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CONTENTS

FISHES FROM BASSAS DA INDIA ATOLL IN THE MOZAMBIQUE CHANNEL

RUDY VAN DER ELST[1*], SIMON CHATER[2], and DENNIS KING[3]

ABSTRACT

Bassas da India is a remote, uninhabited coral atoll in the West Indian Ocean. Its inaccessibility had historically precluded study of its ichthyofauna until a small group of scientists from the Oceanographic Research Institute in South Africa undertook a two-week biodiversity survey in 1991. Since then, the discourse on climate change has taken on a higher relevance, calling for protection and study of biodiversity hotspots such as Bassas da India. The survey recorded 309 fish species, including a number of vulnerable teleosts and elasmobranchs. As the only published information on the biodiversity of this remote small island, it is intended that this dataset will contribute to increased relevance as an ecological baseline for detecting impacts relating to climate change in the South West Indian Ocean. Each species is listed in terms of its individual abundance, IUCN status as well as its museum and photographic record. Comparisons are made with survey results of other small coral islands in the region, notably Europa Island, revealing several distinct differences in fish diversity. There is evidence that giant groupers will replace sharks as apex predators when there is no local exploitation. A total of 86 species were photographed to confirm identity, and a further 84 species were provided to the South African Institute for Aquatic Biodiversity museum in Grahamstown and also to several international species experts.

***Keywords**:* ichthyofauna, climate change, biodiversity, coral reef, apex predator, shark, grouper, South West Indian Ocean, Isles Eparses

INTRODUCTION

Bassas da India is a remote atoll located centrally in the Mozambique Channel at about 21° 28'S and 39° 40'E (Figure 1). It is one of several isolated and ancient volcanic cones that lie to the north of the submarine Mozambique plateau. The nearest island is the French possession of Europa, some 110 km to the southeast. Bassas da India lies at the same latitude as the Bazaruto Archipelago in Mozambique, about 430 km to the west. Tulear, on the Madagascar west coast, lies about 350 km eastward.

The existence of Bassas da India (and Europa Island) was first formally documented in 1510 by Pedro Reinel, a Portuguese cartographer. Originally named *Baixos da Judia,* the atoll of Bassas da India has instilled fear amongst generations of seafarers as an obstacle to ships, and as the cause of great disasters and loss of life (Stuckenberg, 2000). Famed amongst these was the silver-laden Portuguese carrack, *Santiago,* which struck the reef in 1585. A dozen or more other shipwrecks litter Bassas da India, most having resulted in large loss of life.

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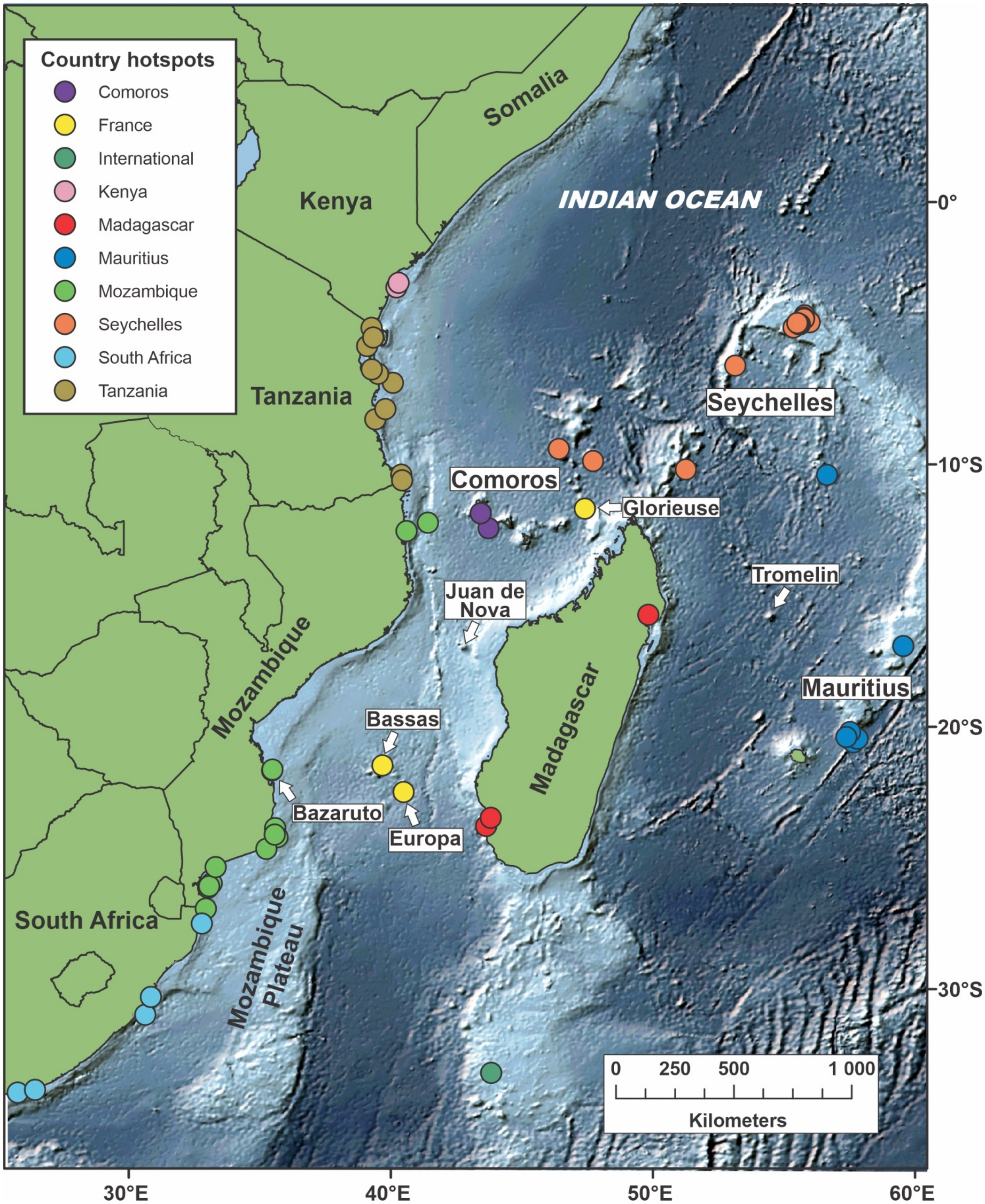

Figure 1. Location of Bassas da India in context to other biodiversity hotspots in the West Indian Ocean (WIO).

Bassas da India was declared a French possession and was established as a 'Reserve Naturelle' on 17 July 1971 (Harroy, 1972). It is formally gazetted under bylaw ('Arrêté') 13 of 18 November 1975 (République Française, 1975), and forms one of the *Isles Eparses*, a group of 'Scattered Islands' claimed by France, and which includes Europa, Glorieuses, Juan de Nova and Tromelin. This group forms a part of the French territories of the southern and Antarctic region (Terres Australes et Antarctiques Françaises – TAAF) which comprises Crozet, Kerguelen, St. Paul and Amsterdam islands (in the sub-Antarctic zone) and Adelie Land (Antarctica). However, ownership of several of the 'Scattered Islands' is also asserted by neighbouring countries, including their share of the 640 000 km^2 Exclusive Economic Zone (EEZ) which France proclaimed in 1978 (République Française, 1978). Although some agreements on this dispute have been reached, several remain unresolved, including Mauritius and Madagascar's claims to Bassas da India (République Française, 1978; Oraison, 2015).

DESCRIPTION OF THE ATOLL

The Mozambique Channel was formed some 130 Ma with the break-up of Gondwanaland (Braithwaite, 1984). More recently, between 40-50 Ma, volcanic activity around several tectonic boundaries in the South West Indian Ocean (20 ° to 22 ° S) increased substantially, leading to the creation of a cluster of some 440 seamounts. Most are low and flat-topped, but many have overgrowths of coral on the subsiding summits. Some have formed shallow reef platforms while others have become atolls with low-lying islands, as in the case of Bassas. While this volcanism process remains to be fully understood, differences in the origin of the magma may have dictated the original shape and size of these seamounts (Courgeon et al., 2017).

In his film series *The Undersea World of Jacques Cousteau* (1966–1967), Jacques Cousteau described Bassas da India as "a perfect atoll, a belt of coral that barely reaches the surface of the sea and is unmarred by a single coconut tree." The atoll is almost circular in shape, has an enclosed lagoon of some 90 km^2, measures about 11.4 km from east to west and 9.9 km from north to south (Figure 2). A single narrow shallow passage, navigable only by small boat, passes through the reef into the lagoon on the northern side of the atoll. This channel is bounded on one side by a shallow sandbar that is exposed at low spring tide. A maximum depth of 14 m has been recorded in the lagoon, which is fringed by reef flats of about 300 m at their widest point. The reef top is dominated by large expanses of bare coral rubble and most of the patch reefs, which abound in the lagoon, consist entirely of dead coral. While this is in part attributable to damage resulting from periodic cyclones that strike Bassas da India, significant coral bleaching mortalities were reported in the region during the 1982–1983 El Niño warming event (Glynn, 1984) and again during the 1998–1999 El Niño warming phase. A number of papers reported on bleaching events as part of the Global Coral Reef Monitoring Network (GCRMN). The severity of coral bleaching in the WIO ranged from 0% to 99%, depending on the vulnerability of the species, latitude and depth. Trends in measurements expressed as percent coral cover, suggest that vulnerability to bleaching is highly variable, indicating zones of high- and low- vulnerability to future climate change. While inadequate sampling has yet to precisely confirm such zones, the use of remote sensing has assisted in the creation of at least two mappings of zones at risk to WIO reefs (Burke et al., 2011; Maina et al., 2008), suggesting that Bassas da India falls within a medium–risk zone (Wilkinson, 2000; Obura et al., 2000; Obura, 2015).

The prevailing winds at Bassas da India are the southeast trade winds which continually pound the surf on the southern and eastern side of the atoll. The atoll is occasionally lashed by tropical cyclones from the south-east during the summer months of December to March. In addition, periodic cyclones migrate southward down the Mozambique Channel and strike the atoll. The destructive effects of these violent weather systems within the shallow waters of the atoll are evident from the large, broken blocks of dead coral upswept over the reef top.

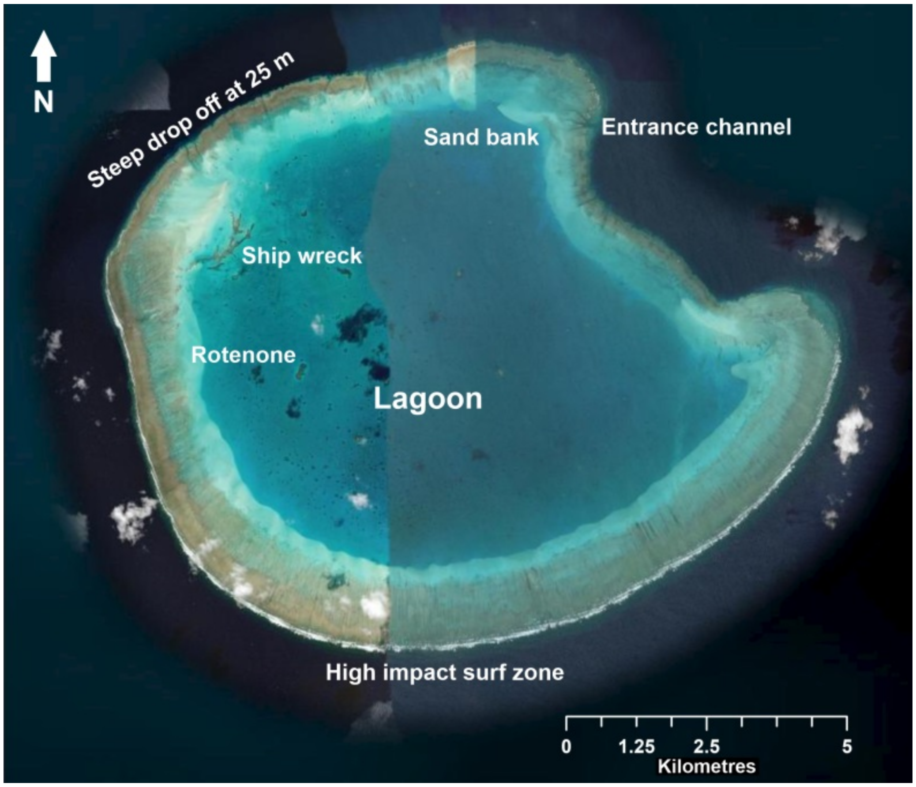

Figure 2. Google Earth image of Bassas da India atoll at low tide. Image © Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Imagery date 23/03/2021. 21°28"S, 39°40"E.

