THE MAPUTO BAY ECOSYSTEM

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Coral Reefs of Maputo Bay

Michael Schleyer and Marcos Pereira

Introduction

The first broad narrative of coral reefs in Maputo Bay is provided by Boshoff (1958) in an account of the natural history of Inhaca Island (Macnae and Kalk, 1958). Limited coral reefs were found on the west side of the island, these being located primarily north of the Biological Research Station and within a channel draining the Saco near Ponta Torres (Figure 1). The former, known as Barreira Vermelha, was the largest and appeared to be associated with coral rubble and rock outcrops. It was estimated to be about 2 km long and a maximum of 65 m wide but was shrinking due to sedimentation at the time of publication (1958). The reef in the channel at Ponta Torres was found to be ephemeral close to the point but showed more permanence than Barreira Vermelha in the headwaters of the channel. Here persistent corals grew to a depth of up to 5 m and the coral field was up to 10 m wide. Salm (1976) later confirmed the width of the reef (7-10 m) and estimated its length to be about 1 km, but noted that sedimentation from dune erosion threatened its existence. Boshoff (1958) found further transient coral communities on coral rubble between Ponta Rasa and Ponta Punduini but these were clearly not permanent. Only solitary colonies occurred elsewhere, for example at Cabo Inhaca in the north. Boshoff (1958) thus correctly concluded that the abundant sandy substrata and sediment dynamics around the island precluded greater coral growth or reef development. Coring undertaken in a later study revealed that reef development has been tenuous, intermittent and dependent on the dynamics of sediment movement along the west coast of Inhaca since the last sea level rise at 6500 BP (Perry, 2005; see also Chapter 3 – Geomorphology and Evolution of Maputo Bay).

There is no other early record of corals in Maputo Bay. A later revision of the Inhaca Island natural history handbook (Kalk, 1995) appears to have been undertaken without further fieldwork and adds no new information on these biota other than mentioning the appearance of another small, transient coral community at Portuguese Island. Boshoff (1958) believed the Inhaca reefs represented the southernmost coral reefs on the East African coast but later discoveries proved this to be untrue. Macnae and Kalk (1958) and Kalk (1995) also provide further information on the most conspicuous echinoderms, molluscs and crustaceans on the reefs, details of which are included in this chapter.

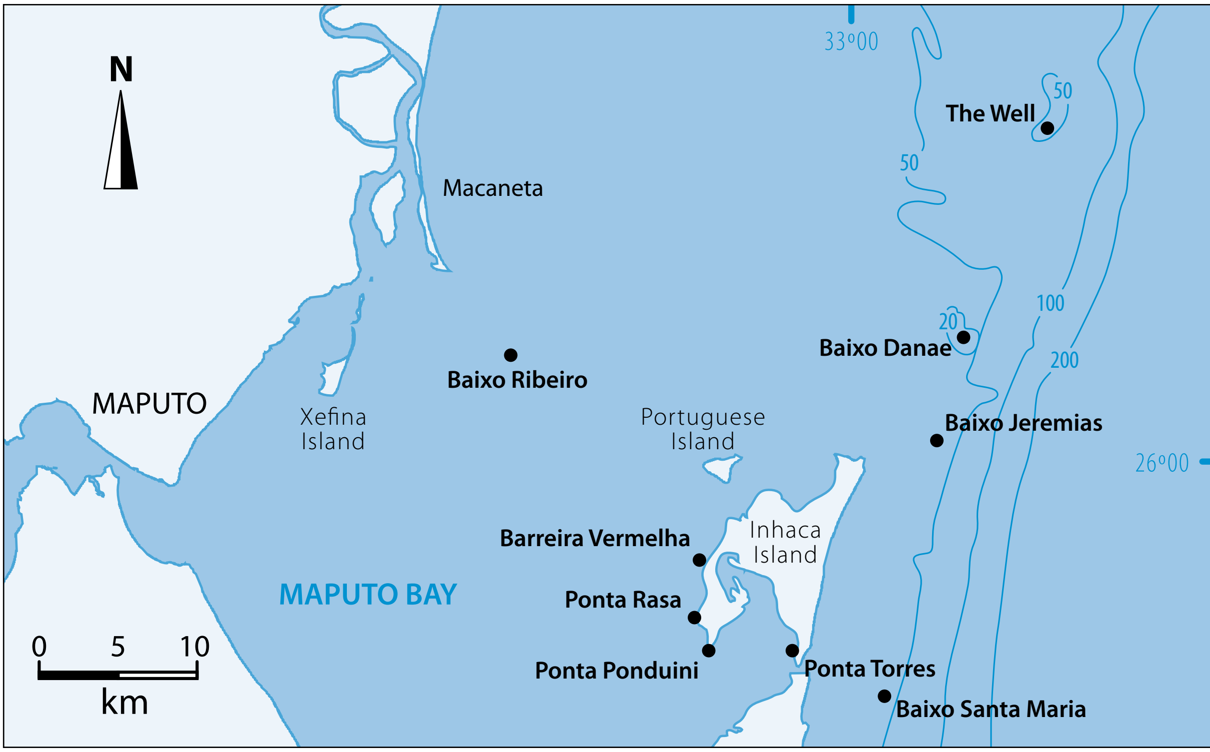

Figure 1. Map of Inhaca Island and Maputo Bay with place names referred to in the text.

Although Inhaca is at the seaward limits of Maputo Bay, it is subjected to high levels of sedimentation and turbidity (see Chapter 2 – Geographical setting of Maputo Bay and Chapter 4 – Hydrology and Circulation of Maputo Bay). It is thus conceivable that corals have always been absent close to the riverine sources of sediment in the Bay. The increase in sedimentation in recent years described in Chapter 3 (Geomophology and Evolution of Maputo Bay) renders conditions even less conducive to coral development in the Bay. In consequence, the primary focus of this chapter will be on the corals and associated biota on reefs around Inhaca Island.

While Barreira Vermelha and Ponta Torres Reef represent coral communities associated with conditions most typical of Maputo Bay, another large reef is found immediately seaward and NE of its entrance, Baixo Danae (Figure 1). This reef is also influenced by the waters of Maputo Bay and is included for completeness as it will become evident that, together, the Inhaca coral reefs are unique and quite different from other coral reefs in the southern reaches of East Africa. The only feature that they share in common is that they are not true, accretive reefs that attain massive proportions through the bio-deposition of calcium carbonate. They rather comprise a veneer of coral growth on existing rock formations or coral rubble and are thus better described as coral communities (Barradas, 1965; Ramsay, 1994; 1996; Schleyer, 1995; 2000).

The following account covers the corals, associated benthos and fish communities found on these reefs.

