

## **A Review on the Ecology, Exploitation and Conservation of Reef Fish Resources in Mozambique**

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### **ABSTRACT**

Coral and rocky reefs are very important ecosystems in terms of their diversity, productivity, abundance and beauty. Mozambique possesses extensive reef areas, where fish fauna is the main exploited resource. Nevertheless, the ecology of these resources is little studied. A recent report listed 794 reef-associated fishes known to occur in Mozambican coral and rocky reefs. This is a first accountancy of the high fish diversity of Mozambican reefs, which must be assessed. Reef-associated fish resources exploitation is conducted at three basic levels: (i) subsistence (artisanal fishery); (ii) commercial exploitation (semi-industrial reef fishery, ornamental fish trade and recreational diving); and (iii) sports fishing. Presently, the artisanal fishery is the most important, as a food source, being responsible for about 70% of the country's total annual catch. However, commercial activities, such as ornamental fish trade and recreational diving, notwithstanding less important presently, show great economical and reef damage potential. Some conservation and management actions are discussed along with research needs.

### **RESUMO**

Os recifes rochosos e de coral são ecossistemas muito importantes, principalmente devido à sua elevada diversidade, produtividade, abundância e também beleza natural. Moçambique possui vastas áreas de recifes, em que a ictiofauna é o principal recurso explorado. No entanto, a ecologia destes recursos é pouco conhecida. Um estudo recente indica a existência de 794 espécies de peixes de recifes identificadas nos recifes de Moçambique. Esta é a primeira contabilização da elevada diversidade de peixes dos recifes de Moçambique, que necessita de ser estudada. A exploração dos recursos ictiológicos associados aos recifes é principalmente feita a três níveis: (i) subsistência (pesca artesanal); (ii) exploração comercial (comércio de peixe ornamental e mergulho desportivo); e (iii) pesca desportiva. Presentemente, a pesca artesanal é a mais importante, constituindo cerca de 70% das capturas anuais, no entanto as actividades comerciais como o comércio de peixe ornamental e o mergulho desportivo apesar de, presentemente pouco importantes, apresentam um elevado potencial económico e também um alto potencial de danificação dos recursos. Algumas medidas de conservação e gestão são discutidas além das necessidades de estudos futuros.

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### **INTRODUCTION**

Coral and rocky reefs constitute one of the most important ecosystems in our planet, being their astonishing diversity, productivity, abundance and beauty some of their main characteristics (Goldman & Talbot, 1976; Sorokin, 1995).

According to recent studies, coral reefs in Mozambique extend for an estimated area of about 1290 km<sup>2</sup> (Motta, 2000) and constitute one of the country's main marine assets (Schleyer *et al.*, 1999; Rodrigues *et al.*, 1999).

Approximately 42% of the Mozambican population live within coastal districts (INE, 1998) and rely largely on coastal resources. There are three types of fisheries in Mozambique, comprising industrial, semi-industrial and artisanal fisheries. These three sectors land about 65 000 tons/year from an estimated MSY of 300 000 tons/year (Palha de Sousa, 1996). The artisanal fishery is responsible for about 70% of the total catch. These fisheries are largely centered on the reefs and are clearly important to the coastal communities and the national economy (Rodrigues *et al.*, 1999).

Reefs are also important for the tourism industry. Most tourism occurs where the best infrastructure for tourism is established, especially near reefs of Pemba, Mozambique Island, Bazaruto Archipelago, Inhambane, Inhaca Island and Cabo de Santa Maria – Ponta do Ouro strip (Rodrigues *et al.*, 1999).

The present paper reviews the present state of knowledge of the ecology, exploitation and conservation of reef fishes in Mozambique.

## REEF FISH RESEARCH IN MOZAMBIQUE

The first studies published in Mozambique regarding reef fishes were carried out at Inhaca Island in the final 30's (Lopes, 1937, 1938). In the 50's and 60's, mainly taxonomic studies were conducted and reef fish species lists were made available especially for Inhaca Island (e.g. Smith, 1958; Sanches, 1963; Smith, 1968).