The south and east side reef front is incised by numerous spur and groove formations (Duce et al., 2014) which open out at a depth of about 10 m and clearly dissipate heavy wave action, providing a measure of protection to the inner zone of corals. The surge through these gullies at the reef edge during periods of heavy swell is enormous and coral growth here is limited to encrusting species. The reef slopes steeply downwards at an angle of ~20°, to a 450 m deep ledge. Beyond the ledge, the sea floor drops to a maximum of 3,000 m within 5 km off the atoll. The drop-offs on the sheltered northwest side of the atoll sustain profuse plate coral (up to 2 m in diameter) and fish communities. The reef-top drops vertically to a plateau at 15 to 25 m, which varies in width up to 80 m before dropping off precipitously to the ocean floor. Depths of 1000 m have been recorded within 2 km of the atoll; relative to its overall size, there is remarkably little shallow shelf area.

Notable amongst the coral species in more sheltered locations throughout the lagoon, are *Ceriotopera hystrix* and *Stylophera pistillata*. These so-called "weed corals" are fragile but fast-growing pioneer species. Frequent storms break up these species and deposit their fragments on the lagoon bottom, where they rapidly form new coral clusters, each providing a niche for small fish and invertebrates. Algae are confined to short encrusting varieties, while seagrasses appear to be very scarce or completely lacking, hence limiting the accretion of the sand substrate that could otherwise occur.

Sea surface water temperatures (SSTs) in the Mozambique Channel are seasonal and range from 20° to 30°C. However, complex eddy formation and anomalies, induced by wind, present a complicated picture (Han et al., 2019). In summer, when SSTs can remain at their maximum for several days, there is a risk of coral bleaching, as in the 1998 event (Obura, 2015). At the time of this study in winter, the prevailing water temperature in the lagoon after sunset was 24°C. It has already been established that the West Indian Ocean (WIO) is warming faster than any other tropical sea (Pfeiffer et al., 2017; Zinke et al., 2019). Based on extensive coral coring at a number of sites in the WIO including Europa, it has been shown that the general

SST in the Mozambique Channel has substantially increased over the past 334 years. The coral paleotemperature proxy data, which is based on the ratio of Sr/Ca, has been validated with direct measurements of SST since 1880, confirming the accuracy of the older core data (Zinke et al., 2019). The tides at Bassas are diurnal with a maximum range measured at spring tide during our visit of about 3.5 m. At high tide, the atoll is completely submerged with only a few large chunks of coral visible that had presumably been cast onto the reef by storms.

That Bassas is remote and a notorious area for shipwrecks has meant that exploitation of reef fishes at this site in comparison to other sites in the region has been exceptionally low. This means that the fishing mortality is in effect F=0, so that stocks can be considered near pristine. There have been periodic but rare commercial linefishing trips, some of which permitted a scientist to be on board. Recreational fishing in the area developed with the advent of GPS technology, mostly originating from Mozambique by South African anglers. However, the distance offshore and the French jurisdiction limited this activity. The only published information on the natural history of Bassas is that which attempts to calculate fisheries data as part of the 'The Sea Around Us' programme, which produced a first estimate of marine fisheries in the Eparses islands by review and extrapolation of existing literature and records (Le Manach and Pauly, 2015).

MATERIALS AND METHODS

Bassas da India is an exceptionally difficult place to visit due to its remote location, lack of safe anchorage, powerful currents, and frequent strong wave action. However, over the years, a number of staff from the Oceanographic Research Institute (ORI) in South Africa paid brief opportunistic visits to the atoll, e.g., when participating in research cruises, as observers on fishing boats or during a two-week expedition in June/July 1991. During these visits, limited collections and recording of fish as well as invertebrates, corals and seaweeds were made. All the material collected has been placed in reputable and appropriate museums.

Fishes were recorded in more detail, although the collecting did not in any way represent an exhaustive and quantitative assessment that would be required for a full biodiversity assessment. Records of line-caught catches were obtained from limited commercial fishing trips. During the two-week survey in 1991, material was collected from several sites using a variety of techniques. The reef top was sampled at low tide using small amounts of rotenone, hand nets, angling and spearing. In the lagoon and over drop-offs to 25 m, hand nets, angling and spearing were used. Photographs, as well as visual sightings were documented and used to identify some of the specimens, but only if there was agreement between at least two knowledgeable divers.

References used for the identification of fish collected, or seen, were by Allen and Steene (1987), Burgess, Axelrod and Hunziker (1990), Compagno (1984a; 1984b), Fischer and Bianchi (1984), Heemstra and Randall (1993), Masuda et al. (1984), Randall and Heemstra (1991), Smith and Heemstra (1986) and Randall (1998). Some of the specimens were dispatched to experts for identification. Where indicated, 35 mm colour transparencies of freshly dead specimens were catalogued in the slide collection of the ORI's library. These have since been digitised. Measurements recorded of collected specimens included total length (TL) and/or fork length (FL). Note that the taxonomy applied in this study relates to that in use at the time of the surveys so as to support comparisons. For example, the Serranidae have now been largely allocated to the Epinephelidae.

RESULTS

Characteristics of the Ichthyofauna

To our knowledge no other collections or actual recordings of fish have been made at Bassas da India, therefore this report represents the first 'published record' of the atoll's ichthyofauna. Le Manach and Pauly (2015) published estimates of landings for Bassas based on extrapolations from various data sources. However, a survey of fishes of the nearby Europa Island had been conducted in 2013 (Fricke et al., 2013) following an earlier study by Fourmanoir (1952).

A total of 309 species, comprising 49 families, was recorded during the six days of sampling at Bassas (Table 1). The overall detailed list of species is presented in Appendix 1, which includes all species recorded by the different techniques, i.e., collecting, photography, fishing, and visual observation. Some 330 individual fish specimens comprising 75 species were dispatched to expert ichthyologists around the world for assistance with identification. The balance of specimens was placed in the Rhodes University Smith Institute (RUSI) collection in Grahamstown, now the South African Institute of Aquatic Biodiversity.

Table 1. Families and number of fish species recorded at Bassas da India during a six-day expedition conducted in June/July 1991

Family	Number of Species
Carcharhinidae	6
Myliobatidae	1
Mobulidae	1
Dasyatidae	1
Muraenidae	4
Clupeidae	1
Chanidae	1
Synodontidae	3
Carapdidae	4
Atherinidae	1
Belonidae	1
Holocentridae	14
Syngnathidae	1
Scorpaenidae	6
Caracanthidae	2
Kuhlidae	1
Serranidae	22
Pseudochromidae	2
Priacanthidae	2
Apogonidae	11
Haemulidae	2
Lutjanidae	9
Caesionidae	5
Lethrinidae	8
Nemipteridae	1
Kyphosidae	1

Family (cont.)	Number of Species (cont.)
Mullidae	8
Malacanthidae	2
Pomacanthidae	7
Chaetodontidae	18
Carangidae	8
Cirrhitidae	3
Pempheridae	1
Pomacentridae	22
Labridae	41
Scaridae	11
Sphyraenidae	2
Mugiloididae	2
Blennidae	11
Gobiidae	10
Acanthuridae	21
Zanclidae	1
Siganidae	2
Scombridae	5
Balistidae	10
Monacanthidae	3
Ostracidae	2
Tetraodontidae	7
Diodontidae	1

Total species = 309
Total families = 49

The abundance and species distribution of fish varied considerably over the entire area of Bassas da India. Highest diversity was recorded on the sheltered northwest side of the atoll, in stark contrast to the exposed and rough southeast side, which displayed a lower abundance and diversity of fishes. The lagoon was generally not prolific in fish, except associated with clusters of coral deposited there by cyclones, which provided niches for a variety of small coral reef fishes. While encrusting and tufted coralline algae were plentiful, the absence of seagrasses and fleshy seaweeds in the lagoon no doubt contributed to a relatively lower abundance of herbivorous fishes.

The geographic ranges allocated to each fish species recorded at Bassas da India encompassed Indo-Pacific, Indo-West Pacific, Indian Ocean, Western Indian Ocean, Indo-Central Pacific and Circumtropical, after Smith and Heemstra (1986). The species not covered in this reference were taken from FAO Species

Identification Sheets for Fishery Purposes; Western Indian Ocean Vols. 1–4 (1984), Masuda et al. (1984) and Winterbottom et al. (1989). Indo-Pacific species (43%) and Indo-West Pacific species (33%) comprised the bulk of the fish species observed at Bassas da India. Indian Ocean endemics contributed 9%. The identities of seven species proved problematic and some remain undescribed, including five gobies, one pomacentrid (*Chrysiptera* sp.) and one dasyatid (*Himantura* sp. *marginatus*?).

The species assemblage of Bassas da India is typically that of a coral reef ecosystem, dominated by Labridae (41 species/13.2%), Pomacentridae (22 species/7.1%), Serranidae (21 species/6.8%), Scaridae (11 species/3.5%), Chaetodontidae (18 species/5.8%) and Acanthuridae (21 species/6.8%) (Table 1). Historically, the Mozambique Current was considered to be a permanent, contiguous and open-ended link between the South Equatorial Current and the Agulhas Current. However, this was shown to be erroneous and oversimplified, when in fact the Mozambique Channel may be hydrologically more homogeneous than originally believed (Lutjeharms et al., 2006). Considering the relatively small distances between the atolls, especially Bassas and Europa, it is expected that the ichthyofauna of other coral reef sites in the region are similar, especially when compared to the fishes reported from nearby Europa Island (22 º 21.5'S; 40 21.5'E), a mere 115 km to the southeast (Fourmanoir 1952, Fricke et al., 2013). In a more or less similar sampling period and methodology, Fricke et al. (2013) reported a total of 389 species in 62 families; similar to Bassas, the largest families being the Labridae (47 species/12.1% of total), Pomacentridae (35 species/9.0%), Serranidae (30 species/7.7%), Gobiidae and Acanthuridae (24 species each, 6.2%), and Chaetodontidae (21 species/5.1%).

Although the top families appear reasonably common between the two atolls, in the case of Europa, there were ten additional families not recorded at Bassas, while conversely, 6 families were found at Bassas but not on Europa. Collectively, this means that the total number of families for the two sites combined is 72 with only 57 of these families common to both sites – i.e., 79.1% similarity in terms of families.

The species recorded from Bassas da India fall into 49 families, with half the total number of species occurring within only seven families. At Bazaruto, the 306 species recorded belong to 69 families, with 12 families accounting for 50% of the species (van der Elst and Afonso, 2009). The larger number of families probably reflect the wider range of habitats sampled in the Bazaruto Archipelago. On the coral reefs in the iSimangaliso Wetland Park (St Lucia MPA, KwaZulu-Natal Province, South Africa) the 405 species recorded fall into 70 families, with only eight families making up half the species. In all cases, the Labridae are the dominant family in terms of number of species. However, there are some notable differences (Table 2). While there is a reasonable similarity in the families present, the species within those families are quite different. For example, comparing the species between Bazaruto and Bassas indicates that only 1/3 of the combined list of 448 species are common to both localities. Several families which are common to both have entirely different species compositions. For example, the butterflyfishes are much more diverse at iSimangaliso and Geyser Reef than the other sites, while elasmobranchs are more diverse at the mainland locations (Table 2).

Despite the apparent congruency in fish families, this is not necessarily reflected when comparison is made at the species level. Hence, while the Bassas and Europa surveys reported 309 and 389 species respectively, the Bassas ichthyofauna accounted for 147 species not reported from Europa, while Europa had an additional 203 species over Bassas. This meant that these two sites represented 534 species in total, out of which only 167 (32%) were common to both atolls. This can be further investigated by analysing the differences in species composition within families. Taking the top 15 families is revealing (Table 3). For example, Labridae are reported to have 41 and 42 species for Bassas and Europa respectively, making it seem congruent. But this may be misleading as only 28 of these are common to both sites (-50.9%), raising the total number of labrids combined to 55 species. Overall, about 40% of the families reported comprised species common to both sites, meaning that almost 2/3 of the species are confined to either one of those atolls (Table 3).

If the same exercise is done comparing Bassas with Juan de Nova ichthyofauna (Chabanet and Durville, 2005), then the composition is closer at 66% common species, with 15 families at 100% similarity.