Inhaca coral communities

Boshoff (1958) stated that 137 coral species in 44 genera were found at Inhaca Island, a figure he later revised to 160 species (Boshoff, 1981). However, systematic revisions of the coral taxa in the region (Riegl, 1995a; 1995b; 1996) necessitate caution in the use of Boshoff's (1958; 1981) earlier works. A list of corals encountered on the Inhaca reefs in more recent surveys (Schleyer *et al*., 1999; Motta *et al*., 2002; Costa *et al*., 2005; Schleyer *et al*., in prep.) is presented in Table 1. This list is not exhaustive as it is not based on collections but from records derived from photographic surveys. Estimates of percentage cover (Schleyer *et al*., in prep.) obtained from point intercept analysis of the latter using CPCe software (Kohler and Gill, 2006) are listed for Barreira Vermelha and Baixo Danae in Table 2.

Barreira Vermelha

Barreira Vermelha is located at approximately 26° 1.2'S; 32° 54.2'E and varies in depth from 2-5 m. The reef appears little changed in nature and extent from Boshoff's (1958) description. It has a mixed coral community (Table 1; Figure 2), particularly of tabulate *Acropora* species, a number of sizeable *Porites* bommies, pocilloporids and encrusting corals (*Montipora* and *Echinopora*; Table 2); this in spite of the fact that it is habitually exposed to high turbidity and periodic fluctuations in salinity from river discharges into Maputo Bay. In this regard, its richness of coral life under conditions that would normally discourage coral growth confounds expectations. While not recorded in recent surveys (Table 1), the colourful sea stars, *Linckia laevigata*, *Protoreaster linckii*, are relatively common at Barreira Vermelha.

In terms of condition, evidence of coral bleaching was found on Barreira Vermelha after the severe 1998 El Nino Southern Oscilliation (ENSO) that so affected coral reefs throughout the Western Indian Ocean (Schleyer *et al*., 1999). A consistent reduction in coral cover has been measured in subsequent years (Costa *et al*., 2005), believed to be attributable not only to deteriorating water conditions but also to destructive fishing practices. The poor condition of the reef is manifested by the relatively high cover of the zoanthid, *Palythoa*, and the fact that nearly 41.4% of its surface consists of non-living material or a turf of bryozoa and algae (Table 2).

Ponta Torres

Differentiation is necessary between the rather transient and isolated coral colonies growing on the rock wall in the channel at Ponta Torres at 26° 3.9'S; 32° 57.2'E and a richer coral community upstream in the channel at 26° 4.5'S; 32° 57.1'E. The former comprises a sparse cover of *Pocillopora verrucosa*, *Stylophora pistillata* and faviids in a channel that presently drops to a depth of 6 m. Sparseness of the corals appears to be at least partially attributable to turbidity and sand movement caused by the tidal race that fills and drains the Saco Bay. Boshoff (1958) noted the effects of the tidal race and the fact that blasting of the rock wall in 1953 partially obstructed the channel. Sedimentation of the channel ensued, reducing its original depth of 18-25 m and limiting the extent of the reef. ENSO-related bleaching in 1998 appeared to be high in this channel and the only unaffected genera were *Pocillopora*, *Goniopora*, *Goniastrea*, *Astreopora* and *Leptoseris* (Schleyer *et al*., 1999). The long-spined sea urchins *Diadema setosum* and *D. savignyi* attain densities as high as 15-20 individuals.10 m^{-2} at Ponta Torres (Pereira *et al*., 2002), and the cushion star, *Culcita schmideliana*, and quadrangular cucumber, *Stichopus variegates*, have also been found here (Table 3).

The coral community in the channel upstream of Ponta Torres is possibly the most enduring relic of reef development at Inhaca. Boshoff (1958) recorded pure stands of *Pavona*, *Porites* and *Montipora* on this reef and noted that it was subject to more gradual changes than Barreira Vermelha. Photographs taken on this reef in 1967 (Schleyer, unpub. data; Figure 3A) reveal massive *Porites* domes that were already of some age and later also noted by Salm (1976). How-

Table 1. Corals and associated biota recorded on reefs at Inhaca Island in recent surveys (Schleyer *et al*., 1999; Motta *et al*., 2002; Costa *et al*., 2005; Schleyer *et al*., in prep.).

CORAL	Barreira Vermelha	Ponta Torres	Baixo Danae
OCTOCORALLIA			
Alcyoniidae			
Anthelia glauca			+
Cladiella australis	+		+
C. kashmani			+
C. krempfi	+		+
Dendronephthya sp.		+	+
Lobophytum crassum			+
L. depressum			+
Lobophytum sp.			+
Sarcophyton glaucum			+
Sinularia abrupta			+
S. brassica			+
S. gravis			+
S heterospiculata			+
Sinularia spp.			+
SCLERACTINIA			
Acroporidae			
Acropora abrotanoides	+	+	
A. austera	+		
A. appressa		+	+
A. clathrata	+		+
A. cythera	+		
A. gemmifera	+	+	
A. digitifera	+		
A. hyacinthus	+		
A. microphthalmus		+	
Acropora spp.	+		+
Astreopora myriophthalma			+
Montipora spp.	+	+	+
Agariciidae			
Gardinoseris planulata	+	+	
Pavona decussata	+	+	
P. clavus	+		
Pavona sp.		+	
Dendrophylliidae			
Dendrophyllia sp.		+	
Tubastrea micrantha		+	
Turbinaria sp.			+
Faviidae			
Cyphastrea sp.	+		+
Echinopora gemmacea	+	+	+
Favia spp.	+	+	+
Favites spp.	+	+	+
Goniastrea sp.	+	+	+
Lepastrea sp.			+
Leptoria phrygia			+
Oulophyllia crispa			+
Platygyra daedalea	+	+	+
Plesiastrea versipora			+
Fungiidae			
Fungia sp.			+
Meandrinidae			
Gyrosmilia interrupta			+
Merulinidae			
Hydnophora exesa			+
Mussidae			
Acanthastrea echinata		+	
Symphyllia sp.		+	
Oculinidae			
Galaxea astreata	+		
G. fascicularis		+	+
Pectiniidae			
Echinophyllia sp.			+
Mycedium elephantotus			+
Pocilloporidae			
Pocillopora damicornis	+	+	+
P. verrucosa	+	+	+
Stylophora pistillata		+	+
Poritidae			
Alveopora allingi	+		
Goniopora sp.		+	+
Porites lutea	+	+	+
P. nigrescens		+	
P. solida	+	+	+
Siderastreidae			
Coscinarea sp.			+
Psammocora haimeana	+	+	
PORIFERA			
Theonella sp.			+
Anthosigmella orientalis			+
Cliona celata	+		
ZOANTHIDEA			
Palythoa sp.	+	+	+
MOLLUSCA			
Tridacna sp.	+		+
Hyotissa hyotis		+	
ECHINODERMATA			
Diadema sp.		+	+
Echinometra mathaei	+	+	+
ASCIDIACEA			
Didemnum molle			+

Table 2. Percentage cover of coral reef genera at Inhaca Island (+ indicates <1% cover; principal components discussed in the text are in bold).

