with respect to the more obscure fish families (e.g. Blennidae, Gobbidae, etc.).

Some species that are endemic to the eastern portion of the Indian ocean occur in this zone (e.g., *Horastrea indica*, *Cladiella kashmani*).

Fogo Island

Two reef zones were visited on Fogo Island, both on the island's continental side. As noted by Schleyer (1999), both zones present a coralline community marked by a low percentage of live-coral coverage (52.4%; Table 3) and a high degree of turbidity (five-meter maximum visibility). It was noted, however, that the reef situated farther to the south presented more favorable conditions. According to Schleyer (1999), the reefs on the continental side became completely covered with sand in 1999, a fact that could possibly explain the relatively low live coral coverage. The reef evinces a rugged aspect with corals towering to 2.5 meters and an approximately even combination of stony and soft corals.

The ramified and finger corals (particularly those of the *Acropora* genus) predominated the benthic fauna with an approximately 19% coverage (Tables 3 and 4). Massive forms, particularly of *Porites* and of favids, are relatively abundant, covering approximately 5% of the area. Soft corals, extending to 22.5% coverage, were dominated by the *Sinularia*, *Lobophytum* and *Cespitularia* genera. In addition, this reef presented an elevated percentage of coral vulnerable to the damage caused by recreational divers (Table 7).

Giant clams (*Tridacna* sp.) occur in great quantities but hedgehogs were remarkably absent. No spiny starfish (*Acanthaster planci*) were encountered. The macroalgae (especially the *Halimeda*) are found in insignificant quantities, with a coverage of but 2.3%.

The low visibility encountered while exploring this reef (as referenced above) affected the sampling effort such that only four "point counts" were carried out (Table 2). This particular reef presented the lowest figures in terms of density, biomass and reef-fish diversity (Tables 5 and 6). The reef's specific composition was dominated by surgeonfish (Acanthuridae), butterfly fish (Chaetodontidae) and parrotfish (Scaridae). The reef's most prevalent trophic group was that of herbivores, and on no other reef was a greater density of herbivorous fish found. Notably absent, though, were larger specimens as the PC's recorded an average of 0.5 fish / PC (1.7% of fish recorded per PC) of sizes greater than 20 cm. The 0-10 cm category was dominated by an average of approximately 27.5 fish (90.9%) per PC.

Table 3. Percentage cover (± standard deviation) of the principal benthic categories of the surveyed reefs.

Category	Fogo	Epidendron	Ndjovo	Puga-Puga	Mafamede
Stony Coral					
Ramified	17.5 ± 3.7	25.4 ± 5.6	12.2 ± 1.5	4.4 ± 0.7	7.7 ± 1.0
Finger	1.4 ± 0.6	1.2 ± 0.6	2.3 ± 0.6	1.3 ± 0.6	0.2 ± 0.1
Encrusting	3.0 ± 0.7	6.3 ± 0.9	3.9 ± 0.8	1.6 ± 0.6	6.0 ± 1.2
Foleaceous	0.1 ± 0.1	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.5 ± 0.4
Fungiid	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Massive	4.8 ± 0.8	4.9 ± 0.0	7.6 ± 1.3	22.5 ±1.5	9.8 ± 2.8
Sub-massive	0.3 ± 0.2	1.7 ± 0.6	2.8 ± 1.2	2.0 ± 0.4	23.5 ± 4.9
Tabular	2.6 ± 0.7	7.9 ± 2.0	1.3 ± 0.4	0.1 ± 0.1	1.7 ± 0.6
Fire	0.0 ± 0.0	0.5 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	0.9 ± 0.9
Total stony coral	29.8 ± 4.4	48.0 ± 5.2	30.4 ± 1.9	32.2 ± 2.6	50.5 ± 5.7
Soft coral	22.5 ± 2.3	23.2 ± 3.0	35.8 ± 1.6	22.7 ± 3.7	12.0 ± 1.9
Unidentified coral	0.4 ± 0.2	0.5 ± 0.2	0.6 ± 0.1	0.3 ± 0.1	0.7 ± 0.3
Total live coral	**52.4 ± 5.3**	**71.2 ± 3.8**	**66.1 ± 2.6**	**54. 9 ± 2.6**	**62.5 ± 4.2**
Macroalgae	2.3 ± 1.1	3.0 ± 0.7	0.6 ± 0.2	0.7 ± 0.2	0.3 ± 0.2
Turf algae	0.6 ± 0.2	0.2 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Coralline algae	0.0 ± 0.0	0.9 ± 0.6	0.6 ± 0.2	0.4 ± 0.3	1.4 ± 0.7
Seagrasses	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.1	1.1 ± 0.4
Invertebrates					
Tridacna	0.2 ± 0.1	0.0 ± 0.0	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0
Ascídeas	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Anémonas	0.0 ± 0.0	0.0 ± 0.0	1.2 ± 0.7	0.0 ± 0.0	0.2 ± 0.1
Hidróides	0.4 ± 0.1	0.2 ± 0.2	1.0 ± 0.4	0.1 ± 0.1	0.2 ± 0.1
Sponges	0.5 ± 0.2	1.0 ± 0.3	0.6 ± 0.2	0.2 ± 0.1	0.5 ± 0.3
Equinoderms	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Zoanthidea	0.6 ± 0.2	0.5 ± 0.3	0.3 ± 0.1	0.3 ± 0.1	0.2 ± 0.2
Dead coral	1.0 ± 0.2	1.3 ± 0.3	0.2 ± 0.1	1.0 ± 0.3	1.6 ± 0.3
Dead coral with algae	2.3 ± 0.6	3.0 ± 1.0	1.0 ± 0.3	1.0 ± 0.3	2.6 ± 0.8
Rocks	5.3 ± 0.9	0.8 ± 0.3	2.2 ± 0.9	0.6 ± 0.2	0.0 ± 0.0
Rocks with algae	28.3 ± 3.1	15.7 ± 4.2	19.7 ± 2.4	35.3 ± 1.9	25.0 ± 2.9
Hard stone	0.6 ± 0.3	0.8 ± 0.4	1.9 ± 0.9	3.4 ± 0.8	2.6 ± 1.2
Sediment	4.5 ± 0.9	0.9 ± 0.4	3.6 ± 0.7	1.3 ± 0.3	0.8 ± 0.6
Water	0.4 ± 0.2	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Shadow	0.6 ± 0.2	0.7 ± 0.3	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1
Unknown	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Unidentified	0.2 ± 0.1	0.0 ±0.0	0.1 ± 0.0	0.0 ± 0.0	0.1 ± 0.1