Table 2. The dominant fish families (including elasmobranchs) expressed as number of species recorded for several WIO coral reef sites

	Bassas[1]	**Europa**[2]	**iSimangaliso**[3]	**Bazaruto**[4]	**Geyser Reef**[5]	**Juan de Nova**[6]
Serranidae	21	30	27	9	23	24
Pomacentridae	22	34	20	16	36	30
Labridae	41	40	45	33	38	41
Scaridae	11	10	7	6	14	12
Chaetodontidae	18	21	21	9	20	18
Acanthuridae	21	23	21	11	23	24
Lethrinidae	8	6	13	7	6	8
Lutjanidae	9	14	21	11	7	10
Carangidae	8	11	23	12	7	9
Holocentridae	14	9	7	7	13	6
Sparidae	0	2	16	2	0	0
Elasmobranch	9	9	25	14	7	11

[1] This study.
[2] Fricke et al., 2013.
[3] Chater et al., 1993.
[4] van der Elst and Afonso, 2009.
[5] Chabanet, 2002.
[6] Chabanet and Durville, 2005.

Table 3. Top 15 families from Bassas and Europa atolls, indicating their low number of species common to both localities

Family	**Number of Species**				**% Common**
	Bassas	**Europa**	**Total**	**Common**	
Labridae	41	42	55	28	50.9
Pomacentridae	22	35	40	16	40.0
Serranidae	21	24	35	10	28.6
Gobidae	10	26	35	1	2.9
Acanthuridae	18	22	30	10	33.3
Chaetodontidae	18	20	22	16	72.7
Blennidae	11	16	21	6	28.6
Scaridae	11	10	17	4	23.5
Apogonidae	11	7	16	2	12.5
Holocentridae	14	9	15	7	46.7
Lutjanidae	10	15	15	9	60.0
Carangidae	8	12	13	6	46.2
Balistidae	10	11	12	8	66.7
Lethrinidae	8	6	10	4	40.0
Pomacanthidae	7	8	9	6	66.7

Clearly it can be risky to compare or assess a coral reef ichthyofauna at the family level only, as we have shown the variability that there may be in the individual family's species mix. Yet families of fishes are generally considered to have similar features and habitat requirements, so that they can be useful in many cases where a semi-quantitative comparison is required or as a proxy for some specific environmental condition. The fish species reported here can broadly be grouped into five trophic categories: carnivores, omnivores, herbivores, planktivores and symbionts (Table 4). Comparisons can thus be made over time or between results reported from different localities (Figure 1): Bassas da India, Europa (22°22'S; 40°22'E), Geyser Reef (12º24'S; 46º13'05E) approximately 1,630 km to the northeast (Chabanet et al., 1996), Juan de Nova (17º03'S; 42ºE) approximately 750 km to the northeast, the Bazaruto Archipelago (21º37'S; 35º28'E) 430 km to the west (van der Elst and Afonso, 2009) and the iSimangaliso Wetland Park (~27º36'S; 32º41'E) 966 km to the southwest (Chater et al., 1993).

Table 4. Percent trophic composition of fishes recorded from several WIO sites

Trophic Category	Bassas[1]	Europa[2]	Geyser[3]	Juan de Nova[4]	Bazaruto[5]	iSimangaliso [6]
Carnivores	73	55	78	73	63	55
Omnivores	12	26	15	11	21	21
Herbivores	8	15	7	16	10	8
Planktivores	6	5	1	6	6	14
Symbionts	2	2	1	1	1	2

[1] This study.
[2] Fricke et al., 2013.
[3] Chabanet et al., 1996.
[4] Chabanet and Durville, 2005.
[5] van der Elst and Afonso, 2009.
[6] Chater et al., 1993.

While these figures are approximations, it is interesting to note that herbivores are of lower diversity at the more oceanic islands of Bassas da India and Geyser. In contrast, regions closer to the continental coast appear to have a higher diversity of plant-eating species.

Apex predators are known to have a strong influence on the structure and dynamics of marine ecosystems, especially in coral reefs, where groupers and sharks often compete for the top spot (Domeier, 2016) and where removal of one apex predator may trigger a trophic cascade, ultimately favouring herbivores. Analysis of such assemblages can be a useful tool in evaluating the protected status of a reef system (Frisch et al., 2016, Anderson et al., 2014). In the case of Bassas, there was an overwhelming presence of large groupers, especially *E. tukula* and *E. lanceolatus*. Sharks were scarce and much less common at Bassas than at the other sites, including the smaller reef sharks (*C. wheeleri, C. melanopteru*s and *T. obesus*) except for a few specimens on the outer drop off. Yet, these species have been recorded from all the other sites reviewed, often as common or abundant. One explanation is the dominant presence of large groupers which, as competing apex predators, are believed to 'attack' sharks that venture close to the reef and in the lagoon. Certainly, the food resources of the two groups are similar and there is compelling evidence that groupers will eat reef sharks of up of up to one metre (Randall, 1977). Such behaviours were witnessed in a captive situation by two of the authors (RP & SC) as well as J Ballard, chief curator at Durban SeaWorld (see Box 1).

Box 1

Report to SAAMBR Council Meeting: 1991

Zambesi shark and Brindle Bass interaction

Some years ago, in Durban's Seaworld complex, we had a problem with predation in our main large fish tank. In our shark tank, originally built for experiments to observe the reaction of sharks to netting and other barriers, we had two super aggressive Zambesi sharks *(C. leucas).* They had grown up from pups caught in 1980 into adults weighing about 240 kg each. They systematically killed every other shark that was introduced from the wild. So, we had a display problem being stuck with only one species.

Simultaneously we had a super hungry (>220kg) giant brindle bass (grouper; *E. lanceolatus)* in the main fish tank. He had lived there for several years but had taken to eating any species that was under about 10kg and newly introduced, including dusky and milk sharks up to 1m in length.

So, we had a double problem! After much deliberation we decided to risk the grouper by moving it to the shark tank and hoping that it would survive.

When the day came for the move, we feared a bloodbath. The grouper was unceremoniously dumped into the shark tank, a totally new environment for it. In a flash the Zambezis attacked, at first by bumping into the grouper with great speed, knocking it around. We had long poles to see if we could avoid a disaster. After about 10 minutes, the grouper recovered and while he had a bruised flank, he faced the next shark head-on and raised his dorsal fin spines. For the next few hours, the grouper attacked the sharks to a point where we were concerned that we might lose them. The grouper rammed into the sharks with his band of teeth doing considerable damage. For the next 4-5 years the grouper was very clearly dominant in the tank. Every time one of the sharks swam close to the grouper, he would raise his spines and the shark would veer away.

Eventually, at dawn one morning in 1991, the tank was red with blood, etc. The sharks had had their day. The grouper was no more, only his head (weighing 115kg!) remained. Bassas is exceptionally endowed with huge groupers, some very aggressive, and one of us was attacked when releasing a live fish overboard. He still has a scar to prove it.

Are the groupers skewing the ichthyofauna or are they a stabilising factor?

EXPLOITATION

While Bassas da India is a very remote atoll and thus not expected to be under much fisheries pressure, it also follows that the unexploited levels of fish stocks present a strong lure for some fishers. Indeed, Bassas has been identified as a regional biodiversity hotspot and could serve as a future indicator in the advance of climate change (Everett and van der Elst, 2015). This report draws together some of the modest but important data sets, thereby documenting historic near-pristine conditions in which levels of reef fishing mortality (F) will be zero.

Tuna Fisheries

Bassas is located at the southern zone of the large tuna fleets that operate in the WIO. While these fleets are flagged in several countries, the main fleet operates out of Seychelles. However, considering the economic zone claimed by France in relation to Bassas da India, tuna vessels are obliged to submit catch records to the French authorities. The region falls under the Indian Ocean Tuna Commission (IOTC), which coordinates research, shares catch information and in future, plans to manage the fisheries through quota allocations. It follows that vessels will at some stage be harvesting in the economic zone of the atoll, although available records indicate that the southern Mozambique Channel is not a preferred tuna fisheries ground (IOTC 2020). It is furthermore likely that there has been some illegal, unreported, and unregulated (IUU) fishing in the area, especially by pelagic longliners (Dez Willens, pers. comm.).

Commercial Linefishing

It is believed, with a reasonable level of certainty, that only two commercial linefish boats have ever operated at Bassas before 2000, and none since. These were the MV Jenny Lee (Capt. Dez Willens) based in Durban and the MV Gilbert Guy (Capt. Roger Maurice) based in Mayotte. The Durban-based operation periodically made exploratory fishing trips to Mozambique waters and on rare occasions fished at one or more of the *Eparses* islands with three or four trips to Europa and Bassas. The Gilbert Guy ran a profitable operation of buying lobsters *(Panulirus ornatus*) (and other products) from rural fishers in Madagascar for re-sale in Mayotte. As a Breton fisherman, Maurice would take regular trips to Geyser Reef and once or twice to Europa and Bassas. The Durban operation was well organised with a strong crew of up to 20 fishermen (Figure 3), while the Mayotte operation mostly involved only the skipper and his wife. On one such trip from Durban, a researcher accompanied the expedition [RvdE] and kept brief records. The landings of these linefish operations were spectacular in comparison to fishing in their traditional Mozambique and South Africa grounds, catching up to 30 tons of reef fish by rod and line in six days. The species composition of catches during the earlier visits (1988) were strongly dominated by Serranidae, considerably in excess of 50% by weight. Most important species were *Epinephelus tukula, Plectropomus laevis and P. punctatus.* One such catch, taken at Bassas and Europa, included a large number of *E. tukula*, some of which were sampled and measured to indicate their large size, with all specimens in excess of one metre (Figure 4).

Analysis of catches from subsequent fishing trips revealed a notable decrease in these species to less than 20% of the total catch, with smaller serranids and species such as bohar snapper (*Lutjanus bohar)* predominating. It was evident that the large resident predators had been the first removed from the system, including Endangered IUCN Red Listed species such as the humphead wrasse, *Cheilinus undulatus.*

Recreational Fisheries

Due to the paucity of recreational fishing data from Bassas, an experiment was conducted during the survey in 1991. The scientific complement on board the research vessel included six experienced recreational anglers. These anglers were divided into two groups (A & B) and at every opportunity, they were encouraged to fish as if they were tourist anglers, except that they maintained comprehensive records to estimate the abundance and nature of the species present. Only artificial lures were used. The results were expressed as catch per unit effort (CPUE) (i.e., number of fish caught per angler per hour). Ranking the CPUE provides a relative insight into the dominant carnivorous species present. A total of 24 species and 1,495 individual fish were recorded, dominated by *L. bohar, Caranx melampygus* and *C. ignobilis* (Figure 5).

In the case of Group A, their fishing location was confined to sites which had been pre-determined from an overall grid map of the atoll divided into minute squares, so as to spread the effort. Group B was free to fish in any area of the atoll. All fish were measured before being released, and all lengths were converted to weights using relevant length-weight equations (Table 5).

Figure 3. Typical fishing scene at Bassas.

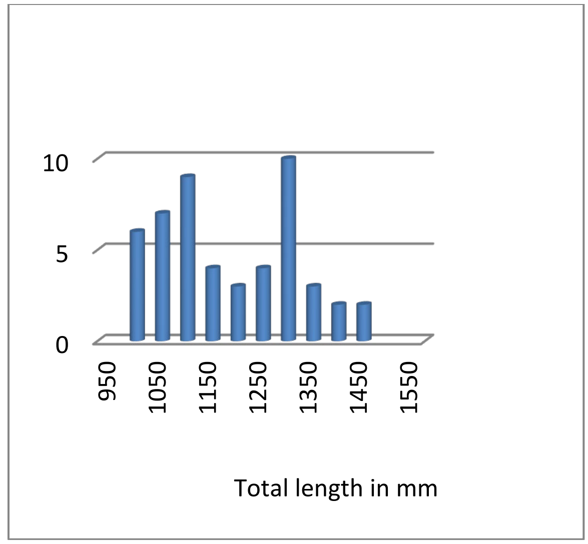

Figure 4. Length frequency distribution (mm total length) of a sample of *Epinephelus tukula* (n=50) caught by commercial linefishers at Bassas da India and Europa Islands in 1985 over a week of linefishing.