Only recently, the investigation of other aspects of the reef fish fauna started. Kalk (1995), elaborated on the trophic composition of the reef fish fauna at Inhaca Island and Pacule *et al.* (1996) and Loureiro (1998) studied the artisanal coral reef fisheries in Mécufi. Under the Darwin/Frontier Mozambique project (Whittington *et al.*, 1998) the diversity, species composition, abundance and fisheries of the coral reef fish fauna of the Quirimbas Archipelago was investigated. A short-term study at Inhaca Island, conducted by two Swedish researchers investigated the fisheries and tourism interaction with reef associated fishes (Nagel & Degerstedt, 1999). Also at Inhaca Island, Pereira (2000a) conducted a comparative study of the coral reef ichthyological communities from two distinct reefs and analysed fish-habitat relationships.

## ECOLOGY OF REEF-ASSOCIATED FISH COMMUNITIES IN MOZAMBIQUE

### Distribution

The occurrence of reef-associated fishes in Mozambique follows the occurrence and distribution of coral and rocky reefs (Figure 1). These reefs occur in two of Tinley's (1971) coastal regions:

- (i) The coral coast in the northern part of the country, from the Rovuma River to Pebane (17° 20'S), which supports true coral reefs that constitute an almost continuous fringing reef on the eastern shores of numerous small islands and the more exposed sections of the mainland coast, and;
- (ii) The parabolic dune coast in the southern part, from Bazaruto Archipelago (21°12'S) to Ponta do Ouro (26° 50'S). The distribution of coral and rocky reefs colonised by corals, along the coast and nearshore islands, is patchy and the reefs are more sparsely inhabited by corals (Rodrigues *et al.*, 1999).

The central section of the coast between Pebane (17° 20' S) and Bazaruto Island (21° 10' S), a distance of about 950 km, is classified as a swamp coast. Twenty-four rivers discharge into the Indian Ocean along this section, each with an estuary supporting well-established mangrove stands. The coastal waters are shallow and combine with the sediment loading from the rivers to cause typically high turbidity levels. Consequently, coral reef formation in this area is severely limited (Rodrigues *et al.*, 1999, 2000).

There are no published literature on distribution patterns and other biogeographical aspects of reef-associated fishes in Mozambique. Some species, however, have been observed only at certain definite locations. For example the palette surgeon (*Paracanthurus hepatus*), have been sighted only at Inhaca Island. The tiger angelfish (*Apolemichthys kingi*) is known to occur from Inhaca Island (pers. obs.) to Durban (Heemstra & Smith, 1995). Some species of butterflyfishes (family Chaetodontidae), also have a restrict distribution along the Mozambican coast. There is, thus, a need to study the biogeography of reef fishes in Mozambique.