	Barreira Vermelha	Baixo Danae
SCLERACTINIA		
Acanthastrea	-	0.7
Acropora	23.9	2.9
Alveopora	+	0
Astreopora	-	2.0
Coscinaria	+	+
Cyphastrea	0.4	+
Echinophyllia	-	+
Echinopora	2.3	0.2
Favia	0.7	0.5
Favites	+	0.8
Fungia	-	+
Galaxea	-	0.5
Gardineroseris	-	+
Goniastrea	-	+
Leptastrea	-	+
Goniopora	0.4	+
Gyrosmilia	-	+
Hydnophora	-	+
Leptoria	-	+
Montipora	7.0	8.3
Mycedium	-	+
Oulophyllia	-	+
Pavona	-	+
Platygyra	1.1	0.3
Plesiastrea	-	+
Pocillopora	2.9	4.1
Porites	6.9	4.7
Psammocora	-	+
Stylophora	-	+
Symphyllia	-	+
Turbinaria	-	+
Unknown Scleractinia	1.6	2.5
OCTOCORALLIA		
Cladiella	+	+
Dendronephthya	-	0.2
Lobophytum	-	0.3
Sarcophyton	-	0.4
Sinularia	+	6.3
Unknown octocorals	+	0.7
PORIFERA	0.2	5.5
ACTINIARIA		
Heteractis	-	+
ZOANTHIDEA		
Palythoa	4.5	+
MOLLUSCA		
Tridacna	+	+
ECHINODERMATA		
Diadema	-	+
ASCIDIACEA		
Polycarpa insulsa	+	0.2
Polycarpa seychellensis	-	+
ALGAE		
Macroalgae	1.8	5.8
Coralline algae	0.4	5.6
Turf (algae and bryozoa)	23.7	35.5
NON-LIVING		
Sand	3.7	3.1
Rock, dead coral	14.0	3.6

Table 3. Relative abundance of the more common echinoderms at Baixo Danae, Barreira Vermelha and Ponta Torres in 2000 (derived from Motta *et al.*, 2002). Figures represent the number of individuals (SD) per 500 m^2 (n = 4).

Group	Baixo Danae	Barreira Vermelha	Ponta Torres
Sea urchins			
Diadema setosum	1.5 (1.3)	0.3 (0.5)	8.5 (5.8)
Echinometra mathaei	0.3 (0.5)		
Echinostrephus molaris	377.8 (212.5)	0.3 (0.5)	5.0 (10.0)
Seastars			
Culcita schmideliana			1.0 (1.4)
Linckia spp.	0.3 (0.5)	2.5 (1.3)	0.8 (1.5)
Protoreaster linckii		23.8 (16.5)	
Sea cucumbers			
Holothuria spp.		0.8 (1.5)	0.3 (0.5)
Stichopus variegatus			0.5 (1.0)

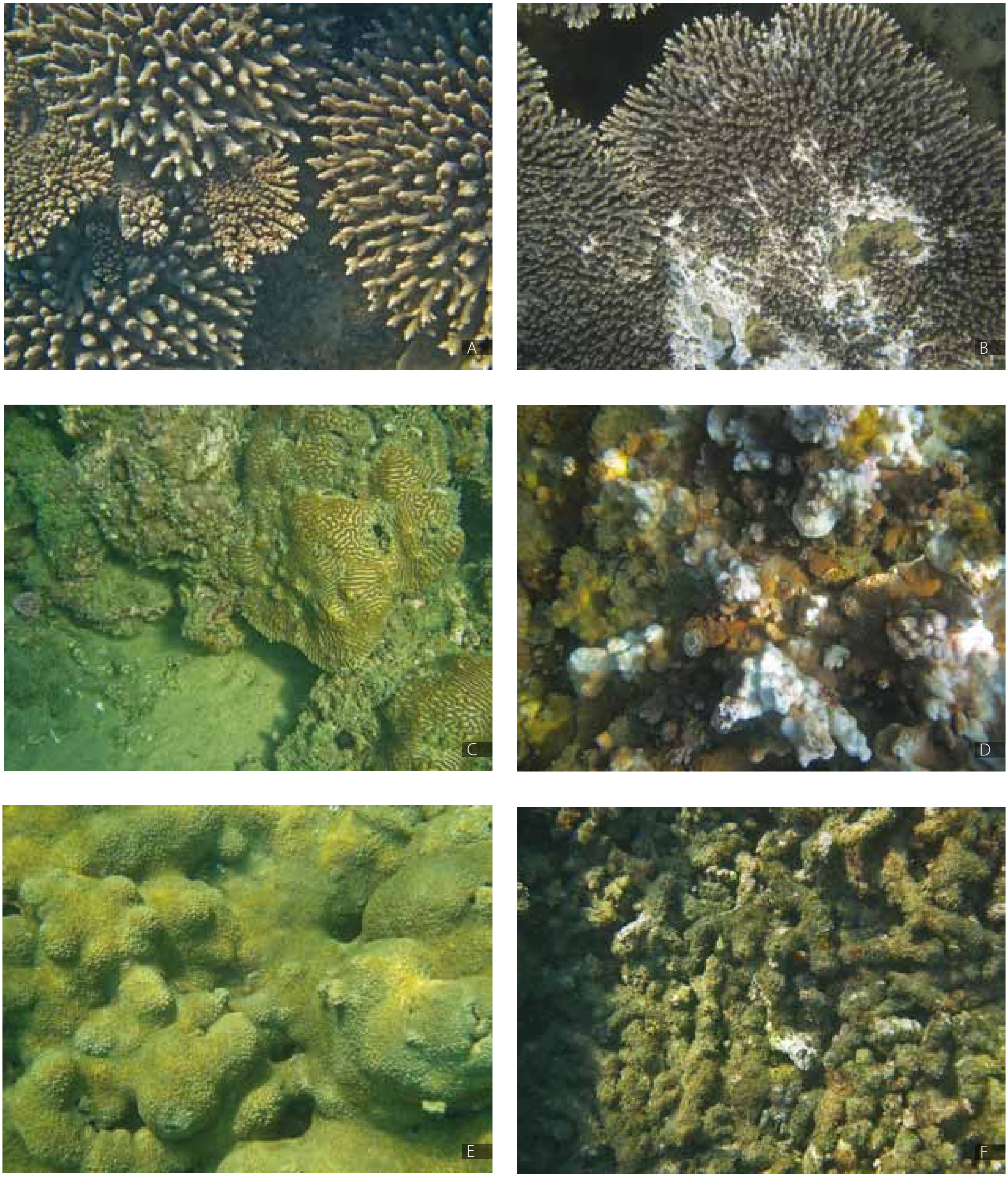

Figure 2. Barreira Vermelha has a community of resilient *Acropora* species **(A)**, including the tabular *Acropora cytherea* **(B)**. The reef is in marginal habitat, so much of the coral cover is low (**C**, showing the faviid *Platygyra daedalea*) with signs of bleaching (**D**, a partially bleached *Montipora* sp.). Parts of the reef are encrusted by the zoanthid, *Palythoa* **(E)**, or comprised of coral rubble **(F)**. Photographs by Michael Schleyer.

ever, Salm (1976) expressed concern over reef sedimentation and this, together with the ravages of destructive fishing practices and coral bleaching, has taken its toll; the reef is now smaller and its condition has deteriorated. It now extends only to 2 m in depth and the tops of the *Porites* colonies are flat and eroded (Figure 3B). These are interspersed by thickets of *Acropora microphthalmus* (Figure 3C) that are partially exposed at full spring low tide. Remnants of the *Pavona* (*P. decussata*) and *Montipora* recorded by Boshoff (1958) remain but the relative sparseness of the corals noted by Salm (1976) appears to have become a consistent feature and persists today. Other corals found at Ponta Torres are listed in Table 1.