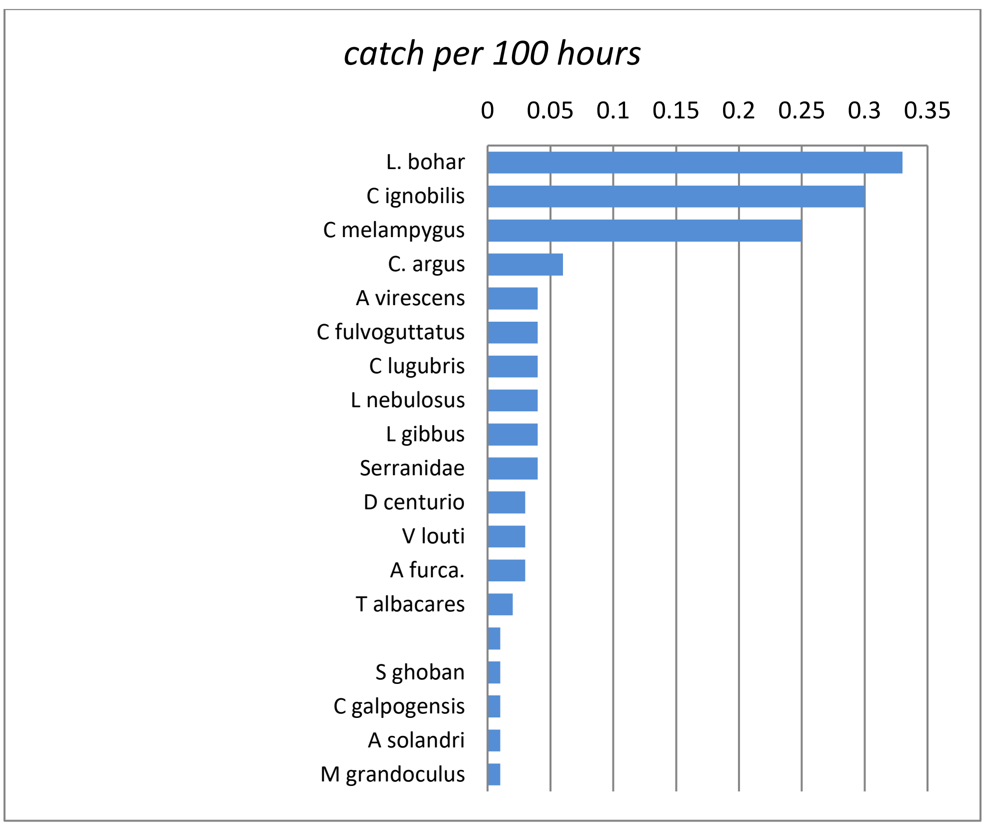

Figure 5. Catch rates of fish species caught by research angling at Bassas da India in July 1991.

Table 5. Details of linefish catch rates for two groups of anglers conducting research fishing at Bassas da India in July 1991

Indicator	Group A	Group B
Total angling hours	122.1	24
Total number of fish caught	149	72
Total weight of catch (kg)	880	226
Overall CPUE (fish per hour)	1.22	3.0
Number of species caught	20	7
Weight per hour (kg)	6.3	9.4

Clearly, these are very high catch rates and indications are that similarly high rates may be obtained by tourist charter operators that fish in the area.

Conservation Status of the Fishes

While there has been very little exploitation at Bassas, and there is also no development of any kind, it follows that the ichthyofauna should mostly reflect a near-pristine or baseline situation. However, the periodic linefishing excursions that remove a high proportion of the large groupers are likely to have a cascade effect on the remaining species. The 309 species reflect a seemingly stable environment which, if monitored, can serve as a benchmark into the future. In order to create such a benchmark, each of the species recorded has been rated with the 2020 IUCN Red List vulnerability index (see Appendix 1). The overall breakdown of Red List status of the Bassas ichthyofauna is shown in Figure 6.

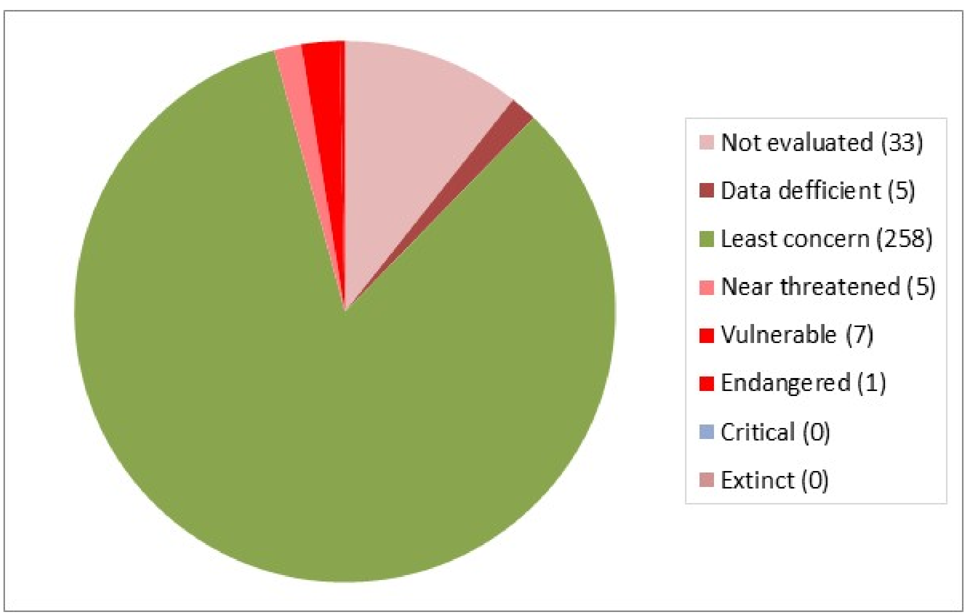

Figure 6. IUCN Red List status of 309 fish species documented at Bassas da India.

DISCUSSION

With accelerating climate change, the task of monitoring biodiversity hotspots on small atolls has become urgent, especially considering the limited sites where vulnerable and endangered species still occur in numbers and as part of an undisturbed ecosystem. Aside from human impacts such as fishing, global warming has already posed a major threat to reef ecology, especially in the tropics. In most cases where ocean warming has resulted in bleaching of corals, changes in the diversity of fishes can also be expected. Chabanet (2002) demonstrated that the 1998 warming event in Mayotte caused considerable coral bleaching which in turn stimulated algal growth on the dead corals, effectively altering the substrate biota. This in turn favoured the herbivorous surgeonfishes, while the butterflyfishes were left without their source of live coral. Similar results were published by Garpe et al. (2006), who related bleaching impacts in Tanzania, highlighting the short term [6 months] effect with increased herbivores followed by a much longer and serious secondary effect on structure of the entire fish community.

Tracking changes in ichthyofauna, either over time or between different sites can be a useful tool in tracking or predicting the impacts of climate change. But, as demonstrated here between the atolls of Bassas da India and Europa, comparing diversity based on families only can be misleading if actual species are not considered. Indeed, certain species can thus also be used a bio-indicators, which can be applied to various localities.

The reasons for the different species composition between Bassas and Europa can be attributed to a number of possible causes. For one, species normally associated with estuarine habitats (*Therapon* sp., *Rhabdosargus sarba, Bothus mancus, Monodactylus* sp., and *Albula* sp.) were recorded at Europa but not on Bassas da India, despite the fact that these species are exceptionally well represented to the east and west in the SW Indian Ocean generally including Europa (Comeros-Raynal et al., 2016). However, these species are often associated with nutrient-rich substrates, which are lacking on Bassas, while Europa has a stand of mangroves and a richer substrate, probably attributable to the great quantity of nutrients brought in by the million or more sooty terns that nest annually on Europa. Their guano must surely assist the growth of mangroves and other terrestrial vegetation.

Several authors have demonstrated changing trends in ichthyofauna associated with climatic events and especially following coral bleaching. Chabanet (2002) demonstrated changes in fish communities at the island of Mayotte, with shifts in the relative abundance of herbivores and browsers two years after the 1998 bleaching event. This was almost certainly related to coral mortality and loss of a food source for coral browsing species. In the case of Bassas da India there is no decades-long sequence of data that could reveal trends in ichthyofauna, but changes linked to climate change can reasonably be expected.

Although the extent and methodology of fish collecting at Bassas da India was preliminary, it points to a considerable diversity of fishes which is broadly similar to that reported from Geyser Reef by Chabanet et al. (1996). While these figures are approximations, it is interesting to note that herbivores are of lower diversity at these more oceanic islands, both of which are fully inundated at high tide. In contrast, regions closer to the continental coast have a much higher diversity of plant-eating species. The reasons for this are at hand when one considers that neither Bassas da India nor Geyser have obvious stands of seaweed or seagrass. Indeed, any future climate change induced mortalities of corals is likely to be detected in the trophic composition of the ichthyofauna should plants (especially algae) replace corals. While not likely in the oligotrophic waters of these offshore atolls, should nutrients be made available, for example via pollution, algae may bloom, creating a eutrophic environment detrimental to coral symbiosis.

All the 40 species reported by Fourmanoir (1952) were also reported by Fricke et al. (2013) from Europa Island. Chabanet et al. (1996) reported on the ichthyofauna of Geyser Reef and Zeelie Bank, with their records of 297 species reflecting a 95% similarity with the species recorded from Bassas da India during this survey. The Bazaruto Archipelago, which lies on the Mozambique coast at approximately the same latitude as Bassas, also has considerable coral reef habitat in addition to other ecosystems. A total of 306 species was reported by van der Elst and Afonso (2009) based on more frequent sampling over a 25-year period, very similar to the 309 species recorded for Bassas over the more intensely sampled but shorter period.

These oceanic sites are also reservoirs of biodiversity that can contribute to recruitment patterns of species overexploited in other regions. In his analysis of current systems in the South West Indian Ocean, Lutjeharms (2006) suggests that the Mozambique and East Madagascar boundary currents are not always well defined and predictable. The waters surrounding Bassas da India are impacted by two current systems which generate periodic cyclonic eddies moving down the Mozambique Channel in a south-westerly direction (Lutjeharms, 2006). These in turn may lead to more homogeneous or well-mixed water masses, which are more conducive to a stable ichthyofauna, and which strengthen the potential role of these atolls in contributing to the region's larval fish population. The fact that Bassas da India has seemingly healthy populations of endangered species, such as the humphead wrasse and several large serranid species, is especially important and justifies the atoll's no-take protected status. The dominance of apex predators at all sites is noteworthy, as is their low abundance reported for Bassas and Geyser Reef (Chabanet et al., 1996). Many of the species that make up the carnivore component are apex predators, often of large size and dominance. Examples include the large Serranidae, Lutjanidae, Sphyraenidae and Carangidae. In particular the presence of giant grouper is believed to exercise dominant 'control' and outcompete sharks. The fact that these species appear to be more dominant on the offshore islands that are difficult to reach is almost certainly attributable to the lower fishing effort that is exerted there, hence the trophic structure and associated biodiversity is likely to be closer to a 'natural' state where little or no human-induced fishing mortality occurs. Further study of this concept is needed as it raises a number of important questions with respect to species dominance on coral reefs. Moreover, what influence could fisheries have if a dominant group is removed (Mourier et al., 2016)?

The catch rates of 1.22 and 3 fish per hour recorded here are very high by most standards, except in cases where the fishing takes place in a fully protected environment, such as within the iSimangaliso Wetland Park (South Africa), where Mann (2019) reported rates of 1.41 fish per hour under similar circumstances as seen here. An estimate of catches taken by the recreational charter operators at Bassas was calculated by Le Manach and Pauly (2015). While this provides a start, our experiences did not entirely concur with these estimates. We find that their postulated 20 charter trips, each for six times per year, was excessive and is likely no more than ½ of that. The proposed estimated catch of 500kg per trip may not be unrealistic if the high catch rates recorded during our survey are considered. However, this would depend on the number of anglers, the number of days and hours fished. Also, freezer capacity on such charter yachts is very modest and the fact that most operations release at least some of their catch, the 500 kg would not be the actual fishing mortality. Moreover, the species composition proposed by Le Manach and Pauly (2015) are not entirely in line with our data and biodiversity of the atoll. Nevertheless, these records may in time play an important role in benchmarking changes in the biodiversity of the atoll.

While the lack of human settlement at Bassas da India will have contributed to the conservation of fishes there, this also means that uncontrolled exploitation can occur surreptitiously. As reported here, periodic visits by fishing boats, tourist yachts and spearfishing groups are known to have harvested fish surrounding Bassas da India. Considering that some of these species have relatively slow growth rates and that the age of many will have been in excess of 30 years, the impact of this targeted removal of the top predators is likely to manifest itself in any future biodiversity assessment of the atoll. Furthermore, the targeting of these apex large predators by pulse fishing may also lead to a gender imbalance and compromise future offspring as many of these species are protogynous hermaphrodites so that many more larger males will be removed.