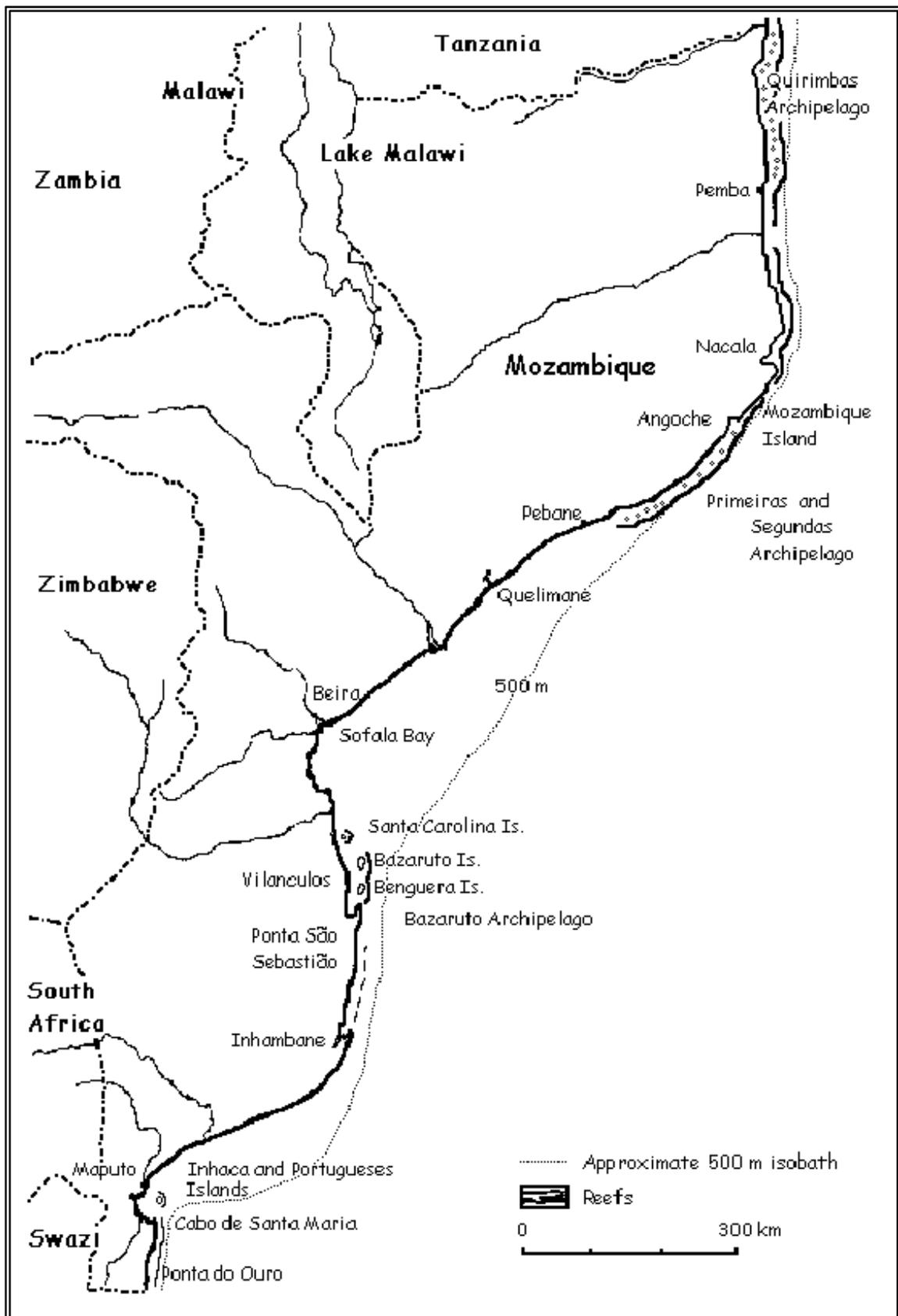


Figure 1. Map showing the distribution of coral reefs in Mozambique (after Schleyer *et al.*, 1999).

## Diversity

Mozambican coastal waters support high and long recognised fish diversity (Smith, 1953, 1955). A recent report (Pereira, 2000b) listed 794 species (in 93 families) of reef-associated fishes. Wrasses (family Labridae) are the best represented with 67 species, followed by groupers (family Serranidae – 57 species), damselfishes (Pomacentridae – 45 species) and gobiies (Gobiidae – 44 species) (Table 1). It is worth mentioning the high number of genera of the Gobiidae family (24), a less known group, thus presenting an elevated potential for the discovery of new species/records in the area.