Baixo Danae

This is a reef more typical of the southern latitudes of East Africa (Schleyer, 2000; Schleyer and Celliers, 2005a; 2005b; Celliers and Schleyer, 2008), being founded on a submerged rock massif and covered by a veneer of coral growth. It is the biggest reef in the vicinity of Maputo Bay, stretching from 25° 54.1'S; 33° 03.1'E to 25° 54.6'S; 33° 03.3'E, or just over a kilometre. It reaches a maximum width of about 500 m and ranges in depth from 10-20 m, a depth at which ENSO-related bleaching is unlikely. In profile, it tends to be flat; though it does have some massive outcrops, ridges and gullies, but it is not well-endowed with such features. Dispersed metal remains of a shipwreck lie on its outer, NE perimeter. Strong currents that appear to include tidal surges flow over it and sedimentation and scouring are evident.

The coral community on Baixo Danae is fairly sparse (Table 2; Figure 3D, E). While it has the highest biodiversity of the Maputo Bay area reefs (Table 1) with the greatest representation of both octocorals and scleractinians, the extent of exposed reef and that covered by turf (42.2%) is similar to Barreira Vermelha. The dominant benthos comprises an assemblage of species of *Montipora*, *Porites* and *Pocillopora*; octocorals of the genus *Sinularia*; the encrusting sponge, *Anthosigmella orientalis*; and algae. The octocorals found on Baixo Danae consist of sediment-tolerant species abundant at the reef-sediment interface on more southern reefs (Schleyer and Celliers, 2003a; Schleyer and Benayahu, 2009). *Anthosigmella orientalis* is an encrusting sponge that is also sediment-tolerant (Schleyer *et al*., 2006). The presence of these sediment-tolerant benthos and the low coral cover are indicative of the level of sedimentation and sand scouring on Baixo Danae. Although various sea urchins occur on Baixo Danae, *Echinostrephus molaris* were found in high numbers here (Table 3).

Other invertebrate fauna

Many of the benthos associated with the coral communities are also found more widely in other habitats within Maputo Bay. The echinoderms are chief amongst these, starfish (Class Asteroidea), brittle stars (Ophiuroidea), sea urchins (Echinoidea) and holothurians (Holothuroidea) being widespread in Maputo Bay, colonizing several habitats including, rocky shores, coral reefs, sand flats and seagrass beds. While they constitute a relatively small group on the reefs in terms of their diversity and abundance, brittle stars are found in high numbers, especially seen at night; about 18 species have been identified at Inhaca Island (Balinsky, 1957). The corallivorous crown-of-thorns starfish (*Acanthaster planci*) has not been recorded in the area (Kalk, 1995), although there have been records of these immediately further to the north and south (Grindley, 1963; Schleyer, 1998).

Macnae and Kalk (1958) and Kalk (1995) provide the only information available on the mollusc fauna on the shallow reefs at Inhaca Island. The corallivorous egg cowry, *Ovula ovum*, is commonly observed on the reefs, feeding on soft corals, particularly *Cladiella* spp. and also *Sinularia* spp. Other reef-associated gastropods include *Rapana rapiformis*, *Cypraea tigris*, *Mitra mitra*, *Cypraecassis rufa* and *Tonna variegata*

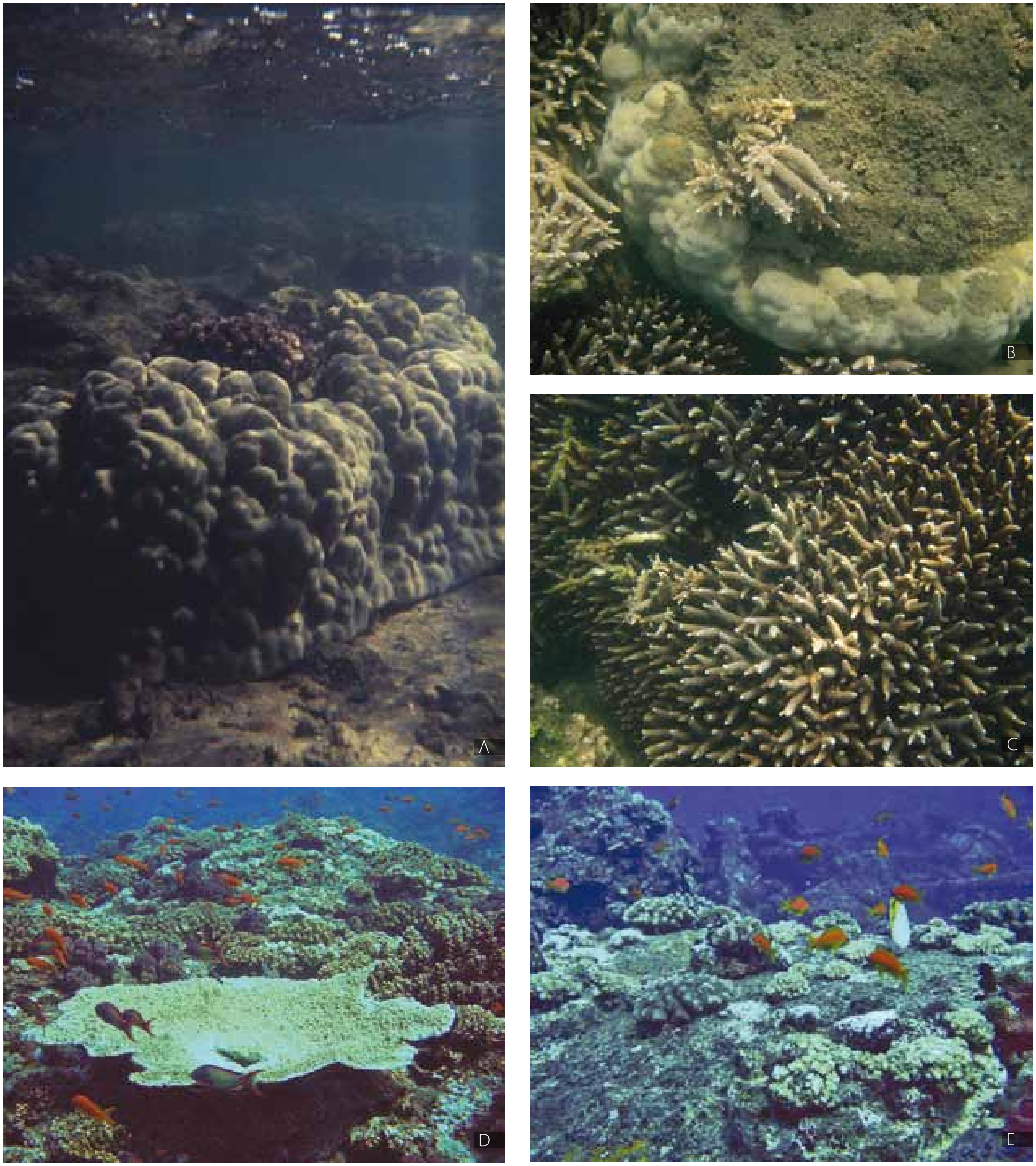

Figure 3. In the past, Ponta Torres consisted of large *Porites* bommies (**A**, taken in 1967). These have become reduced in size and extent by sedimentation and damaging fishing practices, with many encompassed by *Acropora microphthalma* **(B)** that forms thickets **(C)**. Baixo Danae has rich fish and coral communities, the latter dominated by *Pocillopora* spp. **(D)**, but the coral cover in some areas is low (E). Photographs by Michael Schleyer (A-C) and Marcos Pereira (D-E).