Epidentron Island

The reef visited in the northeast zone of Epidendron Island, situated approximately 50 meters from the beach, is characterized by its high degree of rugosity, chiefly owing to the presence of dense amalgamations of *Porites* up to five meters in diameter. Visibility was low, no more than seven meters, within an inspected area between 1.7 and 7.3 meters in depth.

The greatest percentage of coral coverage was found on Epidentron Island (71.2%; Table 2), where stony corals clearly predominated (48%) in the form of ramified and tabular *Acropora* species (Tables 2, 3). The *Porites* genus was represented particularly in the form of massive and sub-massive colonies. The encrusting forms (especially *Echinopora*) were equally well represented with a coverage percentage of approximately 6.3%. The soft corals (23.2%) were represented by diverse species of the *Cespitularia* (9.6%), followed by the *Sinularia* (5.7%; Table 4) genus.

The macroalgae (3.0%, particularly *Halimeda*) attained the highest values on this island. Other invertebrates figured poorly, with the exception of the giant clams (*Tridacna* sp.) that occur in great numbers. No spiny starfish or bleached coral was observed.

Table 4. Coverage percentage (± standard deviation) of the principal coral genera in the reefs that were studied.

Genus	Fogo	Epidendron	Ndjovo	Puga-Puga	Mafamede
Scleractinia (stony corals)					
Acropora	17.5 ± 3.1	33.7 ± 6.4	11.6 ± 1.5	5.9 ± 1.1	16.0 ± 4.6
Astreopora	0.0 ± 0.0	0.2 ± 0.2	0.0 ± 0.0	0.5 ± 0.4	0.2 ± 0.1
Diploastrea	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.7 ± 1.7
Echinopora	0.8 ± 0.3	2.8 ± 0.7	3.1 ± 0.8	0.5 ± 0.2	4.2 ± 0.9
Favia	0.6 ± 0.3	0.3 ± 0.2	0.2 ± 0.1	0.7 ± 0.2	0.7 ± 0.3
Favites	0.2 ± 0.1	0.9 ± 0.3	0.6 ± 0.2	0.8 ± 0.2	0.9 ± 0.3
Fungídeos	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Galaxea	0.3 ± 0.2	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.8 ± 0.4
Goniopora	0.1 ± 0.1	0.9 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	6.4 ± 3.1
Lobophyllia	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	2.8 ± 1.6
Montipora	1.6 ± 0.5	1.0 ± 0.3	0.7 ± 0.2	0.0 ± 0.0	0.5 ± 0.5
Mycedium	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Oxypora	0.7 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.2
Pachyseris	0.1 ± 0.1	0.6 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.8 ± 0.5
Pavona	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Platygyra	0.6 ± 0.3	0.5 ± 0.2	0.9 ± 0.4	0.9 ± 0.4	0.4 ± 0.2
Pocillopora	0.8 ± 0.2	0.7 ± 0.1	1.1 ± 0.5	0.9 ± 0.3	0.5 ± 0.2
Porites	5.5 ± 0.8	3.2 ± 0.9	9.9 ± 2.9	20.5 ± 1.5	11.6 ± 4.2
Seriatopora	0.6 ± 0.5	1.0 ± 0.7	1.4 ± 0.5	0.0 ± 0.0	1.0 ± 0.5
Stylophora	0.7 ± 0.2	0.1 ± 0.1	0.0 ± 0.0	0.1 ± 0.1	0.3 ± 0.2
Alcyonacea (soft corals)					
Cespitularia	3.5 ± 0.9	9.6 ± 1.4	18.6 ± 1.3	12.5 ± 1.5	1.6 ± 0.4
Cladiella	1.2 ± 0.6	1.1 ± 0.6	0.5 ± 0.3	0.2 ± 0.1	0.7 ± 0.5
Lobophytum	2.4 ± 0.9	1.7 ± 0.4	0.4 ± 0.1	0.8 ± 0.3	0.3 ± 0.3
Neftídeos	0.4 ± 0.3	0.0 ± 0.0	6.2 ± 1.4	1.2 ± 0.2	2.0 ± 0.5
Rhytisma	0.8 ± 0.1	0.2 ± 0.2	2.2 ± 0.3	1.2 ± 0.3	4.2 ± 1.5
Sarcophyton	1.9 ± 1.0	2.8 ± 1.1	2.8 ± 1.0	3.2 ± 1.6	0.6 ± 0.2
Sinularia	5.3 ± 0.8	5.7 ± 0.9	3.4 ± 0.6	1.7 ± 0.6	1.6 ± 0.5
Tubipora	0.4 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.1
Xenídeos	6.9 ± 0.9	2.4 ± 0.8	1.5 ± 0.6	1.6 ± 0.5	0.3 ± 0.1

Not unlike the reef visited on Fogo Island, that of Epidentron Island presented relatively low indexes in terms of density, biomass and reef fish diversity. Surgeonfish figured as the most prominent species among the reef's ichthyological fauna, followed by butterfly and parrotfish. The most prevalent trophic group in this reef was also that of herbivores, which presented the elevated density, biomass and diversity indexes of corallivore fish species. In terms of the latter, these values were the highest found of all of the visited reefs (Tables 5 and 6).

This reef stood out as well for its lack of large fish species. Indeed, none was found greater than 20 cm, and 97.6% lay within the 0-10 cm size category.