**Table 1.** Number of genera and species of main reef-associated fishes (data from Pereira, 2000b)

| Family         | Common Name             | N° Genera | N° Species |
|----------------|-------------------------|-----------|------------|
| Acanthuridae   | Surgeonfishes           | 5         | 31         |
| Apogonidae     | Cardinal fishes         | 10        | 35         |
| Balistidae     | Triggerfishes           | 9         | 16         |
| Blenniidae     | Blennies                | 10        | 15         |
| Carangidae     | Kingfishes              | 12        | 28         |
| Carcharhinidae | Requiem sharks          | 3         | 11         |
| Chaetodontidae | Butterflyfishes         | 4         | 23         |
| Gobiidae       | Gobiies                 | 24        | 44         |
| Haemulidae     | Rubberlips and Grunters | 3         | 15         |
| Holocentridae  | Squirrelfishes          | 4         | 20         |
| Labridae       | Wrasses                 | 28        | 67         |
| Lethrinidae    | Emperors                | 4         | 19         |
| Lutjanidae     | Snappers                | 7         | 22         |
| Monacanthidae  | Filefishes              | 9         | 12         |
| Mullidae       | Goatfishes              | 3         | 14         |
| Muraenidae     | Morey eels              | 4         | 27         |
| Pomacanthidae  | Angelfishes             | 5         | 12         |
| Pomacentridae  | Damselfishes            | 10        | 45         |
| Scaridae       | Parrotfishes            | 5         | 24         |
| Scorpionidae   | Scorpionfishes          | 8         | 26         |
| Serranidae     | Groupers                | 12        | 56         |
| Sparidae       | Seabreams               | 8         | 13         |
| Syngnathidae   | Seahorses               | 10        | 11         |
| Tetraodontidae | Pufferfishes            | 4         | 15         |

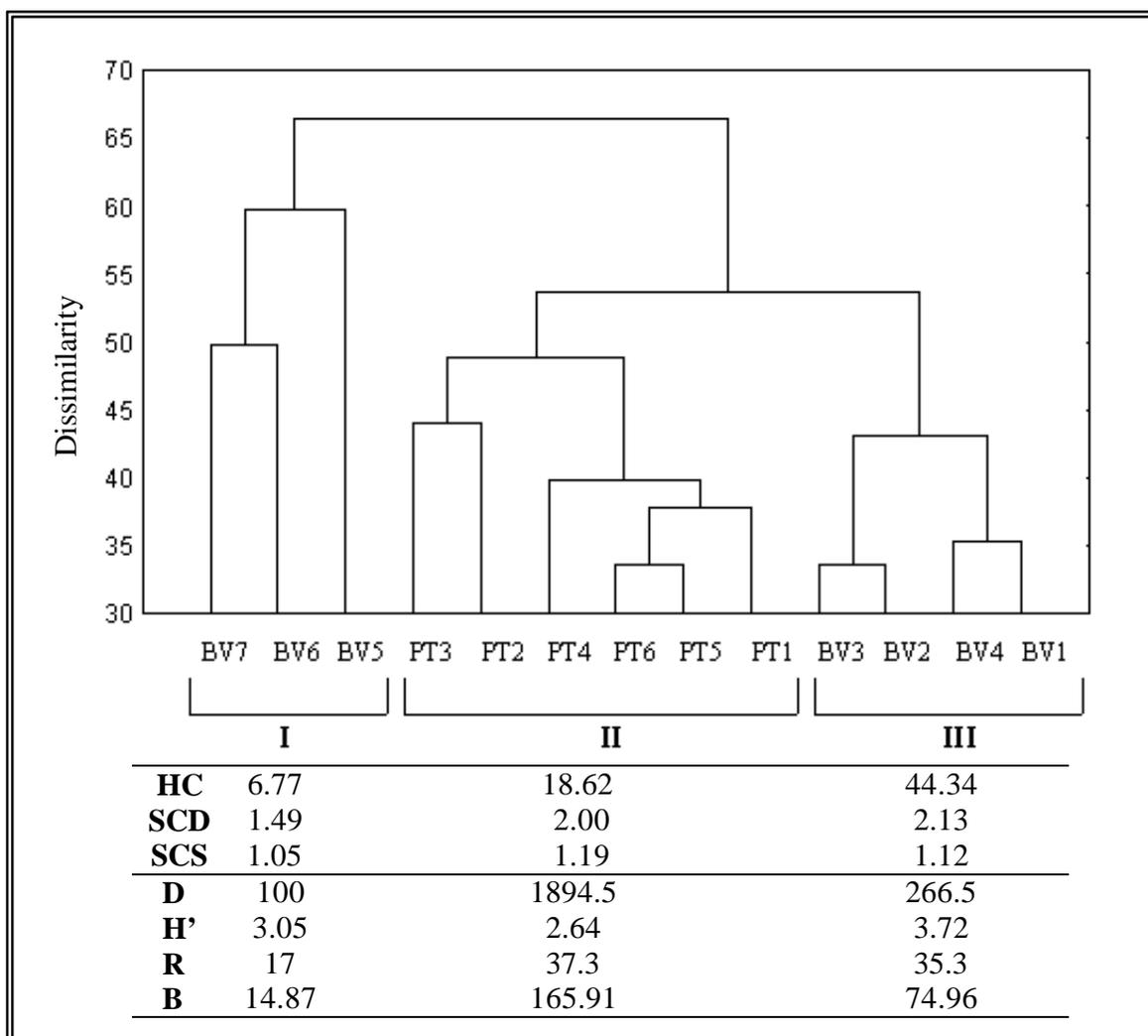
It is a reported fact that the diversity of fishes in southern Africa decreases southwards (Turpie *et al.*, 2000). The number of fish species in major reef systems of Mozambique also decreases southwards (Table 2). The decrease in species richness is largely due to the subtropical subtraction effect (Turpie *et al.*, 2000), resulting mainly from the intolerance of changing oceanographic conditions, particularly decreasing temperature (Smith, 1965 in Turpie *et al.*, 2000), which is influenced by the warm southward-flowing Agulhas current (Turpie *et al.*, 2000). The absence of reefs in the central section of the coast (Figure 1; Rodrigues *et al.*, 1999, 2000), and the fact that the Quirimbas Arquipelago region is subjected to a direct input of larvae and gene inflow from the South equatorial current (Saetre & da Silva, 1984) also contribute to this diversity pattern.