Other intrusions have been reliably reported, including naval exercises using mortars, physical damage to the reefs in search of ship artefacts and a number of shipping accidents with associated pollution and damage to the atoll ecosystem. Although current angling charter operators' websites claim their operations to be environmentally sensitive, their ignorance in this regard is apparent when promoting activities such as: "*On arrival, throw anchor and then…take a walk on the rocks where old shipwrecks can be explored and interesting marine life can be seen in the rock pools (remember your sandals to protect your feet!).*" There are no rocks – only ultra-vulnerable corals!

Notwithstanding the relatively stable global fisheries catch in the WIO over time (van der Elst, 2015), a number of individual populations appear to be increasingly vulnerable. In view of the high and growing dependence on fisheries in the WIO (van der Elst et al., 2005), the protection of small island ecosystems and their fish populations may take on a greater significance in the future, especially as refuges for spawning stock and incubators of new recruits to the region. Considering the ease with which fish can be depleted at such small island sites, it is incumbent on the authorities to ensure that strict surveillance and protection is in place. In turn, this calls for strong regional collaboration through the Nairobi Convention, the FAO regional office and similar structures.

The importance of protecting the 59 marine biodiversity hotspots in the WIO cannot be overstated (Everett and van der Elst, 2015). As the more accessible coastal resources become depleted or impacted through climate change, so fishers will venture further afield, especially attracted by historically protected areas, where a large 'once-off' catch can be made. Clearly this happened at Bassas, with the periodic visits by linefishing boats which impacted a significant number of fishes, especially slow-growing red-listed species. This paper highlights the vulnerability of hotspots like Bassas and raises concern about their protection. Indeed, the conservation status of Bassas da India lies only in its proclamation as a nature reserve and periodic regulations pertaining to fishing. This appears inadequate, accentuated by the contested nature of ownership of this and the other Eparses islands. Only Glorieuses appears to have been formally proclaimed as a no-take marine protected area (MPA) (République Française, 2012).

We hereby make a strong plea for the establishment of a multinational 'Forum of WIO Biodiversity Hotspots,' under the aegis of the Nairobi Convention. The regional need of their protection is further emphasised by the contested ownership of several of these hotspots. A common regional vision and commitment towards the significant protection of these biodiversity reservoirs may well prove to be a critical tool to mitigate against climate change.

CONCLUSION

This study has shown that species surveys can be a useful tool in detecting possible environmental changes brought about by climate change. However, care should be taken when using only the number of families as a basis for such assessments, as in the case of trophic comparisons. For example, the differences in species composition between Bassas and Europa atolls were substantial, even though their family composition appeared similar. The reason for these differences can be one or more of the following:

- The three decades interval between surveys, suggests that climate change may already playing a role by altering the habitat and thus the species composition.
- The level of work and methodology may be dissimilar
- The ecosystems are different between the two atolls. Europa has dry land and wetlands.
- Europa is larger than Bassas

It is clear that groupers and sharks are apex predators that compete for space. A stable population appears to be when large groupers dominate. Removal of the groupers through fishing can lead to an increase in shark activity. This further highlights the importance of protecting these small atolls against fishing and should be recognised as no-take reserves. It is suggested that both Bassas and Europa are considered reference sites, subjected to decadal surveys. Based on these conclusions it considered important to repeat both surveys in order to establish the root causes for the species differences.

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APPENDIX 1: CHECKLIST OF FISHES FROM BASSAS DA INDIA

Systematically arranged according to Nelson et al. (2016)

A combined table of species recorded either as a captured specimen (S), by capture and release (C), visual observation (V) confirmed by two or more experts and/or as a photo record (P). Locality, main region of Western Indian Ocean includes Mauritius, Seychelles, Red Sea, Comoros and the Chagos Archipelago.

Distribution and IUCN Red List status in 2020 is given: Vulnerable VU, Near Threatened NT, Data Deficient DD, Least Concern LC, Not Evaluated NE. The most threatened groups are in red. Note that taxonomy is applied at the earlier dates, pre-2005, so as to be consistent with historic records. For example, the family Epinephalidae is not applied here and remains Serranidae.

Family and Species	Method	Habitat Notes	Specimen Size (mm)	IUCN Red List
CARCHARHINIDAE		GREY SHARKS	6	
Carcharhinus albimarginatus (Ruppell, 1837)	P	Seen on the drop-off, singly or in loose packs; excitable when fish were speared in their proximity. Common. Indo-Pacific.	Adult	**VU**
Carcharhinus altimus (Springer, 1950)	V&P	A single large specimen seen on two separate occasions in 1–2m across the reef top. Circumtropical	Adult	DD
Carcharhinus galapagensis (Snodgrass & Heller, 1905)	V&C	Common: Indo-Pacific. Several seen at night outside the reef.	1400 TL	**NT**
Carcharhinus amblyrhynchos (Garrick, 1982)	V	Several individuals seen on the drop- off. Western Indian Ocean.	Adult	**NT**
Carcharhinus melanopterus (Quoy & Gaimard, 1824)	V	Single specimen recorded from the lagoon. Indo-Pacific.	900 TL	**NT**
Galeocerdo cuvieri (Peron & Lesueur, 1822)	C	One, captured on a baited line in the lagoon. Tagged (SFW-ORI tag no. B 010438) and released. Circumtropical.	1500 TL	**NT**
MYLIOBATIDAE		EAGLE RAYS		
Aetobatus ocellatus (Euphrasen, 1790)	P	Recorded from the drop-off. Circumtropical.	Adult	**VU**
MOBULIDAE		MANTAS		
Manta (Mobula) birostris (Donndorff, 1798)	V	Several large individuals seen outside the entrance channel to the atoll. Circumtropical.	Adult	**VU**
DASYATIDAE		STINGRAYS		
Himantura marginata?	P & S	One specimen collected from the lagoon by spear. Species unknown (new?) tentatively identified as *Himantura marginata* by L. Compagno. Several similar rays were seen in shallow water on the sandbar near the entrance channel to the lagoon. The specimen is housed at the S.A. Museum in Cape Town.	? DW	DD

MURAENIDAE		MORAYS		
Gymnothorax javanicus (Bleeker, 1859)	P	Common on coral bommies in the lagoon and the drop-off. Indo-West Pacific.		LC
Gymnothorax buroensis (Bleeker, 1857)	P&S	Reef-top. Indo-Pacific.	215 TL	LC
Gymnothorax ruepelliae (McClelland, 1845)	P&S	Reef-top. Indo-Pacific.	151 TL	LC
Gymnothorax undulatus (elaineheemstrae) ? (Lacepede, 1803)	S	One specimen sampled. Reef-top. Indo-Pacific.	198 TL	LC
CLUPEIDAE		SARDINES		
Spratelloides delicatulus (Bennett, 1831)	S	Dense shoals were seen over the shallow sandbanks in the Lagoon near the entrance channel. Indo-Pacific.	45 specimens: 40–45 TL	LC
CHANIDAE		MILKFISH		
Chanos chanos (Forskall, 1785)	V	Several large individuals seen swimming over the reef-top at high tide. Indo-West Pacific.	Adult	LC
SYNODONTIDAE		LIZARDFISHES		
Saurida gracilis (Quoy & Gaimard, 1824)	P/S	Lagoon. Indo-west Pacific	145;205FL	LC
Synodus binotatus Schultz, 1953	P/S	Lagoon. Indo-west Pacific	105;80;80;72 FL	LC
Synodus dermatogenys Fowler, 1912	V	Common throughout the lagoon over sand near bommies. Indo-West Pacific.		LC
CARAPIDAE		PEARLFISHES (All pearlfish specimens were identified by Dr John Olney, Virginia Institute of Marine Science.)		
Encheliophis homei (Richardson, 1844)	S	Taken from the holothurian *Bohadschia argus* in the lagoon. Circumtropical. RUSI No:044310	4 specimens	NE
Encheliophis boraborensis (Kaup ?)	S	All collected from specimens of the holothurian *Thelanota anax* in the lagoon. Indo-Pacific. RUSI No:044312	4 specimens	NE
Encheliophis gracilis (Bleeker, ?)	S	Taken from the holothurian *Actinopyga obesa* in the lagoon. Indo-West Pacific. RUSI No:044311	5 specimens	NE
Carapus mourlani (Petit, 1934)	S	Taken from the holothurian *Holothuria atra* in the lagoon. Indo-West Pacific. RUSI No:044309	1 specimen	NE
ATHERINIDAE		SILVERSIDES		
Hypoatherina temminckii (Bleeker, 1853)	S	Shoals occurred throughout the surface waters of the lagoon and were often seen preyed on by carangid fish. Indo-Pacific.	90 specimens (50–100 TL)	NE
BELONIDAE		NEEDLEFISHES		
Strongylura leiura (Bleeker, 1851)	P	Common in the lagoon. Indo-Pacific.		NE
HOLOCENTRIDAE		SQUIRELFISHES		
Neoniphon argenteus (Valenciennes, 1831)	V&S	Lagoon, frequently seen around bommies. Indo-West Pacific.	60 FL	LC

Family and Species	Method	Habitat Notes	Specimen Size (mm)	IUCN Red List
Sargocentron caudimaculatum (Ruppell, 1838)	V	Lagoon and drop-off. Indo-Pacific.		LC
Sargocentron diadema (Lacepede, 1801)	P&S	Reeftop and lagoon	85;105 FL	LC
Sargocentron punctatissimum (Cuvier, 1829)	P&S	Reeftop. Indo-Pacific.	80 FL	LC
Sargocentron spiniferum (Forsskal, 1775)	V	Seen under overhangs on the drop-off. Indo-Pacific.		LC
Myripristis adusta Bleeker, 1853	V&P	Lagoon. Indo-Pacific.		LC
Myripristis berndti Jordan & Evermann, 1903	V&S	Common in the lagoon. Less so on the drop-off. Indo-Pacific. RUSI No:043310	1 specimen	LC
Myripristis hexagona (Lacepede, 1802)	V	Recorded from the drop-off. Indo-Pacific.		LC
Myripristis kuntee Cuvier, 1831	V	Recorded from the drop-off. Indo-Pacific.		LC
Myripristis melanosticta = blotche Cuvier, 1829	V	Lagoon and drop-off. Indo-West Pacific		LC
Myripristis murdjan (Forsskal, 1775)	V	Recorded from the drop-off. Indo-West Pacific.		LC
Myripristis violacea Bleeker, 1851	V	Recorded from the drop-off. Indo-West Pacific.		LC
Myripristis vittata Cuvier, 1831	P&V	Recorded from the drop-off. Indo-West Pacific.		LC
Plectrypops lima (Valenciennes, 1831)	P&S	Lagoon. Indo-West Pacific	50 FL	LC
SYNGNATHIDAE		PIPEFISHES		
Microphis brachyurus (Bleeker, 1853)	S	Reeftop. Western Indian Ocean.	110 TL	LC
SCORPAENIDAE		SCORPIONFISHES		
Pterois miles (Bennet, 1828)	P	Recorded from reeftop and lagoon. Indian Ocean.	Adult	LC
Pterois radiate Cuvier, 1829	P	Recorded from the lagoon. Indo-Pacific.	Adult	LC
Sebastapistes cyanostigma (Bleeker, 1856)	P	Reeftop. Indo-Pacific.	40 TL	LC
Sebastapistes mauritiana (Cuvier, 1829)	S	RUSI No:043307; Reeftop. Indo-Pacific.	5 specimens	LC
Taenianotus triacanthus Lacepede 1802	S	Reeftop. Indo-Pacific.	75 TL	LC
Synanceia verrucosa Bloch & Schneider, 1801	S	Reeftop. Indo-Pacific	65 TL	LC