Table 5. Density (average N° of specimens/154 m^2 ± standard deviation) and Biomass (g/154 m^2) found for each family and trophic group in the reefs that were studied.

Families	Variable	Fogo	Epidendron	Ndjovo	Puga-Puga	Mafamede
Acanthuridae	Density	21.0 ± 9.8	12.9 ± 4.0	12.6 ± 1.0	11.4 ±2.4	21 .3 ± 4.8
	Biomass	186.9 ± 90.3	56.9 ± 14.9	244.4 ± 70.6	178.3 ± 67.5	339.5 ± 103.9
Chaetodontidae	Density	3.8 ± 1.8	7.0 ± 2.2	8.1 ± 1.7	4.6 ± 0.9	7.6 ± 2.0
	Biomass	14.5 ± 6.2	27.2 ± 8.6	29.7 ± 6.2	16.0 ± 3.4	25.5 ± 6.6
Haemulidae	Density	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.4 ± 0.3	0.3 ± 0.3
	Biomass	0.0 ± 0.0	0.7 ± 0.7	0.0 ± 0.0	1.0 ± 0.7	0.7 ± 0.7
Lethrinidae	Density	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	1.3 ± 1.0	0.3 ± 0.2
	Biomass	0.0 ± 0.0	0.0 ± 0.0	0.5 ± 0.5	3.1 ± 2.2	0.8 ± 0.6
Lutjanidae	Density	0.3 ± 0.3	2.7 ± 1.5	6.3 ± 2.4	10.7 ± 6.8	1.9 ± 0.6
	Biomass	0.6 ± 0.6	6.5 ± 3.6	14.5 ± 5.2	27.1 ± 17.4	4.2 ± 1.3
Mullidae	Density	0.8 ± 0.5	1.0 ± 0.4	4.4 ± 1.3	3.0 ± 0.7	0.4 ± 0.2
	Biomass	1.3 ± 0.8	1.1 ± 0.7	6.5 ± 1.6	61.3 ± 37.5	0.6 ± 0.3
Pomacanthidae	Density	1.0 ± 0.7	0.4 ± 0.3	0.4 ± 0.3	2.1 ± 0.7	1.0 ± 0.4
	Biomass	2.8 ± 2.0	1.2 ± 0.8	1.2 ± 0.8	6.1 ± 2.0	2.8 ± 1.0
Scaridae	Density	3.3 ± 1.0	4.1 ± 0.7	7.0 ± 1.8	3.9 ± 1.2	5.3 ± 1.5
	Biomass	157.7 ± 63.7	54.7 ± 28.2	80.7 ± 36.6	125.5 ± 41.8	109.2 ± 35.6
Serranidae	Density	0.3 ± 0.3	0.0 ± 0.0	0.3 ± 0.2	0.4 ± 0.2	0.4 ± 0.2
	Biomass	0.5 ± 0.5	0.0 ± 0.0	28.2 ± 20.2	53.9 ± 25.5	18.4 ± 17.7
Siganidae	Density	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.2	0.3 ± 0.2	0.0 ± 0.0
	Biomass	0.0 ± 0.0	0.0 ± 0.0	1.4 ± 0.9	1.4 ± 0.9	0.0 ± 0.0
Total (per reef)	Density	**30.3 ± 11.1**	**28.4 ± 3.2**	**39.6 ± 4.8**	**38.1 ± 6.6**	**38.4 ± 4.9**
	Biomass	**364.3 ± 123.6**	**148.4 ± 29.2**	**407.1 ± 102.0**	**473.7 ± 101.5**	**501.7 ± 116.8**
Trophic groups						
Carnivore	Density	1.3 ± 0.5	4.0 ± 2.0	11.1 ± 3.0	15.9 ± 6.6	3.3 ± 0.7
	Biomass	2.4 ± 1.0	8.3 ± 4.7	49.7 ± 25.3	146.4 ± 44.4	24.7 ± 18.6
Corallivore	Density	1.0 ± 0.6	5.6 ± 1.8	2.7 ± 0.7	0.7 ± 0.4	0.9 ± 0.5
	Biomass	4.2 ± 2.5	22.4 ± 7.1	11.1 ± 2.8	3.0 ± 1.5	3.6 ± 1.9
Herbivore	Density	344.6 ± 129.0	111.6 ± 27.6	326.5 ± 87.6	305.3 ± 88.1	444.3 ± 131.1
	Biomass	24.3 ± 10.7	17.0 ± 3.5	19.9 ± 1.8	15.6 ± 1.8	22.6 ± 4.9
Omnivore	Density	3.8 ± 2.1	1.9 ± 0.8	5.9 ± 1.3	6.9 ± 1.3	7.7 ± 1.5

Family	Fogo	Epidendron	Ndjovo	Puga-Puga	Mafamede
Acanthuridae	3.5 ± 0.6	2.9 ± 0.6	3.1 ± 0.3	1.9 ± 0.4	4.0 ± 0.4
Chaetodontidae	1.3 ± 0.3	2.6 ± 0.8	3.9 ± 0.6	2.7 ± 0.4	3.7 ± 1.0
Haemulidae	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.3 ± 0.2	0.1 ± 0.1
Lethrinidae	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	0.4 ± 0.2	0.3 ± 0.2
Lutjanidae	0.3 ± 0.3	0.9 ± 0.4	1.3 ± 0.3	1.1 ± 0.3	1.0 ± 0.2
Mullidae	0.5 ± 0.3	0.6 ± 0.2	1.7 ± 0.3	1.3 ± 0.2	0.4 ± 0.2
Pomacanthidae	0.5 ± 0.3	0.3 ± 0.2	0.3 ± 0.2	0.9 ± 0.1	0.9 ± 0.3
Scaridae	2.3 ± 0.5	2.1 ± 0.3	2.1 ± 0.7	2.0 ± 0.5	1.9 ± 0.4
Serranidae	0.3 ± 0.3	0.0 ± 0.0	0.3 ± 0.2	0.4 ± 0.2	0.4 ± 0.2
Siganidae	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.2	0.3 ± 0.2	0.0 ± 0.0
Total (per reef)	**8.5 ± 1.3**	**9.4 ± 1.1**	**13.1 ± 1.3**	**11.3 ± 1.7**	**12.7 ± 1.1**
Trophic groups					
Carnivore	1.0 ± 0.4	1.6 ± 0.6	3.4 ± 0.6	3.6 ± 0.8	2.3 ± 0.5
Corallivore	0.5 ± 0.3	1.6 ± 0.4	1.3 ± 0.2	0.4 ± 0.2	0.6 ± 0.3
Herbivore	5.8 ± 0.9	5.0 ± 0.4	5.6 ± 0.6	4.1 ± 0.7	5.3 ± 0.6
Omnivore	1.3 ± 0.3	1.3 ± 0.6	2.9 ± 0.4	3.1 ± 0.3	4.0 ± 0.7
Planktivore	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.6 ± 0.2