**Table 2.** Diversity of reef fishes in main reef systems of Mozambique.

| Reef system                   | N° of species | Reference                        |
|-------------------------------|---------------|----------------------------------|
| Quirimbas Arquipelago         | 375           | Whittington <i>et al.</i> , 1998 |
| Bazaruto Arquipelago          | 300           | Dutton & Zolho, 1989             |
| Inhaca and Portuguese Islands | 200           | Simões, in prep.                 |
| Santa Maria – Ponta do Ouro   | 150           | Robertson <i>et al.</i> , 1996   |

### Fish-Habitat Relationships

Reef-associated fishes, due to their territorial behaviour, are extremely affected by the characteristics of the reef habitat. Several studies showed that species diversity, abundance and biomass of the fish community is positively related to the structural complexity of the substrate and that live substrate cover and composition diversity influences the fish community structure via feeding interactions. At Inhaca Island, for example, it was recently reported (Pereira, 2000a) that these were the most important habitat characteristics influencing fish communities (Figure 2).



**Figure 2.** UPGMA cluster dendrogram based on the dissimilarity Bray-Curtis index (from  $\sqrt{\sqrt{\cdot}}$  transformed abundance data) of fish visual transects of two coral reefs from Inhaca Island (BV - Barreira Vermelha Reef, PT - Ponta Torres Reef). Main benthic and fish characteristics are also given: HC = percentage of live hard coral cover; SCD = substrate composition diversity and SCS = structural complexity of the substrate; D = density (ind/250 m<sup>2</sup>), H' = Shanon-Wiener diversity index, R = species richness and B = biomass (Kg/ 250 m<sup>2</sup>) (after Pereira, 2000a).

In a survey along various reefs in the Mozambican coast, Rodrigues *et al.* (1999) also found evidence of habitat characteristics affecting fish communities. In reefs with high live coral cover (e.g. Lighthouse reef – Bazaruto Archipelago; Barreira Vermelha reef – Inhaca Island) fish diversity and density was higher, when compared to reefs with lower coral cover. These results highlight the importance and urgent need for management actions of the reefs in better conditions.

## EXPLOITATION

Reef-associated fish resources in Mozambique are exploited at three basic levels: subsistence exploitation (artisanal reef fisheries), commercial (semi-industrial reef fisheries, ornamental fish trade and recreational diving) and sports fishing (skiboat angling, shore angling and spear fishing).