CARACANTHIDA		CORAL CROUCHERS		
Caracanthus madagascariensis (Guichenot, 1869)	S	Lagoon. Indian Ocean.	38;40;45 TL	LC
Caracanthus unipinna (Gray, 1831)	S	Lagoon. Indo-Pacific.	40 TL	LC
KUHLIIDAE		FLAGTAILS		
Kuhlia mugil (Schneider, 1801)	V	Common in pools at low tide on the reeftop. Indo-Pacific.		LC
SERRANIDAE		GROUPERS		
Anthias evansi Smith, 1954	V	Common on the drop-off at depths of 20–30 metres. Indian Ocean.		LC
Pseudanthias squamipinnis (Peters, 1855)	V	Common along the drop-offs and around bommies in the deeper areas of the lagoon. Indo-West Pacific.		LC
Nemanthias carberryi Smith, 1954	V	Common on the drop-offs to a depth of 25 metres. Western Indian Ocean.		LC
Aethaloperca rogaa (Forsskal, 1775)	V	Not common. Recorded from the lagoon and on the drop-off. Indo-West Pacific.		LC
Cephalopholis argus Schneider, 1801	S&P	Reeftop. Most common serranid here and in the lagoon. Indo-Pacific.	170;190 TL	LC
Cephalopholis miniata (Forsskal, 1775)	P	Lagoon and drop-off. Indo-West Pacific.		LC
Cephalopholis urodeta (Forster, 1801) 1828)	V	Recorded from the lagoon and the drop-off. Indian Ocean.		LC
Epinephelus chlorostigma (Valenciennes, 1828)	V	Common in the lagoon and the drop-offs. Indo-west Pacific.		LC
Epinephelus macrospilos (Bleeker, 1855)	S&P	Common amongst coral heads on reeftop. Indo-West Pacific.	200 TL	LC
Epinephelus fuscoguttatus (Forsskal, 1775)	V	Large specimens (up to 700 mm) common, juveniles very common amongst coral bommies in the lagoon. Indo-West Pacific.		**VU**
Epinephelus lanceolatus (Bloch, 1790)	V	Several large specimens seen on the drop-off. Indo-Pacific.		**DD**
Epinephelus merra Bloch, 1793	P &S	Common in pools on the reeftop. Indo-West Pacific.	205;210 TL	LC
Epinephelus polyphekadion (Bleeker, 1873)	P	Common amongst bommies in the lagoon. Indo-Pacific.		LC
Epinephelus multinotatus (Peters, 1876)	P	Recorded from the drop-off. Indian Ocean.		LC
Epinephelus spilotoceps (Schultz, 1953)	V&S	Reeftop. Indo-West Pacific.	250;260 TL	LC
Epinephelus tukula Morgans, 1959	V&C	Numerous large specimens seen on drop-off. Indo-West Pacific.	Commercial record	LC
Gracila albomarginata (Fowler & Bean, 1930)	V	A single specimen seen; drop-off at 22 metres. Indo-Pacific.		LC
Plectropomus areolatus Ruppell, 1828	V&C	Several large specimens seen both in the lagoon and on the drop-off. Indo-Pacific.	Commercial record	**VU**

Family and Species	Method	Habitat Notes	Specimen Size (mm)	IUCN Red List
Plectropomus laevis (Lacepede, 1801)	P&C	Large adult fish recorded from the lagoon and drop-off. Indo-Pacific.	Commercial record	VU
Plectropomus punctatus Quoy & Gaimard, 1824	P&C	Common at the drop-off on the sheltered north west side of the atoll. Recorded from the lagoon but less common there. Western Indian Ocean.	Commercial record	LC
Variola louti (Forsskal, 1775)	V&C	Recorded at the drop-off. Indo-West Pacific.	Commercial record	LC
Grammisties sexlineatus (Thunberg, 1792)	V	Found singly throughout the lagoon and reef. Widespread in the Indo-Pacific.		LC
PSEUDOCHROMIDAE		DOTTYBACKS		
Pseudochromis fridmani (Klausewitz 1968)	V	Common throughout lagoon.		NE
Pseudochromis dutoiti Smith, 1955	V	Common throughout lagoon.		NE
PRIACANTHIDAE		BIGEYES		
Priacanthus cruentatus (Lacepede, 1801)	V	Recorded from the drop-off. Circumtropical.		LC
Priacanthus hamrur (Forskal, 1775)	V	Recorded from the lagoon and the drop-off. Indo-Pacific.		LC
APOGONIDAE		CARDINAL FISHES		
Apogon angustatus (Smith & Radcliffe, 1911)	P&S	Collected from the lagoon. Indo-Pacific.	Identified by J. Randall.	NE
Apogon apogonides (Bleeker, 1856)	P	Recorded from the lagoon.		NE
Apogon aureus (Lacepede, 1802)	V	Recorded from the lagoon. Indo-West Pacific.		NE
Apogon cookii Macleay, 1881	P&S	Collected from the lagoon. Indo-Pacific.	62 FL	NE
Apogon kallopterus Bleeker, 1856	P&S	Collected from the lagoon. Indo-Pacific.	65;85;90;95 FL	NE
Apogon semiornatus Peters, 1876	P&S	Reeftop. Indo-West Pacific.	40;42;45 TL	NE
Cheilodipterus macrodon (Lacepede, 1802)	V	Recorded from the lagoon. Western Indian Ocean.		NE
Cheilodipterus quinquelineatus Cuvier, 1828	S	Common on the reeftop. Indo-Pacific.	65;65;95;95;95; 95;105 FL	NE
Foa brachygramma (Jenkins, 1903)	V	Recorded from the lagoon. Indo-Pacific.		NE
Fowleria aurita (Valenciennes, 1831)	V	Seen under ledges in pools on the reeftop. Indo-Pacific.		NE
Siphamia mossambica Smith, 1955	S	Reeftop. Western Indian Ocean	26;90 FL Plus one	NE

HAEMULIDAE		RUBBERLIPS		
Diagramma centurio (Cuvier, 1830)	V&C	In the lagoon, Indo-West Pacific.	not preserved	NE
Plectorhinchus orientalis (Bloch,1793)	P	At the entrance channel to the lagoon. Indo-Pacific.		LC
LUTJANIDAE		SNAPPERS		
Aphareus furca (Lacepede, 1801)	S	Deep towards the drop-off. Indo-Pacific.	Line-caught: 380 FL	LC
Aprion virescens (Valenciennes, 1830)	V&S	A few large specimens seen in the lagoon and one caught on a trolled lure. Indo-Pacific.	650 FL	LC
Lutjanus bohar (Forsskal, 1775)	P&S	A ubiquitous fish of the lagoon, (600–700 mm TL). Commercial line fishers reported large catches of *L. bohar* at depth of 30 metres. Indo-West Pacific.	200 FL Commercial record	LC
Lutjanus fulvus (Schneider, 1801)	P	A single individual from the lagoon. Indo-West Pacific.		LC
Lutjanus gibbus (Forsskal, 1775)	V&P	Large shoals common around the bigger coral bommies in the lagoon and in pools on reeftop. Indo-West Pacific.		LC
Lutjanus kasmira (Forsskal, 1775)	V&P	Common in shoals both in the lagoon and along the drop-offs. Indo-West Pacific.		LC
Lutjanus rivulatus (Cuvier, 1828)	V	A single adult seen on the drop-off. Indo West Pacific.		LC
Macolor niger (Forsskal, 1775)	V	Individuals seen in the lagoon and on the drop-off. Indo-Pacific.		LC
Pristipomoides filamentosus (Valenciennes, 1830)	C	Numerous specimens caught on line from a depth of 50 m.		LC
CAESIONIDAE		FUSILIERS		
Pterocaesio tile (Cuvier & Valenciennes, 1830)	VS	Common in lagoon. Western Indian Ocean.	145; 155;155 FL	LC
Pterocaesio capricornis Smith & Smith, 1963	P	Single specimen recorded from the lagoon. Western Indian Ocean islands. Identified from photo by K. Carpenter.		DD
Caesio xanthonota Bleeker, 1853	V	Shoals common in lagoon and on drop -off. Indo-West Pacific.		LC
Caesio caerulaurea Lacepede, 1801	V&S	Large shoals common in the lagoon and on drop-off. Indo-Pacific.	170 FL	LC
Caesio teres Seale, 1906	V	Common in the lagoon. Western Indian Ocean.		LC
LETHRINIDAE		SAVENGERS		
Gnathodentex aureolineatus (Lacepede, 1802)	P	Large shoals common in the lagoon near bommies. Indo-West Pacific.		LC
Lethrinus microdon Valenciennes, 1830	V&C	Caught at the drop-off on a line. Indo-West Pacific.		LC
Lethrinus harak (Forsskal, 1775)	V	Common over sand in the lagoon. Indo-West Pacific.		LC

Family and Species	Method	Habitat Notes	Specimen Size (mm)	IUCN Red List
Lethrinus nebulosus (Forsskal, 1775)	V/C	A single large adult speared from a shoal of approximately twenty fish over sand in the lagoon. Indo-West Pacific.		LC
Lethrinus mahsena (Forsskal, 1775)	V	A single specimen seen over sand in the lagoon. This fish was previously known as *L. sanguineus* but is, according to "The World Catalogue of Lethrinid Fishes" by K. Carpenter a colour morph of *L. mahsena.* Western Indian Ocean.		LC
Lethrinus variegatus (Ehrenberg, 1830)	V	Seen over sand in the lagoon. Indo-West Pacific.		LC
Lethrinus xanthochilus (Klunzinger, 1870)	V	A single specimen seen in the lagoon. Indo-Pacific.		LC
Monotaxis grandoculis (Forsskal, 1775)	V&P	Juveniles common in lagoon; adults in deeper drop off. Indo West Pacific.		LC
NEMIPTERIDAE		SPINECHEEKS		
Scolopsis ghanam (Forsskal, 1775)	V&P	A few solitary specimens seen in the lagoon near bommies. Western Indian Ocean.		LC
KYPHOSIDAE		CHUBS		
Kyphosus vaigiensis (Quoy & Gaimard, 1825)	V	Large numbers were seen on the reef-top at high tide near the wreck of the Pep Ice-Indo-Pacific.		LC
MULLIDAE		GOATFISHES		
Mulloides flavolineatus (Lacepede, 1801)	V	Common in the lagoon. Indo-West Pacific.		LC
Mulloides vanicolensis (Valenciennes, 1831)	V	Common in the lagoon. Indo-West Pacific.		LC
Parupeneus barberinus (Lacepede, 1801)	V	Common in pools on the reeftop and in the lagoon. Indo-West Pacific.		LC
Parupeneus bifasciatus (Lacepede, 1801)	V	Seen in the lagoon and on the drop-off. Indo-West Pacific.		LC
Parupeneus cyclostomus (Lacepede, 1801)	V	Recorded from the lagoon. Indo-West Pacific.		LC
Parupeneus indicus (Shaw, 1803)	V	Common in the lagoon. Indo-West Pacific.		LC
Parupeneus macronema (Lacepede, 1801)	S/V	Common in pools on the reeftop. Indian Ocean.	130; 135;165 FL	LC
Parupeneus pleurostigma (Bennett, 1831)	V	Recorded from the lagoon. Indo-West Pacific.		LC
MALACANTHIDAE		TILEFISHES		
Malacanthus brevirostris (Guichenot, 1848)	V	Recorded from the lagoon near bommies. Indo-Pacific.		LC
Malacanthus latovittatus (Lacepede, 1801)	V	Several seen over sand in the lagoon. Indo-West Pacific.		LC

POMACANTHIDAE		ANGELFISHES		
Apolemichthys trimaculatus (Lacepede, 1831)	V	Frequently seen in the lagoon near bommies and on the drop-off. Indo-West Pacific.		LC
Centropyge bispinosus (Gunther, 1860)	V	Recorded from pools on the reeftop. Indo-West Pacific.		LC
Centropyge multispinis (Playfair, 1867)	S/V	Reeftop. Indo-West Pacific.	55;64;80;81; 93;100;110, FL	LC
Genicanthus caudovittatus (Gunther, 1860)	V	Single specimen seen on drop-off. Western Indian Ocean.		LC
Pomacanthus imperator (Bloch, 1787)	V	Seen in the lagoon and on the drop-off. Juveniles seen in reeftop pools. Indo-West Pacific.		LC
Pomacanthus semicirculatus (Cuvier, 1831)	V&P	Adults recorded from lagoon and drop-off juveniles seen in reeftop pools. Indo-West Pacific.		LC
Pygoplites diacanthus (Boddaert, 1772)	V	Recorded from the drop-off. Indo-West Pacific.		LC
CHAETODONTIDAE		BUTTERFLYFISHES		
Chaetodon auriga (Forsskal, 1775)	P&S	Probably the most common butterfly fish in the lagoon and on the reeftop. Indo-Pacific.	140;145+12x (110–145) TL	LC
Chaetodon bennetti (Cuvier, 1831)	V&P	Recorded from the lagoon. Indo-Pacific.		LC
Chaetodon blackburnii (Desjardins, 1836)	V	Common throughout		LC
Chaetodon falcula (Bloch, 1793)	V&P	Taxonomic query		LC
Chaetodon guttatissimus (Bennet, 1823)	V&P	Common around bommies in the lagoon and on reeftop. Indian Ocean.		LC
Chaetofdon kleinii (Bloch,1790)	V&S	Common throughout the lagoon. Indo-Pacific	85;90;95 TL	LC
Chaetodon lineolatus (Quoy & Gaimard, 1831)	V	Recorded from the lagoon. Indo-Pacific.		LC
Chaetodon lunula (Lacepede, 1803)	V&P	Common in pairs in lagoon and drop-off. Indo-Pacific.		LC
Chaetodon madagaskariensis (Ahl, 1923)	V&S	Common throughout the atoll. Indian Ocean.	38;40;45 TL	LC
Chaetodon melannotus (Bloch & Schneider, 1801)	V	Mainly at drop-off		LC
Chaetodon meyeri (Bloch & Schneider, 1801)	V&S	Lagoon. Indo-Pacific.	120 TL	LC
Chaetodon trifascialis (Quoy & Gaimard, 1825)	V	Recorded from the lagoon. Indo-Pacific.		LC
Chaetodon trifasciatus (Mungo Park, 1797)	V&S	Lagoon. Indo-Pacific.	4 (107;110;115; 120 TL	LC

