Frontier Mozambique Environmental Research

REPORT 5

The Seagrass fishery of Quirimba Island

Interim report Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Mozambique

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Darwin Initiative: Department for Environment and Rural Affairs, UK.

Frontier-Mozambique Society for Environmental Exploration

Mozambique
1997

Suggested Technical Paper citation:

Frontier Mozambique (2004) Gell, F. (eds) The Seagrass Fishery of Quirimba Island, an interim report*:* Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Mozambique. Frontier Mozambique Environmental Research Report 5. Society for Environmental Exploration, UK and The Ministry for the co-ordination of Environmental Affairs, Maputo.

ISSN 1479-1196*
***** This supersedes the ISSN number printed in the report**

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Frontier-Mozambique was initiated in January 1996 when a Memorandum of Understanding was signed between The Society for Environmental Exploration and the Ministry for the Co-ordination of Environmental Affairs (Ministério para a Coordenação de Acção Ambiental), Mozambique. The aim of Frontier-Mozambique was to undertake field research within the Quirimba Archipelago, an area of recognised biological interest and conservation value.

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ACKNOWLEDGEMENTS

Field support for this work was provided by the Darwin/Frontier-Moçambique Marine Research Programme, a joint initiative of the Ministry for the Co-ordination of Environmental Affairs, Mozambique and the Society for Environmental Exploration, UK. Financial support for the Programme was provided by the Darwin Initiative, (Department of the Environment, UK). The authors would like to acknowledge the considerable efforts of all personnel involved in the running of the Programme and the many volunteer research assistants, and their sponsors, without whose efforts this work would not have been possible.

The following organisations are acknowledged for their contributions to the Programme: Ministry of Agriculture and Fisheries, Mozambique (Direcção Nacional de Florestas e Fauna Bravia); Institute for Fisheries Research, Mozambique (Instituto de Investigação Pesqueira); Institute for the Development of Small-Scale Fisheries, Mozambique (Instituto de Desenvolvimento da Pesca de Pequena Escala); Tropical Marine Research Unit, York University and British Petroleum, Mozambique. The Society are grateful to the British Airways Assisting Conservation programme.

The authors would like to acknowledge the considerable contribution of Dr Rupert Ormond (TMRU, York University, UK) to the development and refining of the methods described in this report. Dr Rupert Ormond and Will Darwall are also to be thanked for their valuable input in the production of this report.

Finally, special thanks are due to Joachim and Lieglinde Gessner for the use of their land upon which the Programme has based its field operation and for their tireless support, help and encouragement for the Programme's work.

CONTENTS

ABSTRACT

The artisanal fishery of Quirimba Island in the Quirimba Archipelago, Northern Mozambique was studied from May to December 1996. Fish catches were sampled on a regular basis and fishing effort was determined.

Two main fishing methods were identified; seine netting and basket trapping. Net fishing was found to have low selectivity, catching a large proportion of very small fish and a small by-catch of inedible fish and invertebrates. Trap fishing was found to be more selective, avoiding the capture of very small and very large fish.

The fishery was found to have a highly diverse multi-species catch with 195 species in 52 families being identified. Both major fishery types were found to target small fish, particularly the small emperor *Lethrinus variegatus* with a mean fork length of 9 cm. The following four families accounted for over 70% by weight of the fish caught in the net fishery: Lethrinidae (31.5%), Siganidae (22%), Scaridae (11%) and Labridae (9.3%).

The Quirimba seagrass fishery was found to be a key source of food and income for the island with an important role in the island's culture. The future sustainable use of the fishery is discussed and possible management strategies are considered.

1.0 INTRODUCTION

Seagrass beds play an important role in tropical marine ecosystems. They are highly productive, contribute to the productivity of other systems such as coral reefs and deep sea environments, and provide a nursery habitat, shelter or grazing area for many species of coral reef fish. In many fish species there is also thought to be a daily migration between roosting sites in coral reefs and feeding grounds in seagrass beds (Ogden and Gladfelter, 1983; Robblee and Zieman 1977). Seagrasses may thus play an important role in maintaining the diversity and abundance of fish on adjacent coral reefs and in sustaining the reef fisheries that are an important source of income for many people in tropical coastal areas.

In the South East Asian region seagrass fisheries have increased in economic importance as the alternative fishing grounds on coral reefs and in mangroves have been depleted by overfishing, destructive fishing methods and other human impacts. For instance, in some areas of the Philippines the most important fish families in the fishery have been reported as Apogonidae (cardinal fishes), Gobiidae (gobies) and Siganidae (rabbitfishes), predominantly taken from seagrass beds (Fortes 1993). Fisheries specifically exploiting seagrasses appear to have been somewhat neglected in the literature with most studies of tropical artisanal fisheries focusing on reef fisheries.

Few studies in East Africa have concentrated on seagrass fish communities and the fisheries that rely on them. This study is initially a survey of the Quirimba seagrass fishery but hopefully will be extended to look in detail at the ecology and biodiversity of the seagrass fish communities and the impact of the fishery on those communities.

1.1 Study Site

The Quirimba Archipelago (see Figs. 1 and 2) is a chain of small islands on the coast of Northern Mozambique separated from the mainland by seagrass channels and areas of mangrove forest. Most of the islands are bordered on their eastern coasts by coral reefs. The islands are remote and fishing methods are largely traditional.

Quirimba Island (Fig. 3) is 6 km long and the study area, part of the Montepuez Bay between Quirimba and the Mozambican mainland, stretches from the end of the mangroves south of Ibo Island to the south of Quirimba Island, covering an area of approximately 60km^2.