Table 7. Visited reefs' susceptibility to damage from recreational diving. Susceptibility data refer to the coverage percentage of coral categories according to the order presented Table 1.

Category	Fogo	Epidendron	Ndjovo	Puga-Puga	Mafamede
Relatively resistant	30.3	34.4	47.3	46.8	28
Susceptible to very susceptible	21.9	36.7	18.9	7.8	10.1

Coroa Island

The reef was visited very briefly and no quantitative information was gathered. A good coral coverage of approximately 40-45%, however, was observed, especially of *Porites*, giving the reef a rugged character. Ramified forms of *Acropora*, *Pocillopora verrucosa* and *Porites rus* were abundant in the reef, along with a diverse and plentiful community of soft corals. No bleached colonies or spiny starfish was encountered, though giant clams (*Tridacna* sp.) were present in abundance.

No fish count was conducted on this island. On the basis of a brief reconnaissance dive, it was noted that this area presented characteristics similar to those encountered in the two previous reefs: low indexes of fish diversity and density, along with an absence of larger fish species.

Ndjovo Island

The reef that was visited is situated on the island's northwest, approximately 50 meters from the beach. The first colonies, however, are found very close to the beach. Visibility was recorded at seven meters. The reef is characterized by its remarkable rugosity, with massive corals reaching three meters in height. The most extensive coral coverage was found from three to 6.5 meters, where it reaches the sand.

The reef contains extensive live-coral coverage (66.1%) of predominantly soft species (35.8%; Table 3), particularly *Cespitularia* spp., Nephtídeos, *Sinularia* and *Sarcophyton* (Table 4). The stony corals, which cover approximately 30%, were predominantly of the ramified (*Acropora*, *Pocillopora*, *Seriatopora*) and massive (principally *Porites*; Tables 3 and 4) forms. Given the predominance of soft and massive corals, this reef encompassed the greatest percentage of corals that are relatively resistant to damage caused by recreational divers (Table 7).

No significant macroalgae coverage was observed, though rock and algae category figured significantly (above 15%). Anemones and hydroids were abundant despite a number of *Tridacna* sp. Specimens. Neither bleached colonies nor evidence of spiny starfish was found.

This reef presented the greatest degree of fish density and diversity in comparison to all of the other explored reefs. In terms of biomass, however, this reef presented values inferior to the ones visited on Puga-Puga and Mafamede (Tables 5 and 6). The ichthyological community was primarily composed of surgeonfish (Acanthuridae), butterfly fish (Chaetodontidae) and parrotfish (Scaridae). A relatively high density of snapper (Hamulidae) and surmullet (Mullidae) was also encountered. In terms of diversity, this reef evinced a predominance of butterfly fish, followed by surgeons and parrotfish. The predominant trophic group, in the way of diversity, biomass and density, was that of herbivores, though great numbers of carnivorous fish were also recorded (Tables 5 and 6).

The 0-10 cm fish size category of was the predominant one in this reef (92.0%). However, although the PCs registered very few large fish (0.7%), divers encountered some fish specimens greater than 30 cm, such as barracudas (*Sphyraena* sp.), giant trevally (*Caranx ignobilis*), snapper (*Lutjanus rivulatus*) and grouper (*Cephalopholis argus*).

Puga Puga Island

The visited reef is at the northeast coast of the island (approximately 50 to 60 meters from the beach), inclining very little and lacking any sudden alteration in depth, which varied from one to six meters, with a visibility of eight meters. The coral community was less dense than in other reefs and rugosity was unremarkable. The reef was surrounded by seagrass beds.

The corals community was dominated by the stony variety (32.2%), especially massive corals, thereby conferring a high proportion of coverage by corals of the *Porites* and ramified *Acropora* genera that are relatively resistant to the impact of recreational diving (Table 7). Small colonies of *Cespitularia* spp. and *Sarcophyton* (Tables 3 and 4) comprised the greater portion of the soft coral community. A great portion of the reef was covered by turfy algae and very little in the way of invertebrates was observed. No sign of degradation provoked by bleaching, fishing or the *Acanthaster planci* starfish was observed.

This reef's density figures were similar to those found in the Mafamede reef, which has a higher recorded density than the reefs of Fogo Island and Epidendron. Furthermore, this reef presented the second highest biomass indicator found in the study (Table 5), composed primarily of surgeonfish as regards biomass and density and, in terms of diversity, of the Chaetodontidae (butterfly fish) family, with an average of more than two species per PC. This reef presented high degree of Parrotfish (Scaridae), surmullet (Mullidae) and grouper (Serranidae) biomass. Carnivore and herbivore fish densities were similar, although herbivores were predominant in terms of biomass and diversity. The 0–10cm fish size category also prevailed in this reef (86.24%), although a substantial percentage of those of the 10–20 cm (12.00%) category, as well as those greater than 20 cm (1.87%) were also found. Besides the fish observed during PCs recording, some fish bigger than 30 cm, such as blue-finned triggerfish (*Balistoides viridescens*), blue fin trevally (*Caranx melampygus*) and groupers (*Epinephelus flavocaeruleus* and *Cephalopholis argus*), were spotted during the dives.