Family and Species	Method	Habitat Notes	Specimen Size (mm)	IUCN Red List
Chaetodon unimaculatus (Bloch, 1787)	V	Common in the lagoon and on the drop-off. Indian Ocean.		LC
Chaetodon xanthocephalus (Bennett, 1832)	V&S	Recorded from pools on the reeftop. Western Indian Ocean.	130;155 TL	LC
Forcipiger flavissimus (Jordan & McGregor, 1898)	V	Common in the lagoon and on the drop-off. Indo-Pacific.		LC
Heniochus diphreutes (Jordan, 1903)	V	Common along the drop-off. Indo-West Pacific.		LC
Heniochus monoceros (Cuvier, 1831)	V	Recorded from the lagoon. Indo-West Pacific		LC
CARANGIDAE		KINGFISHES/ JACKS		
Carangoides armatus (Ruppell, 1830)	V&S	Lagoon	195 FL	LC
Carangoides fulvoguttatus (Forsskal, 1775)	V&S	Lagoon. Indo-West Pacific.	700 FL	LC
Caranx ignobilis (Forsskal, 1775)	V&C	Very common carangid throughout the atoll. Fish 20-30 kg some at 40-50 kg; in the lagoon and on the drop-off. Indo-west Pacific.		LC
Caranx lugubris (Poey, 1860)	V	Shoals of 5-10 fish common in lagoon and over drop-off. Circumtropical.		LC
Caranx melampygus (Cuvier, 1833)	V	Most common in the lagoon around coral heads. Indo-Pacific.		LC
Elagatis bipinnulata (Quoy & Gaimard, 1825)	V	Common over drop-off. Circumtropical.		LC
Gnathanodon speciosus (Forsskal, 1775)	V	A single large specimen recorded from the lagoon. Indo-Pacific		LC
Trachinotus blochii (Lacepede, 1801)	V	Recorded from the lagoon. Indo-West Pacific		LC
CIRRHITIDAE		HAWKFISHES		
Cirrhitichthys oxycephalus (Bleeker, 1855)	V&S	Common on bommies in the lagoon. Indo-Pacific.	13 x (45–63 TL)	LC
Paracirrhites arcatus (Cuvier, 1829)	V&S	Common on bommies in the lagoon. Indo-Pacific.	80 TL	LC
Paracirrhites forsteri (Schneider, 1801)		Common in the lagoon and on the drop-off. Indo-Pacific.		LC
PEMPHERIDAE		SWEEPERS		
Pempheris schwenkii (Bleeker, 1855)	V&P	Reeftop. Identified from a photograph by Dr Randall, Mooi-Milwaukee Museum. Indo-West Pacific.	7 x (106–155 TL)	NE
POMACENTRIDAE		DAMSELFISHES		
Abudefduf notatus (Day, 1869)	V	Recorded from the reeftop. Indo-West Pacific.		LC

Abudefduf septemfasciatus (Cuvier, 1830)	V&P	Common throughout the lagoon. Indo-West Pacific.		
Abudefduf vaigiensis (Quoy & Gaimard, 1825	V&S	Lagoon. Indo-West Pacific.	8 x (40–95 FL)	LC
Amphiprion akallopisos (Bleeker, 1853)	V	Recorded from the lagoon. Indian Ocean		LC
Amphiprion allardi (Klausewitz, 1970)	V&S	Common in lagoon. Western Indian Ocean.	52; 90; 120 TL	LC
Chromis dimidiata (Klunzinger, 1871)	V&S	Common throughout the lagoon and on the drop-offs. Indian Ocean.	40;45;52;55;50; 50;50;50 TL	LC
Chromis lepidolepis (Bleeker, 1877)	V	Common in the lagoon. Indo-Pacific.		LC
Chromis nigrura (Smith, 1960)	V&S	Found in large numbers over bommies in the lagoon. West Indian Ocean	7 x (45–82 TL)	NE
Chromis opercularis (Gunther, 1867)	V	Recorded from the lagoon. Indian Ocean.		NE
Chromis ternatensis (Bleeker, 1856)	V	Recorded from the lagoon. Indian Ocean.		NE
Chrysiptera glauca (Cuvier 1830)	V&S	Recorded from the lagoon. Indo-West Pacific. RUSI: No: 043305	2 specimens	NE
Chrysiptera unimaculata (Cuvier, 1830)		Reeftop. Indian Ocean.	48;54;58 TL	NE
Dascyllus aruanus (Linnaeus, 1758)	V&P&S	Only in lagoon, especially associated with isolated bommies over sand. Juveniles. abundant	30;38;45;48;50 FL	NE
Lepidozygus tapeinosoma (Bleeker, 1856)	V	Recorded from the drop-off. Indo-West Pacific.		NE
Plectroglyphidodon dickii (Lienard, 1839)	V	Throughout the lagoon and on the drop-off. Indo-West Pacific.		NE
Plectroglyphidodon lacrymatus (Quoy & Gaimard, 1825)	P	Lagoon. Indo-West Pacific	55;72 FL	
Plectroglyphidodon leucozonus (Bleeker, 1859)	V&S	Common in lagoon and reef top	48–57 FL	NE
Pomacentrus caeruleus (Quoy & Gaimard, 1825)	V&P	Recorded from the lagoon. A specimen photographed in the lagoon by D. King exhibited the same unusual colour phase seen by J. Randall in specimens collected from Oman. This phase shows the head, anterior dorsal half of the body and the dorsal fins as a light green colour. Our specimen was identified from a transparency by J. Randall. Western Indian Ocean.		NE
Pomacentrus pavo (Bloch, 1787)	P	Recorded from the lagoon. Indo-West Pacific.		NE

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Pomacentrus sulfureus (Klunzinger, 1871)	P&S	Recorded from the lagoon. Indo-Pacific.	100;118 FL	NE
Stegastes nigricans (Lacepede, 1803)	P	Common on the sheltered north west side of the atoll at the outer edge of the reeftop. Indo-West Pacific.	Identified from photo by J. Randall	NE
Stegastes lividus (Bloch & Schneider, 1801)	P&S	Found in association with the more common *S. nigricans*. Indo-West Pacific.	100;118 FL Identified by P. Heemstra.	NE
LABRIDAE		WRASSES		
Labropsis xanthonota (Randall, 1981)	V&P	Not common. Recorded from around bommies in the lagoon. Indo-Pacific.		LC
Anampses twistii (Bleeker, 1856)	V&P	Recorded from around bommies in the lagoon. Indo-Pacific.		LC
Anampses caeruleopunctatus (Ruppell, 1829)	V	Recorded from lagoon and drop-off. Indo-Pacific.		LC
Anampses lineatus (Randall, 1972)	V	Only recorded from the drop-off. Indian Ocean.		LC
Anampses meleagrides (Valenciennes, 1840)	V	Lagoon & reeftop. Indo-West Pacific		
Bodianus anthioides (Bennett, 1830)	V	Lagoon & drop-off. Indo-Pacific.		
Bodianus axillaris (Bennett, 1831)	V	Lagoon & drop-off. Indo-Pacific.		
Bodianus bilunulatus (Lacepede, 1801)	V	Drop-off. Indo-Pacific.		LC
Bodianus diana (Lacepede, 1801)	V&P	A common wrasse throughout the atoll. Indo-Pacific.		LC
Cheilinus chlorourus (Bloch, 1791)	V	Recorded from the lagoon. Indo-Pacific.		LC
Cheilinus digrammus (Lacepede, 1801)	V&S	Recorded from the lagoon. Indo-Pacific.	215 TL	LC
Cheilinus trilobatus (Lacepede, 1801)	V	Lagoon. Indo-West Pacific.		LC
Cheilinus undulatus (Ruppell, 1835)	V&P	Numbers of large individuals recorded both in the lagoon and on the north west drop-off. Indo-Pacific		EN
Cirrhilabrus exquisitus (Smith, 1957)	S&P	Lagoon. Indo-Pacific.	48;55;55;62 TL	DD
Coris aygula (Lacepede, 1801)	V	Recorded from the lagoon. Indo-Pacific.		LC
Coris caudimacula (Quoy & Gaimard, 1834)	V	Common in the lagoon and on the reeftop. Indian Ocean.		LC
Coris formosa (Bennett, 1834)	V	Recorded from the lagoon. Indian Ocean.		LC
Coris gaimard africana (Smith, 1957)	V	Recorded from the lagoon. Western Indian Ocean.		LC

Cymolutes praetextatus (Quoy & Gaimard, 1834)	P	Recorded from the lagoon. Identified from a transparency by John E. Randall. Indo-Pacific.		LC
Epibulus insidiator (Pallas, 1770)	V	Individual specimens were recorded from the lagoon (yellow colour phase) and on the drop-off. Indo-Pacific.		LC
Gomphosus caeruleus (Lacepede, 1801)	P&S	Common in the lagoon and on the reeftop. Indian Ocean.	205 FL	LC
Halichoeres hortulanus (Lacepede, 1801)	V&S	Common in shallower parts of the atoll. Indo-Pacific.	217 TL	LC
Halichoeres nebulosus (Valenciennes, 1839)	P&S	Lagoon. Indo-West Pacific.	40;85 TL	LC
Halichoeres scapularis (Bennett, 1831)	P	Recorded from the lagoon over sand at the edge of bommies. Identified from photo by John E. Randall. Indo-West Pacific.		LC
Hemigymnus fasciatus (Bloch,1792)	V	Recorded from the lagoon. Indo-Pacific.		LC
Hemigymnus melapterus (Bloch, 1791)	V	A single record from the lagoon. Indo-Central Pacific.		LC
Hologymnosus annulatus (Lacepede, 1801)	P	A single record from the lagoon. Indo-Pacific.		LC
Labrichthys unilineatus (Guichenot, 1847).	P	Recorded from the lagoon. Indo-Pacific		LC
Labroides bicolor (Fowler & Bean, 1928)	V	Recorded from the lagoon. Indo-Pacific.		LC
Labroides dimidiatus (Valenciennes, 1839)	V/S	Common throughout the lagoon. Indo-Pacific.	75;85 TL	LC
Novaculichthys taeniourus (Lacepede, 1801)	V	Recorded from the lagoon. Indo-Pacific.		LC
Pseudocheilinus evanidus (Jenkins, 1901)	V	Recorded from the lagoon. Indo-Pacific.		LC
Pseudocheilinus hexataenia (Bleeker, 1857)	P&S	Lagoon. Indo-Pacific.	55;55;55;56;58 TL	LC
Stethojulis albovittata (Bonaterre, 1788)	P&S	Lagoon. Indian Ocean.	50;85;85;92;96; 100;100; 103;112 FL	LC
Thalassoma amblycephalum (Bleeker, 1856)	P&S	Common over bommies in the lagoon and shallower areas of the drop-off. Indo-Pacific.	70;74;75;76;78; 90 TL	LC
Thalassoma hardwicke (Bennett, 1828)	P&S	Common on the reeftop and in the lagoon. Indo-Pacific.	82; 92;100;100;105 ;110;110 TL	LC
Thalassoma herbraicum (Lacepede, 1801)	P	Common on the reeftop and the lagoon. Indian Ocean.		LC
Thalassoma lunare (Linnaeus, 1758)	P/S	Common on the reeftop and the lagoon. Indo-Pacific.	200 FL	LC
Thalassoma purpureum (Forsskal, 1775)	V	Recorded from the reeftop. Indo-Pacific.		LC