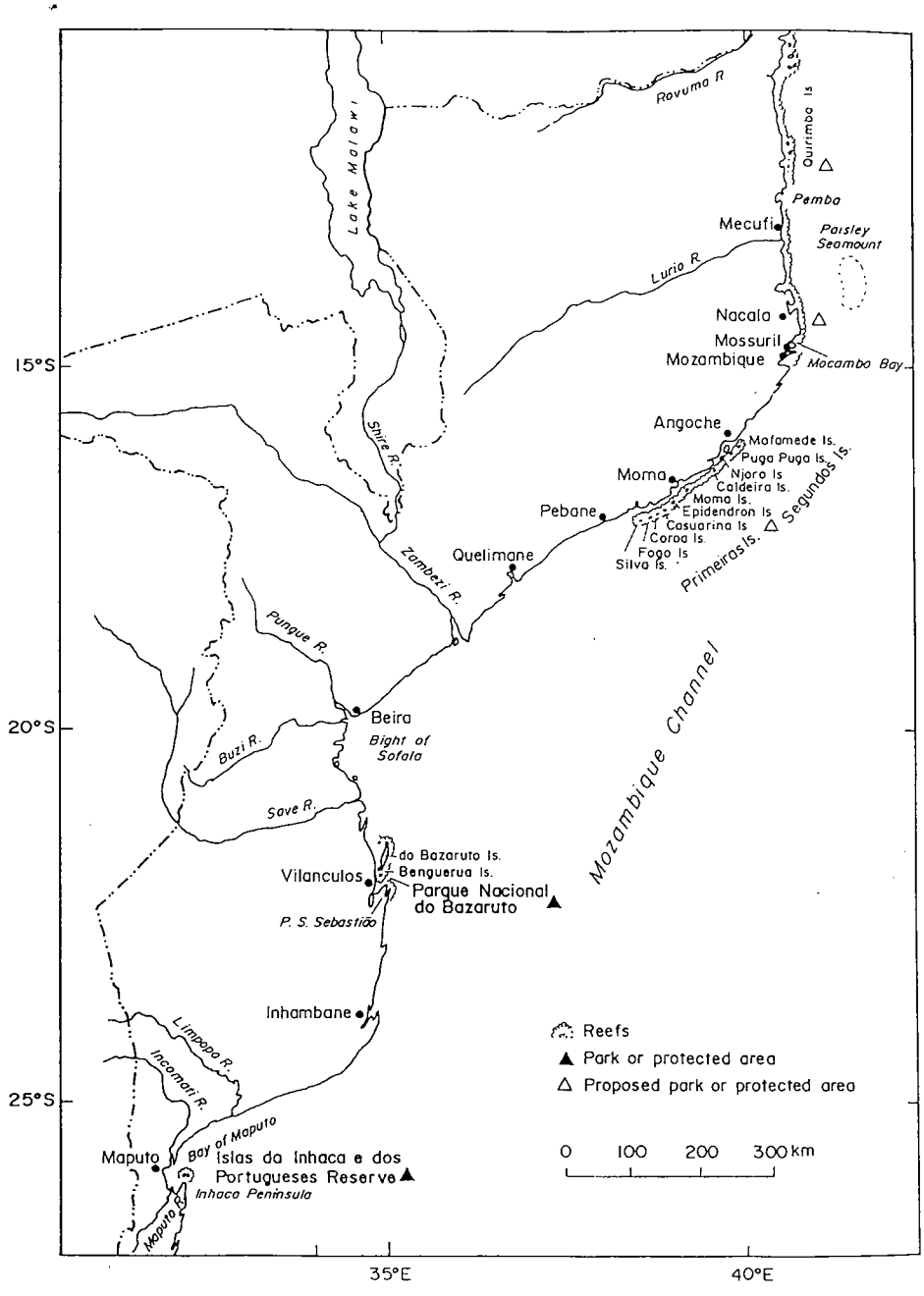

Figure 1. A map of Mozambique and its islands. The Quirimba Archipelago is the most northerly group of islands.

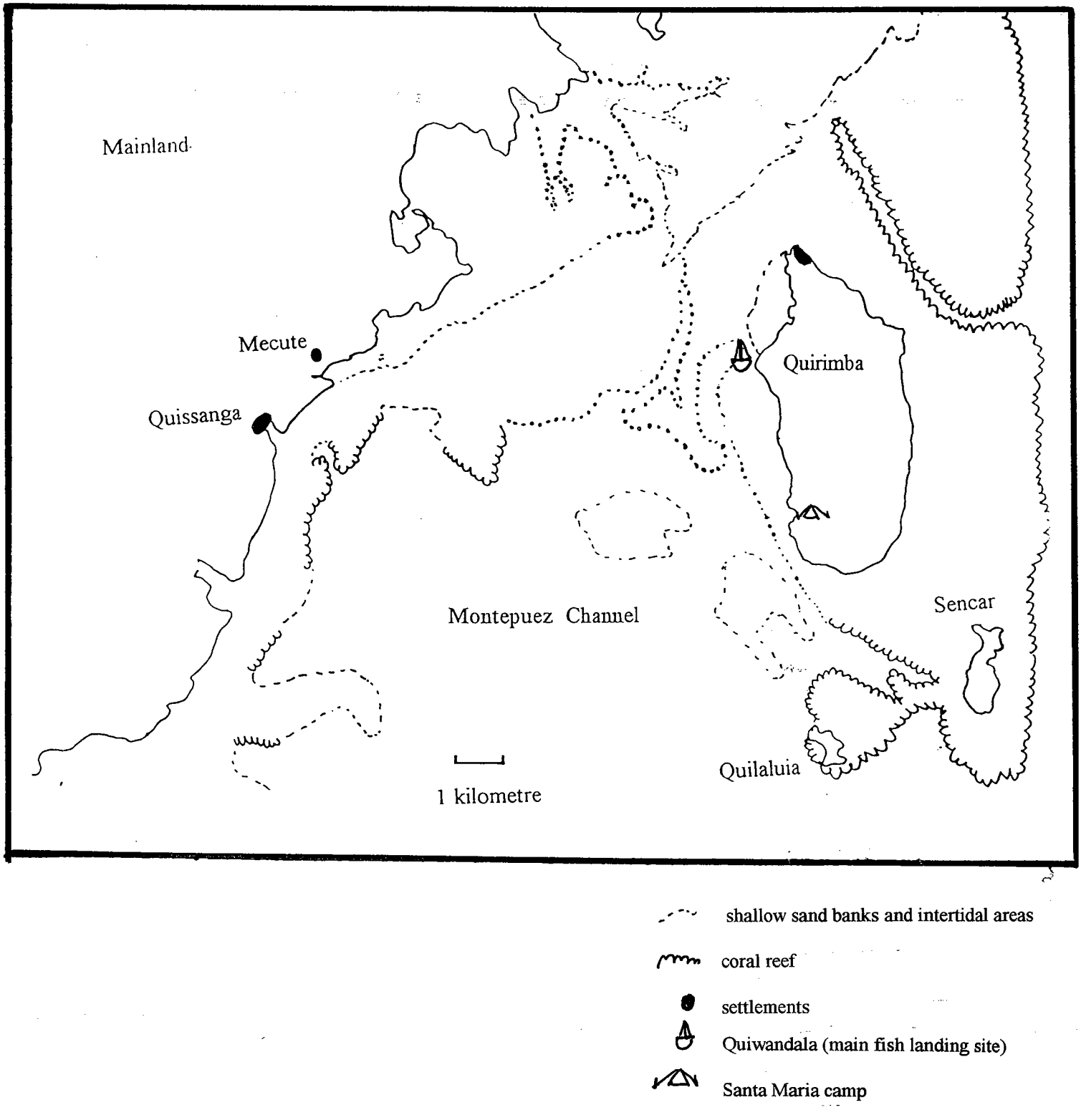

Figure 3. Quirimba Island and the Montepuez Channel

2.0 MATERIALS AND METHODS

Where possible fishermen were accompanied on fishing trips in the seagrass channel on a regular basis, usually every fishing day. Basic details such as boat length, number of fishermen, net size, mesh size, fishing time and fishing site were collected. A sample of the catch was taken (usually amounting to approximately one fifth of the total catch by weight) and the fish were identified to species, measured to the nearest 5 mm and weighed. As it was not practicable to weigh the entire catch, the total catch weight was estimated using a visual method. In addition the numbers and types of boats fishing in the channel were recorded both by the observers on the fishing boats and by shore-based observers.

More general information about the fishery, including its recent history and the local names for the fish, was obtained by talking to the fishermen.

In the case of canoe fishermen where it was impractical to accompany fishermen, catches were sampled on landing and the fishermen interviewed to estimate effort and determine fishing sites.

During the fishing trips and in separate snorkel surveys the seagrass habitat was mapped and the major species of seagrass in the area were identified.

3.0 RESULTS

The bay between Quirimba and the town of Quissanga on the Mozambique mainland was very shallow and most fishing was practised in depths of between one and three metres. The bay had large areas of seagrass (estimated at approximately 30km^2) with some large sand banks exposed at low tide and a number of other sandy patches.

The seagrass beds were dominated by the sub-tidal seagrass *Enhalus acoroides* which grows up to 75 cm high and *Thalassodendrun ciliatum* which is shorter, around 30 cm. There were also smaller areas of the fine cylindrical seagrass *Syringodium isoetifoluim.* Intertidal beds of *Thalassia hemprichii* were also utilised at higher tides for fishing but this area was used more intensively at low tides for intertidal gleaning for invertebrates.

From interview and observation it was evident that these seagrass areas played a vital role in the island community. The population appeared to be almost wholly reliant on the seagrass fishery (which exclusively employed men) and intertidal invertebrate collection (involving women and children) for employment and as a source of animal protein. Approximately 20% of the island's population were directly involved in the fishery as fishermen and it is probable that in total at least 50% of the island's population were involved in the fishery at some stage.

Two main fishing methods were employed in the bay: seine net fishing and trap fishing. No motorised boats operated from Quirimba Island. Seine net fishing was done from traditional sailing dhows of five to ten metres (figure 4) and trap or *marema* fishing from small dugout canoes or *ungalawas* (figure 5).