Mafamede Island

The reef we explored is situated on the island's southwest perimeter and approximately 300 meters from the beach. This reef is marked by its rugosity and large mounds of coral. The lowest area of the reef, where one finds a 60-meter wide coral colony, begins at a depth of approximately two meters. A very accentuated descent occurs after approximately three meters and ends abruptly at a sand bank that runs parallel to the reef. The area of accentuated descent is dominated by massive and sub-massive corals. These large, mono-specific colonies contain *Porites*, *Lobophyllia corymbosa* and *Favites* at depths of up to approximately six meters. The sand-reef interface in the deepest zone is dominated by foleaceous colonies of *Porites* and *Montipora*. Visibility as measured was six meters.

The corals community was clearly dominated by the stony variety (total coverage measuring 50.5%), ramified (genus *Acropora*) and sub-massives (*Porites* and *Goniopora*; Tables 3 and 4). Massive and encrust ting forms also figured prominently, particularly the *Lobophyllia*, *Diploastrea*, *Porites* and *Echinopora* genera (Table 4). The lowest soft corals coverage (12%) was recorded in Mafamede, where the smallest and most flexible colonies (*Rhiytisma* genera and various species of favids) prevailed (Table 4). This resulted in a low coverage of corals that are vulnerable to the impact of recreational diving (Table 7).

The reef presented and elevated percentage of rock and algae (25%), while other invertebrates figured relatively rare. Only one spiny starfish measuring approximately 30 cm was observed.

On the island's northeast perimeter is a reef that borders the atoll surrounding the island. This reef, where soft corals predominate with a 40% coverage, was explored but only briefly. The corals community was composed of massive coral mounds (*Porites* and favid), interspersed with large colonies of soft coral (*Sarcophyton*) and other, smaller colonies of *Cespitularia*, *Lobophytum* and *Sinularia*. The reef almost touches the surface to a depth of approximately six meters, after which the colonies become more dispersed. A number *Porites* colonies evince conspicuous marks from fish bites, probably those of parrotfish – Scaridae. Seven spiny starfish measuring 30-35 cm were encountered in the space of one hour. No bleached corals colony was found. Examples of *Tridacna* sp. (some reaching 40 cm) abound in this reef.

The ichthyological community presented the largest biomass encountered on the five reefs that were explored and the second-largest figures in the way of density and diversity (Tables 5 e 6). It was furthermore dominated by surgeon, butterfly and parrotfish, making the predominant trophic group that of herbivores. The presence of planktivores was remarkable as this trophic group was not encountered in any of the other reefs

The 0-10 cm fish-size category prevailed in this reef, representing 89.91% of the specimens observed. Nevertheless, specimens representing the 10–20 cm (8.56%) size category, along with some greater than 20 cm (at 2.60%, the reef having the greatest density of specimens of this category) were observed as well. Besides the specimens recorded along the PCs, such specimens of considerable size as batfish (*Platax* sp.), snappers (*Lutjanus rivulatus*), porgies (Sparidae) and grouper (*Epinephelus flavocaeruleus*) were encountered by divers.

INDICATORS AND MONITORING

Table 8 presents a proposal for a program to monitor the reef communities of various islands of the Primeiras and Segundas Archipelago. The program's essential function would be to monitor the potential damage stemming from tourism, heavy-sands exploration, fisheries, climatic change and other natural phenomena. The proposal is based upon the findings of the present study as well as the recommendations of Schleyer (1999) and Schleyer & Celliers (2000).

Table 8. Proposed monitoring program for reef communities.

Indicator	Method	Replicated	Frequency	Site
Benthic Community				
% coverage of live coral	Photo transects	6 transects per reef; at least 40 photos per transect	annually	Primeiras (I Silva, Fogo, Epidendron) and Segundas (Caldeira, Ndjovo, Mafamede)
% coverage of benthic categories (genera and growth methods)				
Stony-coral colony size structure				
Bleached coral colonies				
Presence of diseases in corals				
Other invertebrates (hedgehog corals, giant clams - *idacna*)				
Spiny starfish, lobsters	Random counting / time	2 divers per reef during 30 min		
Ichthyological community				
Density of selected families *	Point counts (7 m radius; 3 min)	At least 6 PCs per reef	annually	Primeiras (Silva, Fogo, Epidendron) and Segundas (Caldeira, Ndjovo, Mafamede)
Diversity of selected families				
Biomass of selected families				
Presence of indicator species (e.g. Giant grouper, Napoleon, etc	Presence/absence	Monitoring-team observation		

* selected families: Acanthuridae, Chaetodontidae, Haemulidae, Lethrinidae, Lutjanidae, Scaridae, Serranidae,

MANAGEMENT AND CONSERVATION

Despite the habitat's favorable conditions, such as an elevated percentage of live-coral coverage, the explored reefs presented low values in terms of fish density, biomass and diversity as compared to other regions in the country (Costa *et al.*, 2005).

Intensive fisheries activity may be the most likely explanation for the paltry ichthyological community found in the surveyed area, as demonstrated by the absence of larger, commercially-valuable species. This phenomenon is further exemplified by the difference found between the reefs of the Primeiras (Fogo, Epidendron and Coroa) and those of the Segundas Islands (Ndjovo, Puga Puga and Mafamede), where one finds a more abundant ichthyological community (Table 5). Community inspectors work on these islands and there is an active protection and conservation program for species such as marine turtles administered by the Angoche Artisenal Fishermen's Association.

Owing to their diversity, state of conservation, size, productivity and tourism potential, the coral reefs that were explored constitute an important resource for Mozambique. They are all of equal importance, given the fact that the islands are surrounded by reefs that form almost complete atolls (found nowhere else in the country) and, finally, because they comprise the southernmost extremity of an almost continuous series of reefs the border the west coast of the African continent.