(Kalk, 1995). The large reef bivalves, *Tridacna* spp. and *Hyotissa hyotis*, are sparse. *Octopus granulatus* has been recorded but no quantitative information on its abundance is available.

Crustacean reef fauna are represented by the lobsters *Thenus orientalis*, *Panulirus versicolor* and *P. ornatus*. These are hand-collected on the shallow reefs by local divers (pers. obs.) or in pots and nets set by commercial vessels in the deeper areas (Marshall *et al*., 2001). Small xanthid crabs (*Liomera* sp. and *Lybia* spp.) are found associated with branching corals and larger xanthids are found within the reef matrix (*Atergatis* spp., *Menippe* spp. and *Carpillius* spp.). Stomatopods (mantis shrimps) are important predators and cleaner shrimps (*Stenopus hispidus*) remove parasites from other reef-dwellers (Kalk, 1995; pers. obs.). However, no studies have been conducted on their diversity, status and ecology in Maputo Bay.

Reef Fishes

"Reef fishes" or "coral reef fishes" have not been clearly defined in the literature and, as highlighted by Bellwood (1998), the definition and characterization of reef fish communities has not proven diagnostic. Despite the fact that the reefs in southern Mozambique are not true coral reefs derived from biogenic accretion, but rather a thin veneer of coral communities (Barradas, 1965; Ramsay, 1994; 1996; Schleyer, 1995; 2000), they nevertheless function as coral reefs for the fish communities. Thus, the rather generalized definition of "reef fish" presented by Bellwood and Wainwright (2002) is used here and it encompasses a wide range of species that vary considerably in colour, size and shape. These make up the reef fish communities on reefs located within Maputo Bay and the surrounding area (Figure 1).

The study of the ichthyofauna of Maputo Bay (previously known as Delagoa Bay) was initiated in the early 1930s with pioneering work conducted mostly by J.L.B. and Margaret Smith (e.g. Smith, 1931), which continued for nearly 50 years (Smith, 1939; 1940; 1941; 1955a; 1955b; 1958; 1962; 1967-1968). Their work was mostly taxonomic and descriptive in nature, and made reference to that published by local authors (e.g. Lopes, 1938; 1937; Sanches, 1963). Initially, due to technological limitations, only specimens captured on hook and line, spear or using chemicals were studied (Smith, 1967-1968). More recently, however, studies have incorporated the local fishery (Lichucha, 2000), reproductive biology of certain species (Abdula and Lichucha, 2000) and age and growth studies of commercial species (Fennessy *et al*., 2004). *In situ* ecological studies have also since been initiated, taking advantage of SCUBA diving (e.g. Nagel and Degerstedt, 1999; Pereira, 2000).

Reef fishes occur throughout Maputo Bay and the surrounding areas, from depths as shallow as 5 m (in Macaneta, Baixo Ribeiro, Barreira Vermelha and Ponta Torres) to areas 30-45 m in depth, both inside and outside the Bay (at Baixo Santa Maria, Baixo Jeremias, Baixo Danae, the Well, etc.). These areas range from rocky substrata with scarce coral cover (especially those closest to the western side of the Bay subjected to high levels of turbidity and lower salinities) to extensive reefs with moderate to high coral cover in near oceanic conditions.

A total of 327 species (in 58 families) of reef fishes have been identified in the area (Appendix 1), with the majority being Indo-Pacific in their distribution. Nine families are represented by at least ten species, with the Labridae (wrasses – 31 spp.), Pomacentridae (damselfishes – 25 spp.), Chaetodontidae (butterflyfishes – 21 spp.) and Acanthuridae (surgeonfishes – 21 spp.) being the most speciose (Table 4). It is clear that more in-depth studies will increase this number, as only the most conspicuous species and families have received attention. Families with small or cryptic species (such as the Gobiidae and Blennidae) or those that pose difficulty in their identification (e.g. wrasses and parrotfishes) are frequently overlooked by divers and are seldom recorded. Sharks and rays are also under-represented, only nine and seven species have been recorded respectively. Of these, the whale shark (*Rhincodon typus*) and the manta ray (*Mobula diabolus*) are seasonal. Of special interest, is the fact that the great white shark (*Carcharodon carcharias*) has been observed once in the Baixo de Santa Maria area by spearfishmen, and further south in the Ponta do Ouro area (M. Gonçalves, pers. com.), thus confirming previous suggestions that this species could occur in southern Mozambique (Cliff *et al*., 1989).

Studies conducted at Barreira Vermelha and Ponta Torres have yielded relatively high levels of fish diversity, especially taking into account the size of these reefs. Nagel and Degerstedt (1999) found 121 species of fish at Barreira Vermelha and 113 at Ponta Torres. Pereira (2000), on the other hand, found 117 species at Barreira Vermelha (in 27 families) and 110 species (in 34 families) at Ponta Torres. Pereira (2000) further determined that the species evenness at Barreira Vermelha is higher than at Ponta Torres. He suggested that the fact that the former reef is subjected to extreme environmental conditions (i.e. high variations in temperature, salinity, turbidity and sedimentation), which in turn only allow a certain number of "specialized" fish species to colonize and dominate the reef, explained the differences in fish diversity on these two reefs. Both studies were, however, conducted over short periods of time and were based on relatively small sample sizes (less than eight per reef).

Only three reefs (i.e. Baixo Danae, Barreira Vermelha and Ponta Torres) have been subjected to quantitative fish visual censuses in Maputo Bay (e.g. Nagel and Degerstedt 1999; Rodrigues *et al*., 1999; Pereira, 2000; Motta *et al*., 2002; Pereira *et al*., 2003).

According to Pereira (2000), the reef fish fauna on both Ponta Torres and Barreira Vermelha was dominated in terms of density and biomass by damselfishes (Pomacentridae), surgeonfishes (Acanthuridae), butterflyfishes (Chaetodontidae), parrotfishes (Scaridae) and snappers (Lutjanidae) (Table 5). Other relatively important families included Labridae (wrasses), Haemulidae (sweetlips), Mullidae (goatfishes) and Caesionidae (fusiliers) (Table 5). Acanthuridae, Chaetodontidae, Scaridae and Pomacanthidae were found to be important in terms of density on Baixo Danae (Motta *et al*., 2002; Pereira *et al*., 2003). Pereira (2000) estimated that the reef fish biomass at Ponta Torres was significantly higher (6.64 ton/ha) than at Barreira Vermelha (1.97 ton/ha). These figures were considered high even though these reefs are protected, more so considering the fact that only 83 species were targeted in the surveys.