Most of the net fishing boats and many of the trap fishing canoes landed their catch at Quiwandala, the island's main landing site (see figure 3). Quiwandala was about half an hour's walk from Quirimba village where most of the island's 2,500 inhabitants lived. At landing time the area became the focus of island life as women and children brought food to barter for fish and the catch was gutted and distributed between the owners of boats, the captains and the crew.

3.1 The Net Fishery

3.1.1 Fleet size

From observations made at the main landing site, from fishing boats and from boat counts done from shore, estimates were made of the total fleet size. Approximately 20 large sailing boats worked regularly from Quiwandala, 4 were based in the south of the island around Santa Maria bay, and 5 at the north of the island near the village. An estimated 350 men were directly involved in the net fishery on a full or part time basis. Another 16 sail boats were based at Quissanga, the mainland village opposite Quirimba (Figure 3) and utilised the same seagrass channel area as the Quirimba fishermen. The catches from the Quissanga boats were not sampled but it was observed that they used identical fishing methods to the Quirimba fishermen and obtained similar catches.

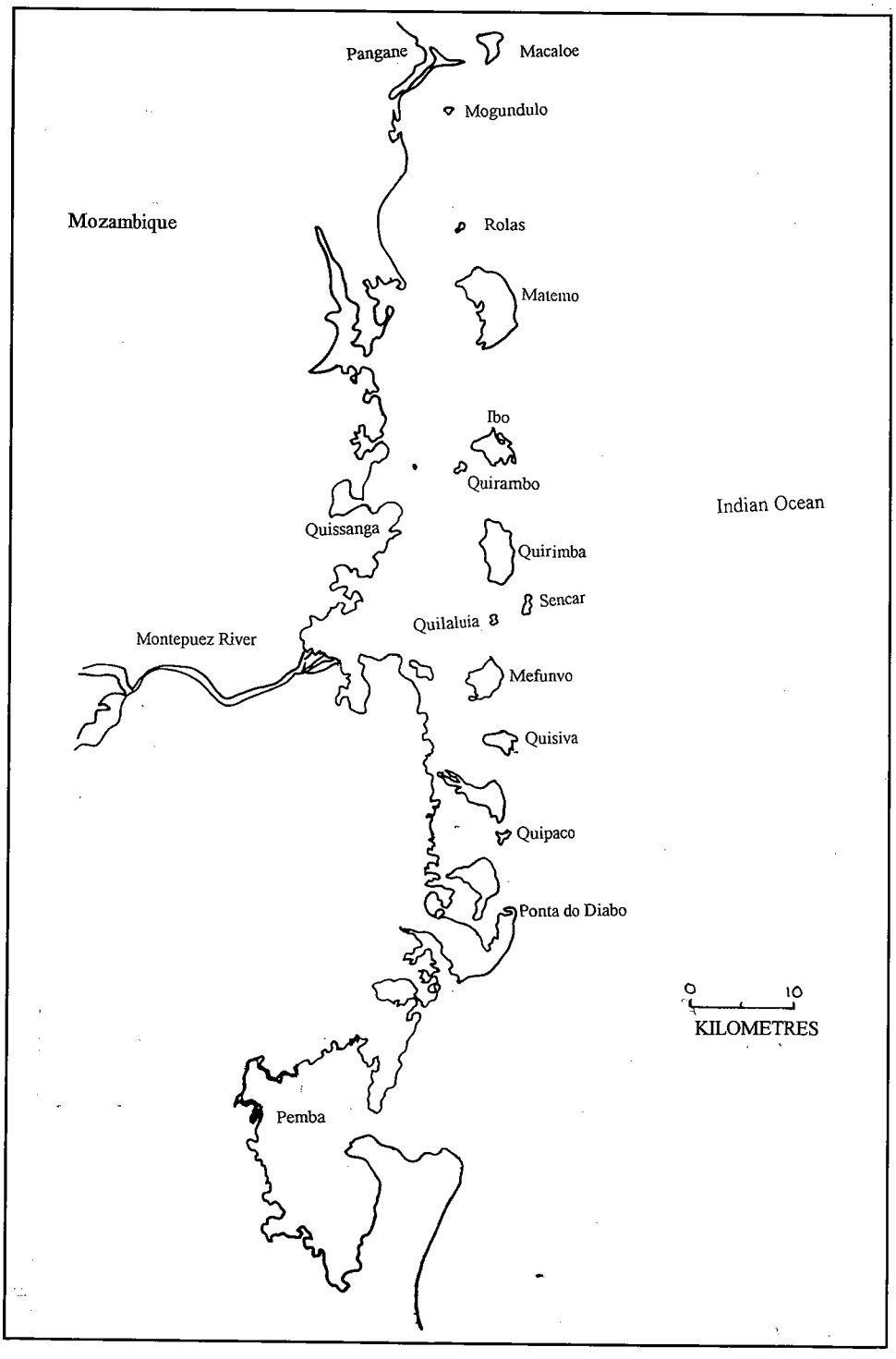

Figure 2. The Quirimba Archipelago with Quirimba Island in the centre.

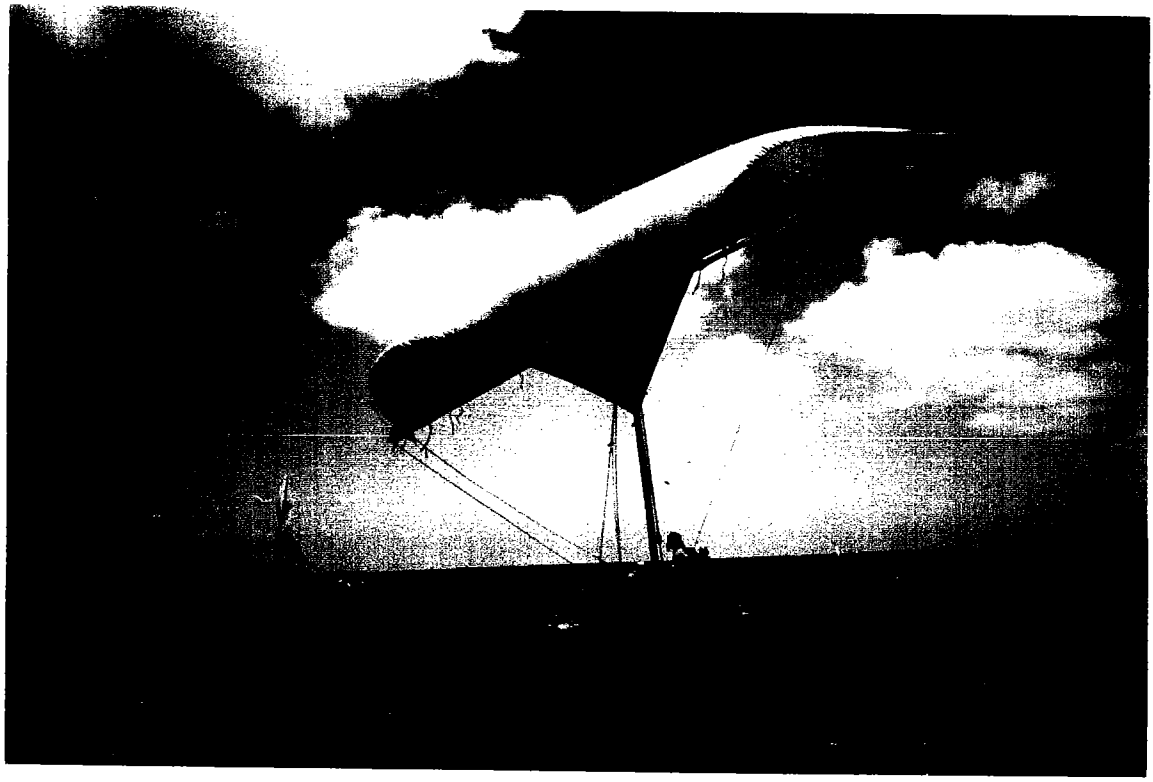

Figure 4: A traditional sailing dhow as used for net fishing in the Quirimba seagrass fishery.