For the aforementioned reasons, implementation of a protection or conservation program for these reefs is urgently needed. To this end, we would recommend the establishment of a system of comprehensive marine reserves (to include coral reefs) that would function as replenishment zones for surrounding areas, in accordance with the General Regulation for Marine Fisheries. In keeping with the findings of the present study and the observations of Schleyer (1999), we would propose a comprehensive protection plan implemented for coral reef areas on the islands of Silva, Epidendron, Caldeira, Ndjovo and Mafamede (Figures 1 and 2). In addition, the following measures should be adopted:

- Restrict underwater fishing to pelagic species;
- Prohibit anchoring above reefs and the use of destructive fishing techniques (i.e., trawls, poisons and explosives) ;
- Adoption by tour operators of good practices, especially as regards activities that directly affect coral reefs, such a diving, employment of vessels and refuse management; and,
- Control over the gathering of invertebrates (clams , starfish and others) by local communities.

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Appendix I. Pre-selected list of reef fish species quantified during the course of the study.

FAMILIES	SPECIES	TROPHIC GROUP
Acanthuridae	*Acanthurus dussumieri*	Herbivore
	Acanthurus leucosternon	Herbivore
	Acanthurus lineatus	Herbivore
	Acanthurus tennenti	Herbivore
	Acanthurus triostegus	Herbivore
	Cirurgiões castanhos *	Herbivores
	Naso annulatus	Planktivore
	Naso brevirostris	Planktivore
	Naso lituratus	Herbivore
	Naso unicornis	Herbivore
	Zebrasoma scopas	Herbivore
	Zebrasoma veliferum	Herbivore
Chaetodontidae	*Chaetodon auriga*	Omnivore
	Chaetodon blackburnii	Carnivore
	Chaetodon dolosus	Omnivore
	Chaetodon falcula	Omnivore
	Chaetodon guttatissimus	Omnivore
	Chaetodon interruptus	Omnivore
	Chaetodon kleinii	Omnivore
	Chaetodon lineolatus	Omnivore
	Chaetodon lun ula	Omnivore
	Chaetodon melannotus	Corallivore
	Chaetodon mertensii	Omnivore
	Chaetodon meyeri	Corallivore
	Chaetodon trifascialis	Corallivore
	Chaetodon trifasciatus	Corallivore
	Chaetodon vagabundus	Omnivore
	Chaetodon xanthocephalus	Omnivore
	Chaetodon zanzibarensis	Corallivore
	Forcipiger flavissimus	Carnivore
	Hemitaurichthys zoster	Planktivore
	Heniochus acuminatus	Omnivore
	Heniochus monoceros	Carnivore
Haemulidae	*Diagramma pictum*	Carnivore
	Plectorhinchus gaterinus	Carnivore
	Plectorhinchus flavomaculatus	Carnivore
	Plectorhinchus plagiodesmus	Carnivore
	Plectorhinchus playfairi	Carnivore
Lethrinidae	*Gnathodentex aureolineatus*	Carnivore
	Lethrinus harak	Carnivore
	Lethrinus nebulosus	Carnivore
	Monotaxis grandoculis	Carnivore
Lutjanidae	*Aprion virescens*	Carnivore
	Lutjanus fulviflamma	Carnivore
	Lutjanus gibbus	Carnivore
	Lutjanus kasmira	Carnivore
	Lutjanus monostigma	Carnivore
	Macolor niger	Carnivore
Mullidae	*Mulloides vanicolensis*	Carnivore
	Mulloidichthys flavolineatus	Carnivore
	Parupeneus barberinus	Carnivore
	Parupeneus bifasciatus	Carnivore
	Parupeneus indicus	Carnivore
	Parupeneus macronema	Carnivore
	Parupeneus rubescens	Carnivore
Pomacanthidae	*Apolemichthys trimaculatus*	Carnivore
	Centropyge acanthops	Herbivore
	Centropyge bispinosus	Herbivore
	Centropyge multispinis	Omnivore
	Pomacanthus chrysurus	Omnivore
	Pomacanthus imperator	Omnivore
	Pomacanthus rhomboides	Carnivore
	Pomacanthus semicirculatus	Omnivore
	Pygoplites diacanthus	Carnivore
Scaridae	*Scarus ghobban*	Herbivore
	Scarus rubroviolaceus	Herbivore
	Scarus scaber	Herbivore
	Scarus Sordidus	Herbivore

* includes *Acanthurus nigrofuscos*, *Ctenochaetus binotatus, C. striatus* and *C. strigosus* species

Appendix I. Continuation.

FAMILIES	SPECIES	TROPHIC GROUP
Serranidae	*Cephalopholis argus*	Carnivore
	Epinephelus flavocaeruleus	Carnivore
	Epinephelus macrospios	Carnivore
	Epinephelus malabaricus	Carnivore
	Epinephelus merra	Carnivore
	Epinephelus tukula	Carnivore
	Plectropomus laevis	Carnivore
Siganidae	*Siganus sutor*	Herbivore

Appendix II. Average density values (average of specimens number/154m^2 ± standard deviation), Biomass (g/154m^2 ± standard deviation) and diversity (average of specimens number/154m^2 ± standard deviation) found for each family and trophic group within the surveyed area.