Results of fish monitoring surveys conducted as

Table 4. The most speciose reef fish families in Maputo Bay (families represented by ≥10 species).

Family	Common name	Number of species
Acanthuridae	Surgeonfishes	21
Balistidae	Triggerfishes	12
Carangidae	Kingfishes	11
Chaetodontidae	Butterflyfishes	21
Labridae	Wrasses	31
Lethrinidae	Emperors	10
Lutjanidae	Snappers	13
Pomacentridae	Damselfishes	25
Serranidae	Rockcods	19
Sparidae	Seabreams	11

Table 5. Dominant reef fish families on Barreira Vermelha and Ponta Torres (from Pereira, 2000) listed in terms of percentage contribution by each family.

Family	Barreira Vermelha		Ponta Torres	
	Density	Biomass	Density	Biomass
Acanthuridae	19.5	38.8	5.0	10.9
Caesionidae	2.6	1.4	2.9	0.2
Chaetodontidae	15.7	16.4	4.8	8.1
Labridae	7.8	4.2	5.1	1.2
Lutjanidae	7.3	1.6	56.2	52.7
Mullidae	2.0	2.2	1.7	4.5
Pomacentridae	25.3	5.0	19.1	15.4
Scaridae	13.7	6.1	2.7	2.8

Table 6. Fish density (individuals.250 m^{-2}) and diversity (Nº spp.250 m^{-2}) on selected reefs in Maputo Bay, recorded as part of the National Coral Reef Monitoring Programme. Figures in brackets represent standard deviation. Data were derived from counts of selected fish families (Rodrigues *et al*., 1999; Motta *et al*., 2002; Pereira *et al*., 2003; Pereira, unpub. data).

Year	Barreira Vermelha		Ponta Torres		Baixo Danae	
	Density	Diversity	Density	Diversity	Density	Diversity
1999	124.8	6.3	534.3	7.3		
2000	157.8 (80.7)	24.0 (3.6)	690.8 (812.4)	19.3 (4.0)	106.5 (59.7)	17.5 (2.9)
2002	218.0 (144.2)	23.0 (2.2)	306.8 (170.7)	16.3 (2.9)	33.8 (14.6)	9.8 (3.1)
2005	41.6 (38.5)	7.5 (2.9)	93.8 (121.4)	6.4 (1.5)	25.9 (21.3)	9.0 (3.3)

part of the National Coral Reef Monitoring Programme (Rodrigues *et al*., 1999; Motta *et al*., 2002; Pereira *et al*., 2003; 2008) revealed substantial temporal variation in fish density and diversity on each reef (Table 3), as well as in trophic structure (Figure 4). There has been a marked decrease in both fish density and diversity on all the reefs from 1999 to 2005. Each reef has manifested a different pattern in the trophic composition of its fish fauna. On Barreira Vermelha and at Ponta Torres, there was a marked decrease in carnivores after 1999, followed by their slow but steady increase until 2005. Concurrently, herbivores have manifested the opposite trend.

These changes could be a response to a multitude of factors, including the 1998 El Nino (Schleyer *et al*., 1999) as well as fishing pressure inside the reserves where Barreira Vermelha and Ponta Torres are located (Costa, 2003). It should also be recognized that the nature of a monitoring programme such as this implies that trends should only be assessed after a much longer period, as the above-mentioned variations may constitute natural cycles.

Pereira (2000) also studied the relationship between habitat characteristics and fish communities at Barreira Vermelha and Ponta Torres. He suggested that the structural complexity of the substratum, its coral composition and coverage influence the fish community structure mainly through feeding interactions.

Conclusions

Environmental conditions in Maputo Bay are not conducive to coral growth or the development of coral

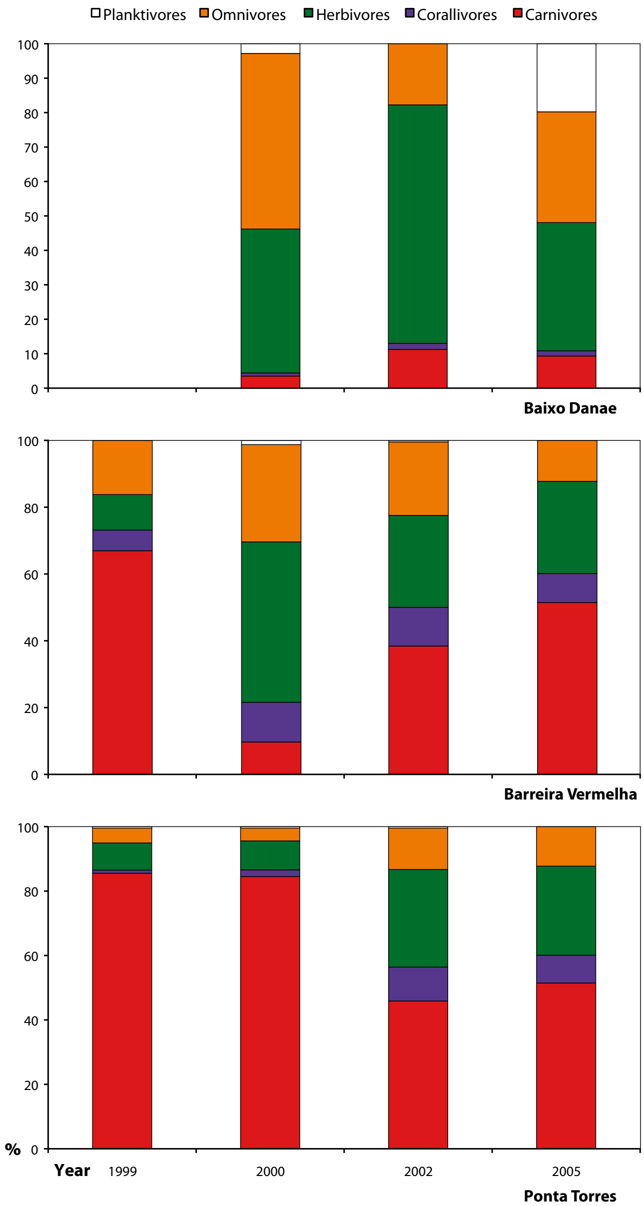

Figure 4. Major trophic fish groups on each of the reefs monitored in Maputo Bay during the Mozambique Coral Reef Monitoring Programme (Rodrigues *et al*., 1999; Motta *et al*., 2002; Pereira *et al*., 2003; Pereira, unpublished). Bar graphs represent the percentage contribution of each trophic group expressed as the number of targeted fish species.250 m^{-2}.

reefs. Only isolated colonies or transient coral communities are likely to occur at localities other than the reefs described above; instances of these are mentioned at Cabo Inhaca, the area between Ponta Rasa and Ponta Punduini, and have been reported for Portuguese Island (Kalk, 1995). The factors that mitigate against coral growth are primarily turbidity, sedimentation and fluctuations in salinity (see Chapter 3 – Geomorphology and Evolution of Maputo Bay and Chapter 4 – Hydrology and Circulation of Maputo Bay) that originate from the river mouths, mangroves and estuaries that surround Maputo Bay.