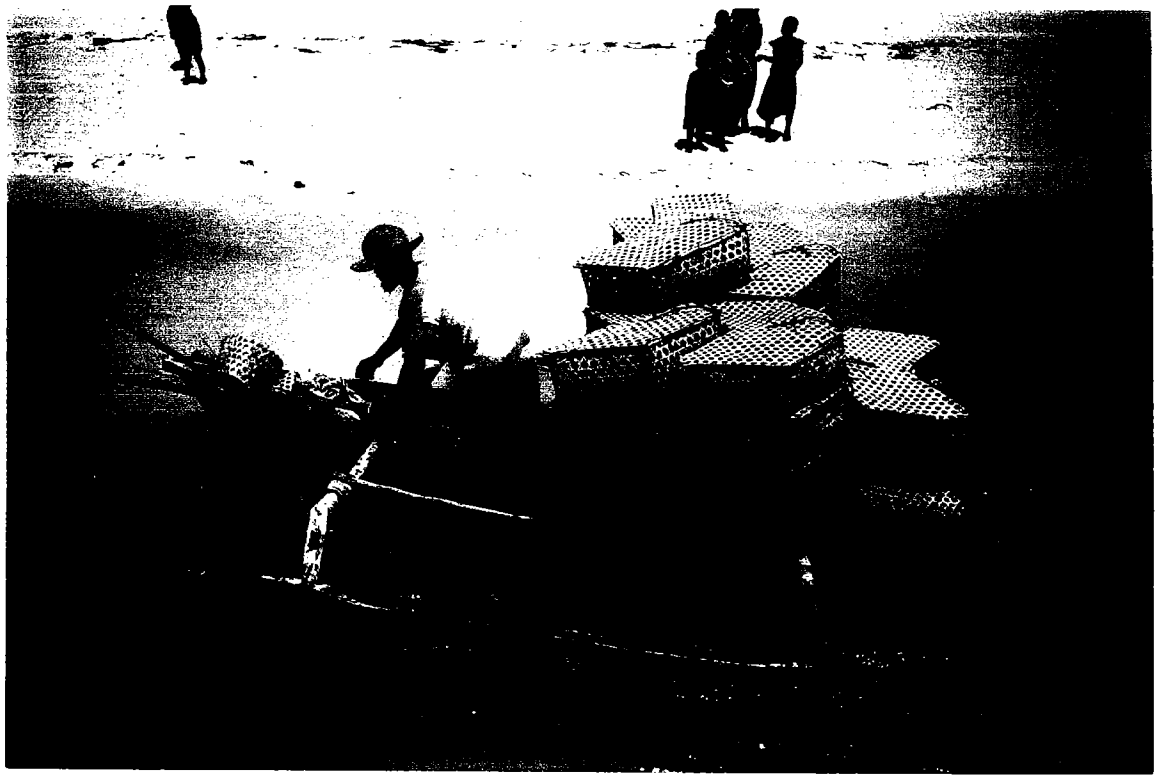

Figure 5: Traditional dug-out canoe used for trap fishing in the Quirimba seagrass fishery, with the woven *marema* traps used.

3.1.2 Gear type and fishing effort

The sailing dhows all used very similar gear. This was usually a 100 metre net with a mesh width of approximately 4 cm stretch, and a 5 metre cod end with a 2 cm mesh. In one case fishermen used a net with a cod end made of flour sacks therefore having a mesh of less than one millimetre. Fishing trips usually lasted for between four and five hours (mean duration of a fishing trip 4 hours, 50 minutes, N=90) with an actual fishing time of between 2.5 and 3 hours (mean time spent fishing per trip 2 hours, 40 minutes). Boats were crewed by between six and twelve fishermen (mean number 9, N=92) who were all needed in the very labour intensive process of hauling the nets. The nets were hauled 2 to 6 times per trip (mean 3.5, N=80) and an average haul yielded around 15 kg of fish. The mean catch per trip was 76kg (N=88) and the mean catch per person per trip was 8.4kg.

The net fishermen worked in a cycle determined by the tide. The fishermen would go out fishing approximately two hours before low tide every day for ten days then for 4 to 5 days around neap tides the boats wouldn't go out and the fishermen would spend their time maintaining nets and boats. Weather conditions such as strong winds or heavy rain could also prohibit fishing. A small proportion of fishermen did not fish on Fridays for religious reasons.

3.1.3 Catch composition

The catch was composed of at least 195 species of fish from 52 families (see Appendix 1). The family Lethrinidae accounted for the largest proportion of fish, 31.5%; Siganidae accounted for 22% and Scaridae represented 11%. Twenty nine species of wrasse (Labridae) were identified and the family accounted for over 9% of all fish caught . Although the dominant species varied considerably from day to day and even between hauls, nearly 70% of catch samples by weight were accounted for by the following five species: *Siganus sutor* (Siganidae, 25.1%), *Lethrinus lentjan* (Lethrinidae, 23.9%), *Leptoscarus vaigiensis* (Scaridae, 8.8%), *Lethrinus variegatus* (Lethrinidae, 8%) and *Gerres oyena* (Gerreidae, 3.5%) (see figure 6).

There were occasional samples which were dominated by a schooling fish not often encountered, for instance, the haemulid *Plectorhinchus gaterinus* accounted for just 1.7% of the total fish sampled, yet in one sample this species accounted for 28% of the total sample weight.

The majority of fish in catches were small. Sixteen of the twenty fish species that accounted for the majority of the catch had a mean length of less than 20cm and *Lethrinus variegatus* which accounted for the largest number of individual fish in the samples had a mean length of 9cm. A number of the fish caught could be recognised as the juvenile forms of the species, for example, the distinctive juveniles of the snapper *Lutjanus gibbus*.

The fishermen had species-specific names for some fish, for example the lethrinids which were common in the catch, although often apparently difficult to distinguish, had individual Kimwani names. Conversely, there was one word for all butterflyfish despite these fish having very distinctive differences in coloration and pattern. Many of the

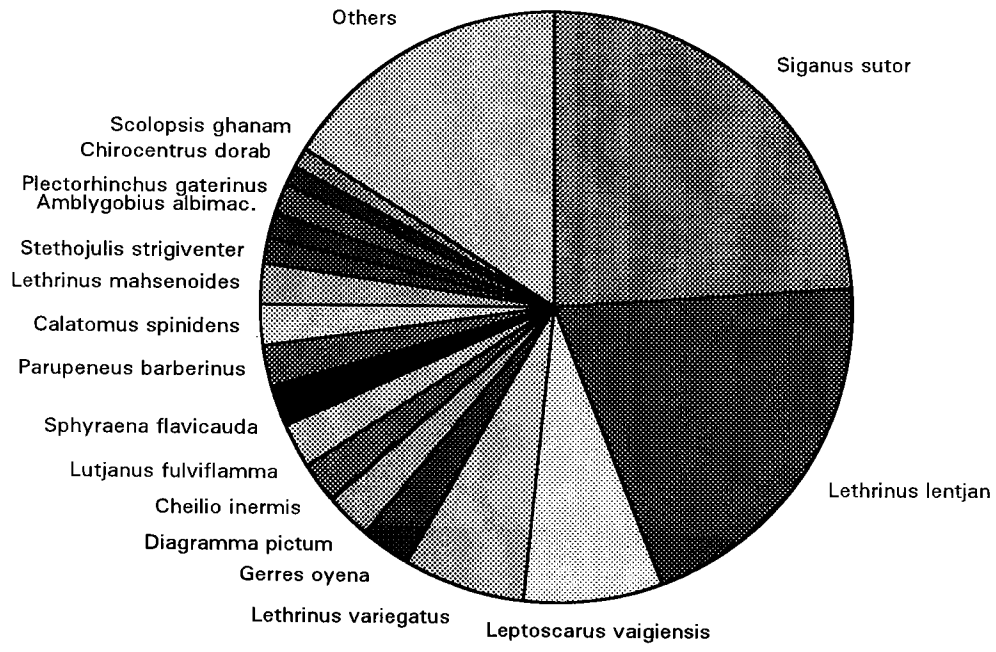

Figure 6[1]. The Quirimba Seagrass Fishery: catch composition by weight, July - November 1996.