The artisanal reef fishery is one of the most important in Mozambique, especially in the northern part of the coast. Various fishing gears are used but hand lines, spearguns and traps are the most important (Loureiro 1998). In Nacala district, north of Mozambique, Ruy *et al.* (1997) report an estimated catch of 470 Kg/day being the families Caesionidae (fusiliers), Scaridae (parrotfishes), Acanthuridae (surgeonfishes), Siganidae (rabbitfishes), Lutjanidae (snappers), Labridae (wrasses) and Serranidae (rockcods) the most frequent in the catches. The artisanal fishery is an important component of the national economy and measures of management are definitely needed.

The semi-industrial reef linefishery is mainly practised in the Southern part of Mozambique (Timochin 1988; van der Elst *et al.* 1994). Two main fishing gears are used: hand lines and traps (Cuco 2000). The best catches were attained in 1990 (almost 90 tons) and were dominated by sparids (slinger - *Chrysoblephus puniceus* and soldier - *Cheimereus nufar*) which accounted for about 69 % of the total catch. The by-catch (31 %) is composed of species of Lethrinidae, Mullidae, Serranidae, Lutjanidae, Dinopercidae, Scombridae and Carangidae (Dengo and David 1993). Recent studies (Lichucha 2000; Abdula and Lichucha 2000) suggested that this resource is reaching overexploitation and there is an urgent need of management measures to be undertaken.

Ornamental (or "aquarium") fish collection and trade in Mozambique has been practised since. However this activity was neither systematic nor regulated. In the 80's, several studies were conducted (e.g. Brichard 1980; Eichler 1981) to investigate the feasibility of collection and exporting ornamental fishes from Mozambique on a systematic and regulated basis. The main areas proposed to support the collection and exportation of ornamental fishes were Vilankulos, Inhambane and Cabo Delgado. There was an established operation in Inhambane and other areas but for many of these, information has been only anecdotal. Ornamental fish collection continued irregularly during the 80's and early 90's but in the late 90's various companies applied for licences for exporting not only fishes but also invertebrates (corals and shells). In 1998 the first concerns about the impacts of this activity were raised (Rodrigues and Motta 1998) following a controversial issue about the deleterious effects of the collecting methods on reef aesthetics in Inhambane, southern Mozambique (Motta 2000b). A two-year ban was established and studies were recommended. According to a recent study (Whittington *et al.* 2000), the main species sought after seemed to be the cleaner wrasses (*Labroides* spp.) and anemone fishes (*Amphiprion* spp.). Other species were also collected and valued and this included members of the families Chaetodontidae (butterflyfishes), Pomacanthidae (angelfishes), Pomacentridae (damsel-fishes) and Labridae (wrasses). According with the same study, the negative impacts on fish populations were insignificant when compared to coral extraction. It was concluded that the major obstacle to the future development of the trade in ornamental fish lied on its management and that further studies were needed.

Recreational SCUBA diving has been growing at incredible rates in Mozambique both in terms of number of Diving Centres and number of dives. This activity is practised along the whole extension of coast where coral reefs can be found. The wide diversity of fishes occurring on the coral and rocky reefs of Mozambique is attractive to SCUBA divers, in particular to those engaged in underwater photography. In southern Mozambique for example, Robertson *et al.* (1996), reported the existence of specific localities such as one called "Bass City" near Ponta Malongane as been regularly visited by divers because of the occurrence of large resident fishes as the such as the potato bass (*Epinephelus tukula*). In 1995, there were about 13 Diving Centres operating only in the Southern Mozambique region of Ponta do Ouro with an estimated number of dives between 30 000 and 40 000 per year (Robertson *et al.* 1996). But this figure is disputed by Rodrigues & Motta (in prep) who suggest that the diving pressure is higher and is situated around 70 000 and 100 000 dives per year. Presently, there are about 25 Diving Centres

operating in the country (H. Motta pers. com.) and some concern has been raised about the effects of such high pressure on reef communities. Various measures to reduce the negative impacts of the excessive diving activity such as codes of conduct and zonation of the reefs have been proposed (Robertson *et al.* 1996) and a new legislation is being prepared (H. Motta, pers. com.).