The coral reefs at Inhaca Island are thus not typical of the other high-latitude reefs that occur in southern Africa (Schleyer *et al*., in prep.). Those at Bazaruto (Schleyer and Celliers, 2005b), in southern Mozambique south of Inhaca (Robertson *et al*., 1996; Pereira, 2003) and South Africa (Schleyer, 2000; Schleyer and Celliers, 2005b; Celliers and Schleyer, 2008) have greater permanence and a much higher biodiversity; they are distant from riverine influence and are not subjected to such extremes of turbidity, sedimentation and fluctuations in salinity. The level to which the coral community on Barreira Vermelha has adapted to these deleterious conditions contradicts conventional wisdom on coral reefs. Tabulate acroporids are particularly abundant on Barreira Vermelha, yet these corals are usually the most sensitive to such poor environmental conditions.

This highlights the uniqueness of the Barreira Vermelha coral community, which merits more intensive study on the specialisation and genetic isolation of its corals. A preliminary examination of the regional genetic connectivity of *Acropora austera* and *Platygyra daedalea* has indicated that the latter is indeed the case with clear genetic isolation of these species on Barreira Vermelha (Macdonald *et al*., 2009).

While the reef at the point of Ponta Torres is also marginal, that in the channel would be more typical of a protected, lagoonal reef but for its poor condition.

This would be partially due to hydrological changes brought about by the aforementioned rock blasting and sedimentation. However, most of its deterioration appears to have been caused by destructive fishing practices.

Baixo Danae most closely approaches the norm for coral biodiversity and community structure on the high-latitude reefs along the south East African coast (Schleyer, 2000; Schleyer and Celliers, 2005a; 2005b; Celliers and Schleyer, 2008). Conditions here nevertheless remain marginal and it must likewise experience some turbidity and sedimentation from water emptying from Maputo Bay. A coral cover of a mere ~35% (Table 2) is indicative of this and it constitutes another reef that merits further study.

Corals are under global threat from climate change and the value of high-latitude reefs for studies on the effects of this phenomenon have been elaborated by Schleyer and Celliers (2002; 2003b). Apparent consequences of climate change have been demonstrated in long-term monitoring on a South African reef (Schleyer *et al.*, 2008), manifested by a shift in community structure and reduced success in coral recruitment (Schleyer *et al.*, 2008; Schleyer, 2009). Corals on the reefs at Inhaca appear to have developed remarkable resilience and a study of their adaptive potential may well provide material for reef conservation and rehabilitation in the face of global climate change. Their conservation is thus imperative.

While the taxonomy of reef fishes in Maputo Bay is relatively well known, aspects of their basic ecology and biology are poorly understood and need further attention, especially for commercially important species or those that are threatened and/or endemic. This is considered important in view of climate change-related threats to local coral reefs as well as those arising from the booming tourism industry and fisheries development. The status, population dynamics, migration, stock assessments, reproduction, age and growth of local reef fishes are poorly known and are fundamental to the management and conservation of these resources. Their conservation is deemed as important as that of the corals.

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APPENDIX 1. Checklist of reef-associated fish species positively identified in Maputo Bay and the surrounding areas (after Kalk 1995; Smith and Heemstra, 1991; Nagel and Degerstedt, 1999; Pereira, 2000; Motta et al. 2002; Pereira et al. 2003; Pereira and Videira, 2005; M. Pereira, unpub. data; T. Simões, pers. com.). Species are organized alphabetically within Families. The taxonomy follows Froese and Pauly (2009).

Acanthuridae
Acanthurus blochii
Acanthurus dussumieri
Acanthurus leucosternon
Acanthurus lineatus
Acanthurus mata
Acanthurus nigricauda
Acanthurus nigrofuscus
Acanthurus tennenti
Acanthurus thompsoni
Acanthurus triostegus
Acanthurus xanthopterus
Ctenochaetus striatus
Ctenochaetus strigosus
Naso annulatus
Naso brevirostris
Naso lituratus
Naso unicornis
Paracanthurus hepatus
Zebrasoma scopas
Zebrasoma desjardinii
Zebrasona veliferum

Apogonidae
Apogon aureus
Apogon fraenatus
Apogon kallopterus
Apogon angustatus
Apogon cookii
Apogon semiornatus
Archamia fucata
Cheilodipterus lineatus

Aulostomidae
Aulostomus chinensis

Balistidae
Balistapus undulatus
Balistoides conspicillum
Balistoides viridescens
Melichthys indicus
Melichthys niger
Odonus niger
Pseudobalistes flavimarginatus
Pseudobalistes fuscus
Rhinecanthus rectangulus
Sufflamen bursa
Sufflamen chrysopterus
Sufflamen fraenatus

Belonidae
Thylosurus crocodilus crocodilus

Blenniidae
Antennablennius australis
Cirripectes castaneus
Exallias brevis
Parapercis hexophthalma
Parapercis punctulata
Plagiotremus rhinorhinchos
Plagiotremus tapeinosoma

Caesionidae
Caesio caerulaureus
Caesio xanthonota

Caracanthidae
Caracanthus maculatus
Caracanthus madagascariensis

Carangidae
Alectis indicus
Carangoides fulvoguttatus
Caranx ignobilis
Caranx melampygus
Caranx sexfasciatus
Elagatis bipinnulata
Gnathanodon speciosus
Pseudocaranx dentex
Scomberoides commersonianus
Seriola dumerili
Trachinotus africanus

Carcharinidae
Carcharhinus brevespinna
Carcharhinus leucas
Carcharhinus melanopterus
Carcharhinus wheeleri
Eugomphodus taurus
Galeocerdo cuvier
Triaenodon obesus

Chaetodontidae
Chaetodon auriga
Chaetodon blackburnii
Chaetodon falcula
Chaetodon guttatissimus
Chaetodon interruptus
Chaetodon kleinii
Chaetodon lineolatus
Chaetodon lunula
Chaetodon madagaskariensis
Chaetodon melannotus
Chaetodon meyeri
Chaetodon trifascialis
Chaetodon trifasciatus
Chaetodon vagabundus
Chaetodon xanthocephalus
Chaetodon zanzibarensis
Forcipiger flavissimus
Hemitaurichthys zoster
Heniochus acuminatus
Heniochus diphreutes
Heniochus monoceros

Cirrithidae
Cirrhitichthys oxycephalus
Paracirrhites arcatus
Paracirrhites forsteri

Congridae
Conger cinereus cinereus

Coryphaenidae
Coryphaena hippurus

Dasyatidae
Dasyatis kuhlii
Himantura uarnak
Rhinobatos leucospilus
Taeniura lymma
Taeniura melanospilos
Torpedo fuscomaculata
Torpedo sinuspersici