[1] The catch composition by weight of the species of fish that represent 1% of more of the total catch weight sampled in the Quirimba seagrass net fishery taken from a total sample weight of over 300kg of fish. The category "others" is the total mass of all other fish sampled.

Kimwani names bore a strong relationship to the Swahili names used in Tanzania (pers. obs. and Darwall 1996).

It was noted that when the fishermen fished in the area to the south of Santa Maria bay (see fig. 3) where there were a few coral bommies in the seagrass, the catches were dominated by large individuals of the emperor *Lethrinus lentjan* (over 50% of the total sample weight) whereas in the catches taken from pure seagrass areas in the middle of the channel were dominated by the rabbitfish *Siganus sutor* (27%), with the *Lethrinus variegatus* forming an important component (11%) (see fig. 7). The catch weight per haul was also greater in the areas of seagrass and bommies and the fishermen were often able to reduce the number of hauls they did because they very quickly caught what they regarded as "enough" fish. Surprisingly, however, this site was not visited particularly often. It was a fairly long distance from Quiwandala, approximately 5 km, but the fishermen would often sail an equal or further distance to obtain typical catches dominated by small fish elsewhere.

3.1.4 By-catch

A very high proportion of the catch was retained to eat and to dry including the very small juveniles and less commercial fish such as butterflyfishes and damselfishes. Only poisonous fish such as pufferfishes, scorpionfishes and catfishes were thrown back. Large pufferfish were often stunned before being returned to the water and it seemed likely that many of these returned fish died. Tobies (smaller members of the Tetraodontidae family) were not eaten but were rarely returned to the sea alive. Pipefishes (Syngnathidae) and filefishes (Monacanthidae) which were present in small numbers in most catches were not returned to the sea but discarded when the catch was landed (after one landing more than 300 pipefish were recovered from the landing site). Seahorses (Syngnathidae) and seamoths (Pegasidae) were caught extremely rarely and the presence of these fish in a catch was said by the fishermen to be good luck. The fishermen would either keep them to dry and wear as charms or more often to be sold in Tanzania.

In one instance a turtle was accidentally caught but was released immediately. The fishermen involved in this case were aware that it was forbidden to kill turtles and said that they released turtles caught in nets. However, during the study period three turtle carcasses without shells were found around the landing site.

A number of invertebrates were also brought up in the nets. Squid were occasionally caught in large numbers and were sold for approximately the same price as the fish. Sea urchins and large sponges were often brought up in the nets but were always thrown back. The whelks *Chicoreus pomosus* and *Fasciolaria lugubrius* were also sometimes caught and were retained to sell the operculum to Tanzanian traders. Sea cucumbers were collected during fishing to be sold to traders in Ibo (a neighbouring island) or Tanzania who export them to the Far East.

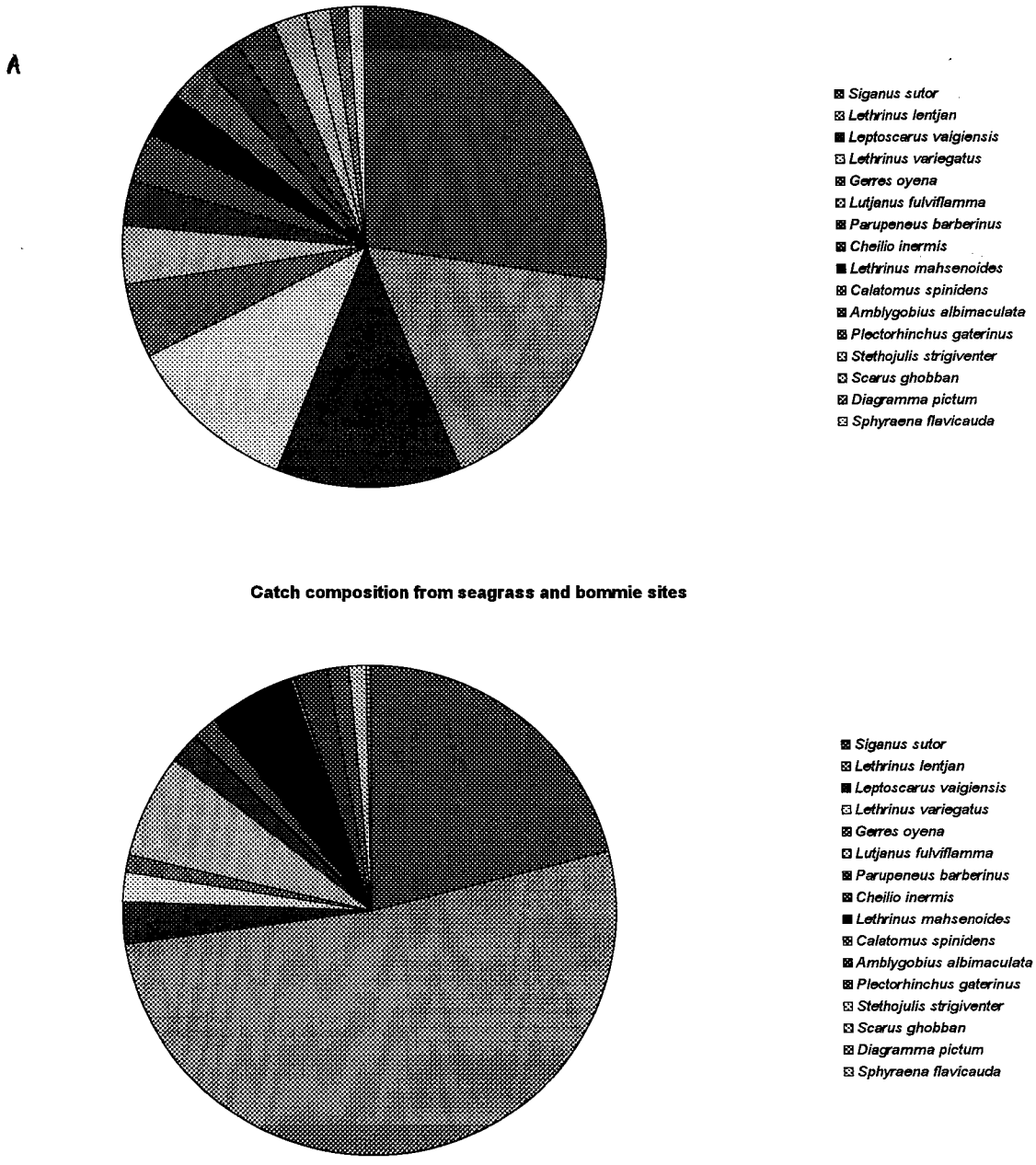

Figure 7[2]. (a) Catch composition from seagrass fishing sites (b) catch composition from seagrass and bommie sites.

[2] Piechart A shows the composition by weight of catches taken in areas of seagrass and sand only, which represents the majority of catches in the fishery.

Piechart B shows the catch composition by weight of catches taken from the seagrass area with small coral bommies in the area to the south of the Quirimba channel. This area was not fished as intensively as the normal seagrass area.

In both charts only the species which represented over 1% of the total weight are shown.

3.2 The Trap Fishery

Catches from the trap fishery were much more difficult to sample, and consequently less quantitative data was collected from this fishing method. It was virtually impossible to accompany the trap fishermen on their fishing trip as their canoes were definitely designed for one person and their traps only. A number of trips were made accompanying trap fishermen to see at first hand the methods involved, but it was not practical to do this on a regular basis, and the remainder of data was collected from landed catches. This was less convenient for the fishermen who were often anxious to get back to the village to prepare and sell their catch.