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Thalassoma trilobatum (Lacepede, 1801)	V	Recorded from the reeftop. Indo-Pacific.		LC
Xyrichthys (Iniistius) pavo (Valenciennes, 1840)	V	A single record from the lagoon. Indo-Pacific.		LC
SCARIDAE		PARROTFISHES		
Cetoscarus bicolor (Ruppell, 1828)	V	Recorded from the drop-off. Indo-Pacific.		LC
Bolbometopon muricatum (Valenciennes, 1840)	V	Several adults recorded from the drop-off. Indo-Pacific.		**VU**
Hipposcarus harid (Forsskal, 1775)	V	Recorded from the lagoon. Indian Ocean.		LC
Scarus gibbus (Ruppell, 1828)	V	Quite common in the lagoon. Indo-Pacific.		LC
Scarus frenatus (Lacepede, 1802)	P	Recorded from both the lagoon and drop-off. Identity confirmed by Phillip C. Heemstra. Indo-Pacific.		LC
Scarus enneacanthus (Lacepede, 1802)	P&S.	Previously considered rare (Smith & Heemstra,1986). Shoals (10-20) were common on the sheltered north-west drop-off in mid water. Identity confirmed by P. Heemstra and J. Randall. Central and Western Indian Ocean. RUSI No:037368	200; 200 TL	LC
Scarus ghobban (Forsskal, 1775)	V&P	Common in the lagoon and on the reeftop in shallow water where large adults frequently become stranded by the receding tide. Indo-Pacific.		LC
Scarus sordidus (?)	V&S	Reef top- many juveniles in pools; RUSI No:043311	1 specimen	
Scarus psittacus (Forsskal, 1775)	P&S	Reeftop. Also recorded from the lagoon. Indo-Pacific. RUSI No:037342	180 TL	LC
Scarus rubroviolaceaus (?)	V	Common in lagoon; sometimes over drop off.		LC
Scarus russelii (Valenciennes, 1840)	P	Lagoon. Identified from photo by Jack Randall. Central and West Indian Ocean	1 specimen	LC
SPHYRAENIDAE		BARRACUDAS		
Sphyraena barracuda (Walbaum, 1792)	P&V	Large individuals up to 1,5 metres seen patrolling on the deeper drop-offs. Common. Circumtropical.		LC
Sphyraena qenie (Klunzinger, 1870)	V&C	A single specimen taken by spear in the lagoon but not kept. Indo-Pacific.	850 FL	NE
MUGILOIDIDAE		SANDPERCHES		
Parapercis hexophthalma (Ehrenberg, 1829)	S	Lagoon. Indo-West Pacific.	210 TL	NE
Parapercis punctulata (Cuvier, 1829)	V	Recorded from the lagoon and on the drop-off at 20 metres. Western Indian Ocean.		NE

BLENIIDAE		BLENNIES		
Aspidontus taeniatus tractus (Fowler, 1903)	V	Recorded from the lagoon. Indian Ocean.		LC
Cirripectes castaneus (Valenciennes, 1836)	V&S	Reeftop. Indo-West Pacific.	50;80 TL	LC
Cirripectes perustus (Smith, 1959)	V&S	Collected from reeftop. RUSI No:043306	3 specimens	LC
Ecsenius midas (Starck, 1969)	V	Recorded from the lagoon. Indo-West Pacific.		LC
Ecsenius bicolor (Day, 1888)	V	Recorded from the reeftop. Indo-West Pacific.		LC
Exallias brevis (Kner, 1868)	V	Recorded from bommies in lagoon. Indo-Central Pacific.		LC
Istiblennius edentulus (Schneider, 1801)	V&S	Common on reeftop	105 TL	LC
Istiblennius periophthalmus (Valenciennes, 1836)	V&S	The most common blenny on the reeftop. Indo-Pacific.	63;90;105;108; 120;130;141; 165;170;175 TL	LC
Plagiotremus rhinorhynchos (Bleeker, 1853)	V	Recorded from the lagoon. Indo-Pacific.		LC
Plagiotremus tapeinosoma (Bleeker, 1857)	V	Recorded from the reeftop and the lagoon. Indo-Pacific.		LC
Salarias fasciatus (Bloch, 1786)	V&S	Reeftop. Indo-Pacific. RUSI No:043309	1 specimen	LC
GOBIIDAE		GOBIES		
Gnatholepis sp.	P&S	Awaiting revision of this genus		NE
Ctenogobius feroculus (Lubbock & Polunin, 1977)	P	One specimen. Identified by R. Winterbottom. Recorded from the lagoon. Indo-West Pacific.		LC+
Favonogobius reichei? (Bleeker, 1953)	P&S	Recorded from the lagoon. Awaiting ID confirmation.		NE
Istigobius ornatus (Ruppell, 1830)	S	Indo-Central Pacific. Awaiting ID confirmation.		LC
Nemateleotris magnifica (Fowler, 1938)	V	Recorded from the lagoon. Indo-Central Pacific.		LC
Paragobiodon xanthosomus (Bleeker, 1852)	S/P	Awaiting ID confirmation		-
Ptereleotris evides (Jordan & Hubbs, 1925)	V	Common in the lagoon over sand next to bommies. Indo-West Pacific.		LC
Ptereleotris heteroptera (Bleeker, 1855)	V	Recorded from the lagoon. Indo-Central Pacific.		LC
Valenciennea helsdingenii (Bleeker, 1858)	S	A single specimen collected from the lagoon. Indo-Pacific.		LC
Valenciennea strigata (Broussonet, 1787)	V	Recorded from the lagoon. Indo-Pacific.		NE

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ACANTHURIDAE		SURGEONFISHES		
Acanthurus blochii (Valenciennes, 1835)	V	Recorded from the drop-off. Indo-Pacific		LC
Acanthurus dussumieri (Valenciennes, 1835)	P	Common in the lagoon. Indo-Pacific.		LC
Acanthurus leucosternon (Bennett, 1832)	P	Common in lagoon and on the drop-off. Indo-West Pacific.		LC
Acanthurus lineatus (Linnaeus, 1758)	V	Common in the lagoon. Indo-Pacific.		LC
Acanthurus mata (Cuvier, 1829)	V	Recorded from the drop-off. Indo-Pacific.		LC
Acanthurus nigricauda (Duncker & Mohr, 1929)	S&V	Common in lagoon.	210–230 FL	LC
Acanthurus nigrofuscus (Forsskal, 1775)	S&V	The most commonly encountered surgeon in the lagoon and in pools on the reeftop. Indo-Pacific.	100;110 FL	LC
Acanthurus tennenti (Gunther, 1861)	V	Recorded from the lagoon. Western Indian Ocean		LC
Acanthurus thompsoni (Fowler, 1923)	V	Recorded from the drop-off. Indo-Pacific.		LC
Acanthurus triostegus (Linnaeus, 1758)	S/V	Reeftop; in great numbers but mostly confined to very shallow areas	39 x (60–95 FL)	LC
Acanthurus xanthopterus (Valenciennes, 1835)	V	Recorded from the drop-off. Indo-Pacific.		LC
Ctenochaetus striatus (Quoy & Gaimard, 1825)	V	Recorded from the lagoon and reeftop. Indo-Pacific.		LC
Zebrasoma veliferum (Bloch, 1797)	V	Recorded from the lagoon. Indo-Pacific.		LC
Ctenochaetus strigosus (Bennett, 1828)	V	Recorded from the lagoon. Indo-Pacific.		LC
Zebrasoma gemmatum (Valenciennes, 1835)	V	Recorded from the drop-off. Western Indian Ocean.		LC
Zebrasoma flavescens (Bennett 1828)	V	A single specimen recorded from the lagoon. Indo-West Pacific.		LC
Zebrasoma scopas (Cuvier 1829)	V	A single specimen recorded from the lagoon. Indo-West Pacific.		LC
Naso annulatus (Quoy & Gaimard, 1825)	V	Shoals numbering 10-20 fish seen foraging on the reeftop at high tide. Indo-Pacific.		LC
Naso brevirostris (Valenciennes, 1835)	V	Recorded from midwater on the drop-off. Indo-Pacific		LC
Naso hexacanthus (Bleeker, 1855)	V	Shoals numbering 20 to 30 fish seen in midwater on the drop-off. Indo-Pacific.		LC
Naso lituratus (Schneider, 1801)	V	Usually seen in pairs on the drop-off. Indo-Pacific.		LC
ZANCLIDAE		MOORISH IDOL		
Zanclus canescens (Linnaeus, 1758)	V	Recorded from the lagoon and drop-off. Indo-Pacific		LC

SIGANIDAE		RABBITFISHES		
Siganus stellatus (Forsskal, 1775)	V	Recorded from the lagoon. Indo-Pacific.		LC
Siganus sutor (Valenciennes, 1835)	V	Recorded from the lagoon. Western Indian Ocean.		LC
SCOMBRIDAE		TUNAS & MACKERELS		
Acanthocybium solandri (Cuvier, 1831)	V&C	Commonly caught on line over drop-off. Cosmopolitan.	1030 FL	LC
Euthynnus affinis (Cantor, 1849)	V	Large shoals seen feeding on the surface in the vicinity of the atoll. Indo-Pacific.		LC
Gymnosarda unicolor (Ruppell, 1836)	V	Common. Large adults seen whilst diving on the drop-off. Indo-West Pacific.		LC
Katsuwonus pelamis (Linnaeus, 1758)	V	Feeding shoals recorded in the vicinity of the atoll. Cosmopolitan.		LC
Thunnus albacares (Bonnaterre, 1788)	V&C	Several caught over the drop-off. Cosmopolitan.	1500 FL	**NT**
BALISTIDAE		TRIGGERFISHES		
Balistapus undulatus (Mungo Park, 1797)	V	Recorded from the lagoon. Indo-West Pacific.		LC
Balistoides conspicillum (Bloch & Schneider, 1801)	V	Recorded from the lagoon and the drop-off. Indo-West Pacific.		NE
Balistoides viridescens (Bloch & Schneider, 1801)	V	Recorded from the lagoon and the drop-off. Indo-West Pacific.		NE
Melichthys indicus (Randall & Klausewitz, 1973)	V	Common around bommies in the lagoon. Indian Ocean.		NE
Melichthys niger (Bloch, 1786)	V	Recorded from the lagoon. Less common than the previous species. Circumtropical.		NE
Pseudobalistes fuscus (Bloch & Schneider, 1801)	V	Recorded from the lagoon and the drop-off. Indo-West Pacific.		NE
Rhinecanthus aculeatus (Linnaeus, 1758)	V	Recorded from the lagoon and the reeftop. Indo-West Pacific.		NE
Rhinecanthus rectangulus (Bloch & Schneider, 1801)	V&S	Reeftop. Indo-West Pacific.	140 TL	
Sufflamen bursa (Bloch & Schneider, 1801)	V	Recorded from the drop-off. Indo-West Pacific.		LC
Sufflamen chrysopterus (Bloch & Schneider, 1801)	V	Recorded from the drop-off. Indo-West Pacific.		LC
MONACANTHIDAE		BIGEYES		
Cantherinnes dumerilii (Hollard, 1854)	V&S	Recorded from lagoon & the reeftop. Indo-Pacific.	125 TL	LC
Paraluteres prionurus (Bleeker, 1851)	V	Recorded from the lagoon. Indo-West Pacific.		LC

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Pervagor janthinosoma (Bleeker, 1854)	V	Recorded from the reeftop. Indo-West Pacific.		LC
OSTRACIIDAE		BOXFISHES		
Ostracion cubicus (Linnaeus, 1758)	V	Recorded from the lagoon. Indo-West Pacific.		LC
Ostracion meleagris (Shaw, 1796)	V	Recorded from the lagoon. Indo-Pacific.		LC
TETRAODONTIDAE		PUFFERS		
Arothron hispidus (Linnaeus, 1758)	V	Recorded from the lagoon. Common. Indo-West Pacific.		LC
Arothron meleagris (Bloch & Schneider, 1801)	V	Recorded from the lagoon. Common. Indo-West Pacific.		LC
Arothron nigropunctatus (Bloch & Schneider, 1801)	V	Recorded from the lagoon. Common. Indo-West Pacific.		LC
Canthigaster amboinensis (Bleeker, 1865)	V	Recorded from the lagoon. Common. Indo-West Pacific.		LC
Canthigaster bennetti (Bleeker, 1854)	P&S	Recorded from the lagoon. Indo-West Pacific.	65 TL	LC
Canthigaster janthinoptera (Bleeker, 1855)	P&S	Recorded from the lagoon. Indo-West Pacific.	57, 65 TL	LC
Canthigaster valentini (Bleeker, 1853)	V	Recorded from the lagoon. Common. Indo-West Pacific.		LC
DIODONTIDAE				
Diodon hystrix Linnaeus, 1758	V	Recorded from the lagoon. Circumtropical.		LC