Families	Average Density	Average Biomass	Average Diversity
Acanthuridae	15.3 ± 1.9	202.6± 35.6	3.0 ± 0.2
Chaetodontidae	6.4 ± 0.8	23.3± 3.0	3.0 ± 0.3
Haemulidae	0.2 ± 0.1	0.5± 0.3	0.1 ± 0.1
Lethrinidae	0.4 ± 0.2	1.0± 0.5	0.2 ± 0.1
Lutjanidae	4.8 ± 1.7	11.5± 4.2	1.0 ± 0.1
Mullidae	2.0 ± 0.4	15.4± 8.9	0.9 ± 0.1
Pomacanthidae	1.0 ± 0.2	2.8± 0.7	0.6 ± 0.1
Scaridae	4.8 ± 1.7	100.7± 17.4	2.1 ± 0.2
Serranidae	0.3 ± 0.1	22.0± 8.4	0.3 ± 0.1
Siganidae	0.1 ± 0.1	0.6± 0.3	0.1 ± 0.1
Total (for region)	**35.4 ± 2.5**	**380.4± 47.2**	**11.3 ± 0.7**
Trophic groups			
Carnivore	7.7 ± 1.8	50.4± 14.7	2.5 ± 0.3
Corallivore	2.3 ± 0.5	9.3± 2.2	0.9 ± 0.1
Herbivore	19.4 ± 1.9	302.9± 45.0	5.1 ± 0.3
Omnivore	5.2 ± 0.7	16.8± 2.2	2.6 ± 0.3
Planktivore	0.9 ± 0.8	1.0± 0.9	0.1 ± 0.1

Appendix 3. Cumulative provisional list of benthic species observed in the coral reefs of the Primeiras and Segundas Archipelago. Species presented in alphabetical order. Includes species reported for the Primeiras Islands by Schleyer (2000) and Schleyer & Celliers (2000).

CNIDARIA

Alcyonacea
Anthelia sp.
Cladiella australis
Cladiella kashmani
Cladiella krempfii
Cladiella spp.
Cespitularia spp.
Dendronephthya sp.
Heteronexia sp.
Lemnalia sp.
Litophyton sp.
Lobophytum crassum
Lobophytum depressum
Lobophytum latilobatum
Lobophytum patulum
Lobophytum venustum
Nephthea sp.
Rhytisma fulvum fulvum
Sarcophyton spp.
Scleronephtya sp.
Sinularia abrupta
Sinularia brassica
Sinularia dura
Sinularia firma
Sinularia gyrosa
Sinularia heterospiculata
Sinularia leptoclados
Sinularia macrodactyla
Sinularia variabilis
Sinularia spp.
Tubipora musica
Xenia sp.

Black corals and gorgonias
Cirrhipathes sp.
Rumphella sp.

Scleractinia (corais duros)
Acanthastrea echinata
Acropora austera
Acropora clathrata
Acropora cytherea
Acropora danai
Acropora gemmifera
Acropora humilis/digitifera
Acropora hyacinthus
Acropora microphthalma
Acropora palifera
Acropora robusta
Alveopora allingi
Alveopora spongiosa
Anomastrea irregularis
Astreopora myriophhalma
Blastomussa merletti
Coscinarea monile
Coscinarea mcneilli
Cycloseris sp.
Cyphastrea sp.
Diploastrea heliopora
Echinopora gemmacea
Echinophyllia aspera
Favia stelligera
Favia spp.
Favites abdita
Favites flexuosa
Favites peresi
Favites pentagona
Favites spp.
Fungia spp.
Galaxea fascicularis
Gardinoseris planulata
Goniopora djiboutiensis
Gyrosmila interrupta
Heteropsammia cochlea
Horastrea indica
Hydnophora microconos
Hydnophora exesa
Leptoria Phrygia
Leptoseris explanata
Leptoseris hawaiensis
Lobophyllia corymbosa
Lobophyllia hemprichii
Merulina ampliata
Montastrea annuligera
Montipora aequituberculata
Montipora monasteriata
Mycedium elephantotus
Oulophyllia crispa
Oxypora lacera
Phachyseris speciosa
Pavona clavus
Pavona minuta
Pocillopora damicornis
Pocillopora eydouxi
Pocillopora verrucosa
Platygyra daedalea
Platygyra meandrina
Platygyra sinensis
Porites cylindrica
Porites lichen
Porites lobata
Porites lutea
Porites nigrescens
Porites rus
Porites sp.
Psammocora haemeana
Seriatopora caliendrum
Seriatopora histrix
Stylophora pistillata
Symphyllia valenciennesii
Turbinaria peltata
Turbinaria mesenterina
Turbinaria reniformis

Milleporina (fire coral)
Millepora platyphyllia
Millepora tenelta

Anthozoa (anémonas)
Cryptodendron adhaesivum
Heteractis magnifica
Stilodactyla sp.

Zoanthidea
Zoanthus sansibaricus

Hidrozoa
Algaophenia cupressina
?Thecocarpus sp.

PORIFERA (sponges)
Acanthella sp.
Callyspongia sp.
Dysidea herbacea
Haliclona sp.

ECHINODERMATA
Acanthaster plancii
Culcita sp.
Diadema sp.
Fromia sp.
Holothuria atra
H. edulis
H. scabra
Linckia laevigata
Pseudocolochirus violaceus
Stichopus chloronotus
S. horrens
Synaptea maculata

MOLLUSK
Gastropod
Charonia tritonis
Lambis sp.
Cypraeia tigris
Cypraeia spp.
Ovula ovum

Bivalvia
Tridacna sp.

Cephalopoda
Octopus sp.

Nudibranchia
Chomodoris africana
Phyllidia varicosa

CRUSTACEA
Panulirus sp.

ASCIDIA
Policytor africanus
Eudistoma caeruleum

ALGAE (macroalgae)
Boergesiana sp.
Caulerpa sp.
Codium sp.
Cystoseira sp.
Halimeda sp.
Padina sp.
Turbinaria decurrens
Turbinaria conoides
Sargassum sp.

SEAGRASSES
Zostera capensis
Thalassodendron ciliatum

Appendix 4. Cummulative list of fish species observed in the Primeiras and Segundas Archipelago. Includes species reported for Caldeira Island by Paterson *et al*. (2000).