3.2.1 Fleet size

About twenty trap fishing canoes were based at Quiwandala, but a further twenty other canoes operated along the length of Quirimba's western coast. At least five of these canoes were based around Santa Maria bay and the others around the south-west of the island. Trap fishermen on Quirimba were always observed to work alone and an estimated fifty individuals were regularly involved in trap fishing on the seagrass.

The canoe fishermen set their traps in areas that were also used for seine net fishing, although whereas the net fishermen seemed to utilise areas of seagrass indiscriminately, the trap fishermen were more specialised in their use of the seagrass. Traps were only placed in areas of *Enhalus acoroides.* The trap fishermen interviewed said that this was because the small fish lived in the *jani-lala* (*Enhalus acoroides*) whereas the *jani-bare* (*Thalassodendrun ciliatum*) and the *jani-nvua* (*Syringodium isoetifoluim*) were the home of big fish that could not be caught in their traps.

3.2.2 Gear type and fishing effort

The traps were woven from palm fronds into a hexagonal shape with a funnel entrance. They were 50 cm wide and 25cm deep. The fishermen sometimes baited the traps with crushed *Terebralia* spp. snails (although it was believed that this was not necessary in the case of new traps) and usually set them at low tide in one to two metres of water along a line marked at either end with a stick or a buoy.

The canoe fishermen were at sea for a shorter period of time than the net fishermen, usually between 2 and 3 hours. Most fishermen owned between 30 and 50 traps. The average catch for one person on one trip emptying 40 traps was 12 kg but ranged from 7 kg to 27 kg. Trap fishermen did not have the 4 to 5 rest days per fortnight that net fishermen had but were also much more dependent on favourable weather conditions and could not go out on very windy days which were common.

3.2.3 Catch composition

The catches from traps were composed of a smaller number of species. The most common species caught in the marema traps was *Leptoscarus vaigiensis*. *Siganus sutor*, *Parupeneus barberinus*, *Parupeneus macronema* and *Calotomus spinidens* also formed an important component of the catch. Trap fishing was much more selective than net

fishing. The mesh of the trap allowed very small fish to escape and the size of the entry funnel prevented very large fish from entering. The only major by-catch was the swimming crab, *Portunus pelagicus*, which were often kept for eating or to use as bait. If any inedible fish were caught the trap fishermen were much more likely to return them to the sea alive as each trap was retrieved and emptied individually and each usually contained a relatively small number of fish so it was possible to spot and remove unwanted fish immediately.

3.3 Socio-economics

On the sail boats the majority of the catch was sold to the owner of the boat and this money was divided between the crew. However, some of the fish was bartered for other food before the catch is landed, and most of the crew also took a small share of the fish for themselves. The boat owner was responsible for the maintenance of the boat and the nets so the individual fishermen had no initial outlay.

Net fishing on the sailing boats was a very sociable activity. The same fishermen would crew the same boat on a relatively long term basis with the fishermen working closely as a team. Fishermen used the time travelling to and from the fishing site to exchange stories, gossip and to sing traditional songs.

4.0 DISCUSSION

4.1 Economic and social importance of the seagrass fishery

The Quirimba seagrass fishery was found to be a highly diverse multi-species fishery with a vital economic and social role in the community of the island. The people of Quirimba are unusually dependent on the direct utilisation of this natural resources because are the lack of alternative sources of income. Elsewhere, areas with such highly developed coral reefs invariably have tourist developments and more intensive reef fisheries which can be relatively lucrative for local populations. Thus, although the fishery is not on a commercial scale, its value to the community is high.

4.2 Fish diversity

One of the most striking facts about the fishery was the diversity of species in the catch. The number of species and families recorded from seine net catches alone exceeded the diversity of many seagrass fish faunas studied elsewhere (see Pollard 1984, a review of 30 seagrass fish faunal studies). The only studies that show a comparable level of fish diversity is Vivien's (1974) study of *Thalassia* in Madagascar where 189 species from 46 families were identified using poison and Blaber *et al* (1992) who identified 156 species from a variety of seagrass types in northern Australia, sampling day and night with poison.

Despite the high total diversity of fish in the seagrass at Quirimba, the majority of fish caught in the fishery were accounted for by a small number of species. Of almost two hundred species of fish already identified from the catch just five species accounted for nearly 70% of the total weight of fish sampled. This seems to be a more manageable number of species to study in detail to look at population structure and levels of exploitation. Data has been collected on the length-frequency and the relationship between length and weight in these species so that cohorts can be identified and rates of growth and mortality estimated. The ageing of the fish is also underway, and all together this information should allow an initial assessment of the population structure of these species and the impact of the present level of exploitation on stocks.

4.3 Impacts of the fishery on the seagrass environment

Seagrass provides shelter for fish and is a source of food so the health of the seagrass habitat is obviously important in maintaining the fish populations that supply the fishery. In studies where the fish productivity of seagrass areas has been compared with that of similar unvegetated areas, seagrass areas have unsurprisingly been found to yield a higher biomass and a higher density of fish. The structural complexity of the habitat is also acknowledged to be important in maintaining species diversity.

The direct impacts on the seagrass habitat that might be expected to be a consequence of fishing include damage by nets, traps, weights, trampling, anchor damage and boats.

Damage to other elements of the habitat such as the damage to or removal of small coral heads, sponges and anemones, thus reducing structural complexity, should also be considered. (The large sponges that were often brought up in the nets were usually returned to the sea but the impact of their removal on associated organisms must be considered.) Future experimental work will attempt to assess the impact of damage to the seagrass habitat on fish yields. The level of damage caused to the habitat by fishing would be expected to depend on the intensity of fishing. Some areas of the channel, particularly some of the shallow sites near Quiwandala are used particularly intensively and future studies are planned to assess to impact at sites fished at different intensities.

4.4 Impacts of the fishery on the populations of target fish

The usual expected impact of fishing on ecosystems is a decrease in the number of the large predatory fish targeted. In this fishery large predators were rarely caught and small fish appeared to be targeted so the impact of the fishery on the ecosystem would not be expected to follow the typical pattern. This leads us to one interesting point about this fishery. In many other places large fish are preferred for eating and command a better price per kilo than small fish, but in the Quirimba seagrass fishery it appears that though large fish could have been caught using the same methods and within the same area that was used to catch small fish, the fishermen usually chose to catch the small fish. In theory, the same fishing boats could also have fished on the reef flat on the east side of the island where a few boats fish when the winds are right and caught large parrotfish, snappers, emperors and other large reef fish.

There were a number of reasons for this preference for small fish, all of which appeared to stem from the economic situation on the island. Small fish were easier to sell in small quantities and were easier to cook and to dry for future use than pieces of larger fish. Although it would only account for a small proportion of the total weight of fish, an important use of the small fish before the catch was even landed was the barter of fish with women for bread. This exchange may seem trivial but many women from the village were involved in this exchange and many fed their families on fish solely from this source.

These observations seem to establish the fact that people do *choose* to catch the smaller fish and that they do not do it through ecological necessity, in the absence of larger more traditionally desirable fish. In the Philippines for instance there are areas where catches are dominated by small fish but this is thought to be because overfishing has eliminated all other fish (Fortes 1989).

Studies to assess the impact of the fishery on the populations of some of the major species, including *Siganus sutor*, *Lethrinus variegatus, Lethrinus lentjan* and *Leptoscarus vaigiensis* are ongoing.

4.5 Sustainability of the fishery

The important question that must be asked about this fishery is "is it sustainable?". The seagrass fish community of Quirimba was obviously highly diverse and productive but is diversity or productivity being affected by the level of exploitation? Other aspects which

also need to be considered are how the intensive exploitation of this area of seagrass effects adjacent ecosystems such as coral reefs and mangroves and the intertidal flats and consequently the resource use in these areas.