Diodontidae
Diodon hystrix
Diodon liturosus
Lophodiodon calori

Echeneidae
Echeneis naucrates

Ephippidae
Platax orbicularis
Platax teira
Tripterodon orbis

Fistulariidae
Fistularia commersonii

Gerridae
Gerres acinaces

Gobiidae
Cryptocentrus cryptocentrus
Gobiodon rivulatus
Istigobius decoratus
Nemateleotris magnifica
Paragobiodon modestus
Valenciennea strigata

Haemulidae
Plectorhinchus flavomaculatus
Plectorhinchus gaterinus
Plectorhinchus gibbosus
Plectorhinchus plagiodesmus
Plectorhinchus playfairi
Plectorhinchus sordidus

Holocentridae
Myripristis adusta
Myripristis kuntee
Myripristis murdjan
Neoniphon sammara
Sargocentron caudimaculatum
Sargocentron diadema
Sargocentron spiniferum

Istiophoridae
Makaira indica
Istiophorus platypterus
Tetrapturus audax

Kyphosidae
Kyphosus bigibbus
Kyphosus cinerascens
Kyphosus vaigiensis

Labridae
Anampses caeruleopunctatus
Anampses meleagrides
Bodianus axillaris
Bodianus diana
Cheilinus fasciatus
Cheilinus trilobatus
Coris aygula
Coris caudimacula
Coris formosa
Coris gaimard
Gomphosus caeruleus
Halichoeres cosmetus
Halichoeres dussumieri
Halichoeres hortulanus
Halichoeres lapillus
Halichoeres marginatus
Halichoeres nebulosus
Halichoeres scapularis
Hemigymnus fasciatus
Hemigymnus melapterus
Hologymnosus doliatus
Labroides bicolor
Labroides dimidiatus
Pseudocheilinus hexataenia
Stethojulis albovittata
Stethojulis interrupta

Stethojulis strigiventer
Thalassoma amblycephalum
Thalassoma hardwicke
Thalassoma hebraicum
Thalassoma lunare

Lethrinidae
Gnathodentex aureolineatus
Gymnocranius griseus
Lethrinus crocineus
Lethrinus harak
Lethrinus lentjan
Lethrinus mahsena
Lethrinus microdon
Lethrinus nebulosus
Lethrinus sanguineus
Monotaxis grandoculis

Lutjanidae
Aphareus rutilans
Aprion virescens
Lutjanus argentimaculatus
Lutjanus bohar
Lutjanus ehrenbergii
Lutjanus fulviflamma
Lutjanus gibbus
Lutjanus kasmira
Lutjanus lutjanus
Lutjanus monostigma
Lutjanus rivulatus
Lutjanus sanguineus
Lutjanus sebae

Mobulidae
Mobula diabolus

Monacanthidae
Canterhines pardalis

Monodactylidae
Monodactylus argenteus

Mullidae
Mulloidichthys flavolineatus
Mulloidichthys vanicolensis
Parupeneus barberinus
Parupeneus bifasciatus
Parupeneus cyclostomus
Parupeneus indicus
Parupeneus macronema
Parupeneus rubescens

Mugilidae
Liza macrolepis
Valamugil buchanani

Muraenidae
Echidna nebulosa
Echidna polyzona
Gymnomuraena zebra
Gymnothorax eurostus
Gymnothorax favagineus
Gymnothorax flavimarginatus
Siderea grisea

Nemipteridae
Parascolopsis eriomma
Scolopsis ghanam
Scolopsis vosmeri

Orectolobidae
Stegostoma fasciatus

Ostraciidae
Cantherhines pardalis
Ostracion cubicus
Ostracion meleagris

Pempheridae
Pempheris adusta
Pempheris schwenkii

Pinguipedidae
Parapersis hexophthalma

Platycephalidae
Papilloculiceps longiceps
Platycephalus indicus

Pomacanthidae
Apolemichthys trimaculatus
Centropyge acanthops
Centropyge bispinosus
Centropyge multispinis
Pomacanthus imperator
Pomacanthus semicirculatus
Pomacanthus rhomboides

Pomacentridae
Abudefduf natalensis
Abudefduf sordidus
Abudefduf sparoides
Abudefduf vaigiensis
Amphiprion allardi
Amphiprion akallopisos
Chromis caerulea
Chromis dimidiata
Chromis dasygenys
Chromis lepidolepis
Chromis nigrura
Chromis ternatensis
Chromis viridis
Chromis weberi
Chrysiptera annulata
Chrysiptera unimaculata
Dascyllus aruanus
Dascyllus carneus
Dascyllus trimaculatus
Neopomacentrus cyanomus
Plectroglyphidodon dickii
Plectroglyphidodon lacrymatus
Plectroglyphidodon leucozonus
Pomacentrus caeruleus
Pomacentrus trichourus

Pseudochromidae
Pseudochromis dutoiti
Pseudochromis natalensis
Pseudochromis tauberae

Rhincodontidae
Rhincodon typus

Rhinobatidae
Rhina ancylostoma

Scaridae
Calotomus spinidens
Scarus ghobban
Scarus rubroviolaceus
Scarus sordidus

Scombridae
Acanthocybium solandri
Euthynnus affinis
Gymnosarda unicolor
Katsuwonus pelamis
Sarda orientalis
Scomberomorus commerson
Scomberomorus plurilineatus
Thunnus albacares

Scorpaenidae
Pterois antennata
Pterois miles
Scorpaenopsis diabolus
Scorpaenopsis gibbosa
Scorpaenopsis oxycephala
Scorpaenopsis venosa
Sebastapistes cyanostigma
Synanceia verrucosa

Serranidae
Pseudanthias squamipinnis
Aethaloperca rogaa
Cephalopholis argus
Cephalopholis boenack
Cephalopholis miniata
Epinephelus caeruleopunctatus
Epinephelus fasciatus
Epinephelus flavocaeruleus
Epinephelus fuscoguttatus
Epinephelus guaza
Epinephelus lanceolatus
Epinephelus longispinis
Epinephelus malabaricus
Epinephelus merra
Epinephelus tauvina
Epinephelus tukula
Plectropomus areolatus
Plectropomus punctatus
Grammistes sexlineatus

Siganidae
Siganus sutor

Sparidae
Argyrops filamentosus
Argyrops spinifer
Acanthopagrus bifasciatus
Cheimeirus nufar
Chrysoblephus puniceus
Diplodus cervinus hottentotus
Diplodus sargus capensis
Polysteganus coeruleopunctatus
Polysteganus praeorbitalis
Rhabdosargus sarba
Rhabdosargus thorpei

Sphyraenidae
Sphyraena barracuda
Sphyraena jello

Sphyrnidae
Sphyrna mokarran

Synodontidae
Saurida gracilis
Synodus dermatogenys
Atherinomorus lacunosus

Tetraodontidae
Arothron hispidus
Arothron meleagris
Arothron nigropuntactus
Arothron stellatus
Canthigaster amboinensis
Canthigaster bennetti
Canthigaster solandri
Canthigaster valentini

Zanclidae
Zanclus cornutus