Acanthuridae
Acanthurus dussumieri
Acanthurus leucosternon
Acanthurus lineatus
Acanthurus nigricauda
Acanthurus nigrofuscus
Acanthurus triostegus
Ctenochaetus spp.
Naso brevirostris
Naso lituratus
Naso unicornis
Zebrasoma scopas

Apogonidae
Apogon apogonides

Aulostomidae
Aulostomus chinensis

Balistidae
Balistapus undulates
Balistoides conspicillum
Balistoides viridescens
Melichthys niger
Odonus niger
Rhinecanthus rectangulus
Sufflamen chrysopterus
Sufflamen fraenatus

Blenniidae
Ecsenius midas
Plagiotremus rhinorhynchos
Plagiotremus tapeinosoma

Caesionidae
Caesio caerulaureus
Caesio xanthonota
Pterocaesio tile (?)

Carangidae
Caranx ignobilis
Caranx melampygus
Caranx sexfasciatus
Scomberoides commersonnianus
Scomberoides tol

Chaetodontidae
Chaetodon auriga
Chaetodon blackburnii
Chaetodon falcula
Chaetodon guttatissimus
Chaetodon interruptus
Chaetodon kleinii
Chaetodon lineolatus
Chaetodon lunula
Chaetodon melannotus
Chaetodon mertensii
Chaetodon meyeri
Chaetodon trifascialis
Chaetodon trifasciatus
Chaetodon vagabundus
Chaetodon xanthocephalus
Heniochus acuminatus
Forcipiger flavissimus

Cirrhitidae
Paracirrhites arcatus
Paracirrhites forsteri

Dasyatidae
Taeniura lymma (?)

Ephippidae
Platax teira
Tripterodon orbis

Fistulariidae
Fistularia commersonii

Gobiidae
Nemateleotris magnifica
Ptereleotris evides

Haemulidae
Diagramma pictum
Plectorhinchus chubby
Plectorhinchus gaterinus
Plectorhinchus flavomaculatus
Plectorhinchus playfairi

Hemiramphidae
Hemiramphus far

Holocentridae
Myripristis melanosticta
Myripristis murdjan
Neoniphon samara
Sargocentron caudimaculatum
Sargocentron diadema

Kyphosidae
Kyphosus cinerascens
Kyphosus bigibbus

Labridae
Anampses caeruleopunctatus
Anampses lineatus
Bodianus axillaris
Bodianus bilunulatus
Bodianus diana
Cheilinus fasciatus
Cheilinus trilobatus
Cheilinus undulates
Coris caudimacula
Coris frerei
Epibulus insidiator
Gomphosus caeruleus
Halichoeres hortulanus
Halichoeres iridis
Labroides bicolor
Labroides dimidiatus
Macropharyngodon spp.
Stethojulis strigiventer
Thalassoma Hardwicke
Thalassoma hebraicum
Thalassoma lunare
Xyrichtys pavo

Lethrinidae
Gnathodentex aureolineatus
Lethrinus elongatus
Lethrinus harak
Lethrinus sanguineus
Monotaxis grandoculis

Lutjanidae
Aprion virescens
Lutjanus bohar
Lutjanus fulviflamma
Lutjanus fulvus
Lutjanus gibbus
Lutjanus kasmira
Lutjanus rivulatus
Lutjanus russellii
Lutjanus sanguineus
Macolor niger

Malacanthidae
Malacanthus latovittatus

Mobulidae
Manta birostris

Monacanthidae
Cantherhines dunerilii
Oxymoncanthus longirostris
Paraluteres prionurus

Monodactylidae
Monodactylus argenteus

Mugiloididae
Parapercis hexophthalma
Parapercis punctulata?

Mullidae
Mulloides vanicolensis
Mulloidichthys flavolineatus
Parupeneus barberinus
Parupeneus bifasciatus
Parupeneus cyclostomus
Parupeneus indicus
Parupeneus macronema
Parupeneus pleurostigma
Parupeneus rubescens
Upeneus sulphureus

Muraenidae
Echidna nebulosa
Gymnothorax favagineus

Oplegnathidae
Oplegnathus robinsoni

Ostraciidae
Ostracion meleagris

Pempheridae
Pempheris adusta
Pempheris mangula

Appendix 4. Continuation

Pomacanthidae
Centropyge acanthops
Centropyge bispinosus
Centropyge multispinis
Pomacanthus chrysurus
Pomacanthus imperator
Pomacanthus semicirculatus
Pygoplites diacanthus

Pomacentridae
Abudefduf sparoides
Abudefduf vaigiensis
Amphiprion akallopisos
Amphiprion allardi
Chromis dasygenys
Chromis dimidiate
Chromis nigrura
Chromis viridis
Chromis weberi
Chrysiptera unimaculata
Dascyllus aruanus
Dascyllus carneus
Dascyllus trimaculatus
Pectroglyphidodon dickii
Pectroglyphidodon imparipennis
Pectroglyphidodon lacrymatus
Pectroglyphidodon leucozonus
Pectroglyphidodon phoenixensis
Pomacentrus caeruleus
Pomacentrus trichourus
Stegastes nigricans

Pseudochromidae
Pseudochromis dutoiti

Priacanthidae
Priacanthus cruentatus
Priacanthus hamrur

Scaridae
Scarus ghobban
Scarus rubroviolaceus
Scarus scaber
Scarus Sordidus

Scom bridae
Scomberomorus commerson
Scomberomorus plurilineatus

Scorpaenidae
Pterois miles

Serranidae
Aethaloperca rogaa
Cephalopholis argus
Cephalopholis miniata
Epinephelus flavocaeruleus
Epinephelus longispinis
Epinephelus macrospilos
Epinephelus malabaricus
Epinephelus merra
Plectropomus punctatus
Pseudanthias squamipinnis
Va riola louti

Siganidae
Siganus sutor

Sphyraenidae
Sphyraena flavicauda
Sphyraena jello
Sphyraena spp.

Tetraodontidae
Arothron hispidus
Arothron nigropunctatus
Arothron stellatus
Canthigaster amboinensis
Canthigaster bennetti
Canthigaster coronata
Canthigaster janthinoptera
Canthigaster solandri
Canthigaster valentini

Zanclidae
Zanclus canescens