The generally small size of fish caught may be interpreted as evidence of overfishing, but since young fish commonly occupy seagrass areas one would expect to catch small fish. If large numbers of juveniles were caught the eventual breeding population might be expected to be greatly reduced, although juvenile fish have a high natural mortality. It appears that the majority of fish caught, although small, may not be juveniles. For example, the mean length of the emperor *Lethrinus variegatus* was just 9cm which for most emperors would be a juvenile. However, the maximum length for *Lethrinus variegatus* is just 20cm so it is likely that the majority of the fish caught are actually adults. Further studies of the physiology of this and other important catch species will be necessary to determine the maturity of the fish.

Trap fishing, with a relatively high selectivity and minimal waste, would appear to have less negative impact on the habitat and fish populations than net fishing. A move from the dominance of net fishing to trap fishing may have advantages in making the fishery more selective and avoiding the capture of the really tiny fish, and almost eliminating bycatch of both fish and invertebrates. However, this seems unlikely to happen because of the cultural and social importance attached to net fishing, and the high economic investment necessary for boats and nets.

There was evidence that the high level of fishing intensity in the Montepuez Bay is a fairly recent development. The majority of fishermen spoken to during this study had moved to the island in the past decade or so, some to escape the fighting during the civil war which was intense in some areas of mainland Cabo Delgado, but many who had moved more recently actually said that they moved from their original homes on the mainland to Quirimba because there were no fish left where they had lived previously.

In addition to this, the use of such small mesh sizes to capture small fish may also be a fairly recent phenomena. Before the independence of Mozambique in 1975 the Portuguese had strictly, if sporadically, enforced mesh-size legislation and small mesh nets of the kind commonly used now were routinely burned (J. Gessner, pers. comm.).

As well as the more permanent immigrants who have settled on Quirimba in the last decade, there was also evidence of an increase in the number of itinerant fishermen who visited the island for short periods of weeks or months, catching fish to dry and sell when they returned home. Camps of visiting fishermen were much more common on other islands with smaller permanent populations such as Quisiva which was a favourite destination of fishermen from the province of Nampula, but during the seven month study period on Quirimba at least on group of fishermen from Mahati, a mainland town stayed for over a month and a large group of fishermen from Zanzibar stayed near the village for a few months. It was also apparent that the Tanzanian fishermen were increasingly moving as far south as Quirimba on fishing trips and that although Quirimba was not one of the major destinations for the large numbers of seasonal fishermen from other provinces that invaded other islands in the archipelago, there were occasionally small encampments of visiting fishermen.

The main acknowledged threat to seagrass fisheries is the loss of seagrass. Seagrass loss usually results from excessive siltation and turbity. A major cause of siltation is the felling of trees in land and other land use changes. Forestry seems to be developing fast on mainland Mozambique and any management of the seagrass area and fishery would have to include the integrated management of land use in the area (Bell and Pollard 1989).

4.6 The future of the fishery

At the moment the whole Quirimba Archipelago may be on the brink of development in terms of commercial fisheries, industry and tourism, as economic growth in all parts of Mozambique is being actively encouraged and Cabo Delgado, the province most remote from the Mozambican capital Maputo, begins to receive attention. Even over the next year and a half the changes to Quirimba could be considerable. Potential changes include an increase in fishermen from outside the area bringing in more intensive fishing techniques, using motorised boats, SCUBA equipment, and more destructive methods such as dynamiting reefs which has already been reported from islands in the extreme north of the Archipelago. There is also a strong possibility of coastal development in the form of heavy industry or tourism.

The growth of tourism on the island would only be possible if it was accompanied by the dramatic improvement of infrastructure in the area. Roads and other transport provision would have to be improved and electricity would probably be required and the availability of these resources to the fishermen would allow fish to be stored and distributed. Tourist would also demand large reef fish. This could take some of the pressure off the seagrass fishery as some fishermen may move to fishing for large fish on the reef flat on the east coast which could either be sold to tourists at a much higher price than fish is usually sold at or sold on the mainland.

If fishing effort moved to the reef flat on a small scale both fisheries could perhaps continue sustainably and tourism could therefore have a positive effect on the community and the environment. However, tourist developments could also have a number of negative impacts, both environmental, in the form of pollution, sedimentation from coastal development and so on, and social, as fishermen are forced to leave traditional lifestyles.

Whichever way Quirimba develops in the near future careful management considerations will have to be made by the community and the provincial administration to ensure that their diverse marine resources are protected. If more detailed study of the seagrass fish populations suggest that the fishery is or could in the near future be overexploited moves must be made to prevent the decline or loss of this vital resource. One obvious improvement may be to enforce mesh size regulations, but most typical fishery management tools such as issuing licences, minimum size regulations and closed seasons would all be impractical because they would lead to loss of income for the fishermen and would be almost impossible to enforce.

5.0 POSSIBLE MANAGEMENT STRATEGIES

One possible option which has proved popular and effective in similar economic situations in Kenya and the Philippines is the establishment of small marine reserves where fishing is prohibited over an area small enough not to adversely effect the incomes of fishermen initially but large enough to provide a refuge for fish. In a number of cases small "no take" reserves have lead to a significant increase in the biomass of fish caught in surrounding fishing areas.

There have already been calls for the designation of all or part of the Quirimba Archipelago as a marine national park and the future of some sort of protected area in the area does look promising at present. In many of the places where marine reserves have been successfully implemented protection has focused on coral reef areas. The protection of selected coral reef areas in Quirimba would be a positive move in terms of the protection of biodiversity and would be a rare case of an area being protected *before* it has been exploited beyond recognition, but would not address the more imminent problems that may be faced by the seagrass fishers.

In any designation of marine reserves it will be very important to protect small areas of seagrass from fishing to reap the potential benefit of allowing fish a refuge and also perhaps sustaining the remarkable diversity of the seagrass habitat. More detailed study of the dynamics of the fish communities and their reponse to fishing will be necessary to determine optimal sizes and situations for seagrass reserves.

In the long term the biggest threats to the Quirimban fishery are likely to come from outside in the form of visiting fishermen who have no long term interest in the resource, and ill-planned development. Despite hearing the stories of the fishermen from Tanzania and Nampula of dwindling fish and other marine resources in their once coastal areas, the fishermen of Quirimba have complete faith in an endless supply of fish to feed them and their children. As one fisherman put it "There will be fishermen at Quiwandala until the end of the world."

The seagrass fishery of Quirimba is obviously a highly productive resource that currently sustains a large proportion of the island's population but how resilient it is to the present level of exploitation or how it will respond to imminent changes remains to be seen.

6.0 WORK IN PROGRESS

This report is a summary of the more general findings of the fisheries research programme on Quirimba Island. A large component of the research is ongoing and the results of these studies will be published in the final report.

At the moment the extensive length-frequency data collected over the first year is being analysed to estimate the growth and mortality rates of the populations of some of the more important species in the catch. The age of the fish of the selected species will also be determined from otoliths and scales that have been collected. A large proportion of the fish sampled in this study were also weighed and length-weight relationships have been determined for the more common species where sufficient data was available.

The collection of baseline fisheries catch and effort data will continue for the second year of the project but will be accompanied by a selection of more focused studies into questions that have been raised by this initial work.

Proposed future studies include:

1. A study of the fisheries potential of the accessible reefs of Quirimba.
A small number of fishermen do utilise the reef flat and some sheltered reef areas around Quirimba. It is hoped that it will be possible to collect more data on these reef fisheries and also to undertake experimental fishing to compare catch per unit effort and catch composition from reef sites with seagrass sites.