Mostly practised by South African tourists sports' fishing in Mozambique is carried out in the southern coast, over coral and rocky reefs (David *et al.* 1996). Skiboat angling, speargun fishing and shore angling aim at: bottom dwelling species such as groupers and rockcods (Serranidae), sweetlips (Haemulidae), sea breams (Sparidae), emperors Lethrinidae) and snappers (Lutjanidae) and the great pelagics such as mackerels (Scomberidae), barracudas (Sphyraenidae) and kingfishes (Carangidae). This activity is also showing very high growth rates and some concern about overexploitation of the resources were also raised and a new legislation was prepared (H. Motta, pers. com.).

## **CONSERVATION AND MANAGEMENT**

### **Existing Areas**

In Mozambique, there are four National Parks, five game reserves, twelve hunting areas and fourteen forest reserves covering a total area of 89 602 km<sup>2</sup> or approximately 11.4% of the country's surface area (DNFFB, 1995). However, virtually all this cover is terrestrial ecosystems. Only 250 km<sup>2</sup> of the marine environment are protected (Sousa, 1998). Considering the diversity of habitats along the length of Mozambican coastline and the economic importance of littoral waters, remarkably few coastal areas are under protection (Rodrigues & Motta, in press). Moreover, the only protected areas were declared before the independence of Mozambique, 25 years ago.

Only two marine areas are under protection in Mozambique: the Bazaruto National Park and Inhaca and Portuguese Islands Marine Reserves. Three other protected areas are typically coastal, such is the case of Maputo Elephant Reserve and Pomene Reserve. At present, only the Inhaca and Portuguese Islands Marine Reserves and Bazaruto National Park involve coral reef protection. The other coastal reserves (Pomene and Maputo) only protect marine endangered species such as dugong and turtles and the protected area usually ends at the high tide mark (Motta, 2000).

The Ministry of Agriculture is responsible for the administration of all protected areas except for Inhaca and Portuguese Islands Marine Reserves, which are managed by Universidade Eduardo Mondlane.

### **Proposed Protected Areas with Emphasis on Reef Fishes in Mozambique**

Various new marine protected areas have been proposed (see Rodrigues & Motta, in prep.). some of the proposals only refer to the protection of endangered marine species like dugongs and turtles, others to the actual physical space where coastal and marine ecosystems are located. Table 3 shows a summary of the proposed areas as far as reef fishes are concerned.

**Table 3.** Proposed marine protected areas with emphasis on reef fishes in Mozambique.

| Area                               | Sites   | Type of protection       |
|------------------------------------|---|--------------------------|
| Quirimbas Arquipelago              | Quilaluia, Sencar and Matemo islands<br>Other islands | Santuaries<br>Multi-use  |
| Nacala                             | Bay of Nacala and Relanzapo                           | Multi-use                |
| Mossuril                           | Chocas and Cabaceira                                  | Multi-use                |
| Mozambique Is. and Lumbo           | Cobras and Goa islands<br>Mozambique Is.              | Sanctuaries<br>Multi-use |
| Primeiras and Segundas Archipelago | Epidendron, Casuarina, Coroa Fogo and Silva islands   | Santuaries               |
| Bazaruto Archipelago               | Bazaruto Is.  | Multi-use                |
| Inhambane                          | Paindane  | Sanctuary                |
| Ponta do Ouro–Santa Maria          | Techobanine, Malongane and Ponta do Ouro              | Sanctuaries              |

## RESEARCH NEEDS

Although Mozambican reef fish research capacity is low, there are various research issues that are in need of been undertaken. These include monitoring, baseline ecological and taxonomic surveys, and management-orientated studies. These studies could be carried out under graduation programs, such as honours and masters degrees, which would help improve Mozambican capacity building.

Specifically, the following studies are needed:

- The continuation and expansion of coverage of the national coral reef monitoring program in order to study human and natural impacts on fish communities and to monitor changes over time scales.
- Compilation of taxonomic lists to determine the fish diversity of Mozambique's coral reefs along with studies on distribution patterns and species composition of reef fish resources;
- Research on interaction of species and how fish assemblages relate to the various reef characteristics in Mozambique;
- Studies on present fish standing stocks and co-management measures should be undertaken, in order to ensure the present sustainable use and future availability of fish resources;

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