2. A comparison of the fish assemblages in different seagrass species.
Trap fishermen are very selective about the type of seagrass they place their traps in. An experimental program of trap fishing in different species of seagrass will be carried out to determine whether the fish assemblages in different seagrasses are significantly different, in terms of fish species and life stage and size of resident fish. Martin and Cooper (1981) studied the fish faunas found in two species of seagrass in the Atlantic and found significant differences in the fish faunas at species and family level and a significant difference in levels of biomass and it would be interesting to make an Indo-Pacific comparison.

3. Total diversity of fish
In addition to the fish diversity data collected from the fishery it is hoped to begin a programme of fish collecting from the seagrass bed to add the smaller and more cryptic species to the current species list.

4. A comparison of the biomass and diversity of fish in the intensively fished Quirimba channel and a lightly fished site off Ibo island to the north of Quirimba
A combination of techniques will be used to compare these two areas of seagrass. A subtidal point count technique will be used to make a fishery-independent of fish densities in both areas. Fish collections will be made at both sites to compare fish diversity. It is also hoped that it will be possible to undertake experimental fishing at the lightly fished site, using both trap and net fishing methods to compare catch per unit effort and catch composition with those of Quirimba.

5. Productivity studies

A programme to study the primary productivity of the seagrass beds is being undertaken as a component of the main project and it is hoped to incorporate an element of the primary productivity of the various seagrass species with studies of the faunal productivity.

6. Trophic structure

In relation to productivity studies the trophic structure of fish in the seagrass community will be determined through the analysis of stomach contents taken from fisheries samples.

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Appendix 1: Fish species caught in the Quirimba seagrass fishery and their scientific, common and local names.

Scientific	English	Portuguese	Kimwani
Acanthuridae	**Surgeonfishes**	**Cirurgioes**	**Ngadga**
Acanthurus auranticavus	Orange socket surgeon		Ngadga
Acanthurus dussmieri	Eye stripe	Cirurgiao coroada	Ngadga
Acanthurus mata	Elongate	Cirurgiao comprido	
Acanthurus nigricauda	Black streak	Cirurgiao graduado	Ngadga
Acanthurus nigrofuscus	Dusky surgeon	Cirurgiao castanho	Ngadga
Acanthurus nigroris	Blue-lined surgeon		Ngadga
Acanthurus thompsoni	Thompsons	Cirurgiao chocolate	Ngadga
Ctenochaetus striatus	Striped bristletooth	Barbeiro estriado	Ngadga
Naso brevirostris	Spotted unicornfish	Rufia manchada	Muju (juvenile)
Naso unicornis	Blue-spine unicorn	Rufia espigao azul	Ngadga
Zebrasoma desjardini	Desjardin's sailfin tang	Canivete	Ngadga
Antennariidae	**Frogfishes**	**Peixes-sapo**	
Antennarius spp.			Kindwani
Apogonidae	**Cardinalfishes**		
Apogon aureus	Ringtail cardinalfish		
Apogon cyanosoma	Yellowstriped cardinal		
Apogon nigripinnis	Bullseye cardinal		
Cheilodipterus quinquelineatus	Fiveline cardinal		
Foa brachygramma	Bay cardinal		
Fowleria variagata	Variagated cardinal		
Balistidae	**Triggerfishes**	**Peixes-porco**	**Kokomwe**
Balistapus undulatus	Orange-striped triggerfish	Porco ondulado	
Balistoides viridescens	Titan triggerfish	Porco ponteado	
Sufflamen chrysopterus	Half-moon triggerfish	Porco meia-lua	
Belonidae	**Needlefishes**	**Agulhas**	**Nzera**
Tylosurus crocodilus	Hound needlefish	Agulha crocodilo	Nzera
Blenniidae	**Blennies**	**Marachombas**	
Meiacanthus mossambicus	Mozambique fangblenny		
Petroscirtes variablis	Variable fangblenny		
Bothidae	**Left-eye flounders**	**Areeiros**	**Kipama**
Bothus mancus	Tropical flounder	Areeiro tropical	Kipama
Bothus pantherinus	Leopard flounder	Areeiro leopardo	Kipama
Caesionidae	**Fusiliers**	**Fuzileiros**	**Neeto**
Caesio caerulaurea	Blue and gold fusilier	Fuzileiro azul	
Caesio lunaris	Blue fusilier	Fuzileiro lua	
Caesio teres	Yellowback fusilier	Fuzileiro bonito	
Caesio xanthonota	Yellowfin fusilier	Fuzileiro barbatana amarela	
Pterocaesio chrysozona	Goldband fusilier	Fuzileiro banda dourada	
Pterocaesio marri	Twinstripe fusilier	Fuzileiro de Marr	
Pterocaesio pisang	Ruddy fusilier		
Callionymidae	**Dragonets**	**Peixes-pau**	**Dunfera**
Synchiropus marmoratus	Marbled dragonet		
Carangidae	**Jacks etc**	**Carapaus etc**	
Alectis indicus	Indian threadfish	Xareu cabecu	Njolwe
Carangoides fulvoguttatus	Yellow spotted trevally	Xareu cintilante	Njolwe
Scomberoides tol	Needlescale queenfish	Machope comum	Njolwe
Selar crumenopthalmus	Big eye scad	Carapau preto	Kirumbwe
Selaroides leptolepis	Smooth-tailed trevally		Njolwe
Chirocentridae	**Wolf-herrings**	**Machopes**	
Chirocentrus dorab	Dorab wolf-herring	Machope espada	
Chaetodontidae	**Butterflyfishes**	**Peixes-borboleta**	**Sungaramarime/Kipapes**
Chaetodon auriga	Threadfin		
Chaetodon kleinii	Dot-dash		
Chaetodon melannotus	Black-backed		
Chaetodon trifasciatus	Red fin		

Chaetodon xanthocephalus	Yellow head		
Heniochus acuminatus	Bannerfish		
Clupeidae	**Sardines**	**Sardinhas**	
Herklotsichthys quadrimaculatus	Bluestripe herring	Sardinha banda azul	
Cynglossidae	**Tongue soles**	**Linguados**	**Kipauma**
Cynnoglossus spp.			
Dactylidae	**Flying gurnards**	**Voadores de fundo**	**Manzi**
Dactyloptena orientalis	Oriental flying gurnard	Voador oriental	
Dasyatidae	**Stingrays**	**Ratao**	
Taeniura lymna	Bluespotted ribbontail ray	Ratao pintalgado	
Echeneidae	**Remoras**	**Pegadores**	
Echeneis naucrates	Sharksucker		
Remora remora	Remora		
Engraulidae	**Anchovies**	**Anchovas etc**	
Stolephorus heterolobus	Shorthead anchovy		
Entriscidae	**Shrimpfishes**		
Aeoliscus punctulatus	Speckled shrimpfish		Kifu
Fistularidae	**Cornetfishes**	**Cornetas**	
Fistularia commersoni	Cornetfish	Corneta pintada	Uvuve
Gerreidae	**Mojarras**	**Melanurias**	
Gerres acinaces	Longtail silver biddy	Melanuria timoneira	Sala
Gerres oyena	Blacktip mojarra	Melanuria comum	Sala
Gobiidae	**Gobies**	**Cabozes**	
Amblygobius albimaculatus	Tailspot goby		Dunfera
Amblygobius semicinctus			Dunfera
Bathygobius cyclopterus	Spotted frill goby		
Haemulidae	**Grunts**	**Peixes pedra**	
Diagramma pictum	Painted sweetlips	Pargo mulato	Neke
Plectorhinchus gaterinus	Blackspotted grunt	Pargo galinha	Nrere
Plectorhinchus orientalis	Oriental grunt	Pargo oriental	Nrere
Plectorhinchus schotaf	Minstrel sweetlips	Pargo trovador	Sende
Plectorhinchus sordidus	Sordid rubberlips	Pargo sordido	Sende
Hemiramphidae	**Half-beaks**	**Meias-agulhas**	
Hemiramphus far	Black-barred halfbeak	M-agulha manchada	Ningalare
Hemiramphus lutkei	Lutke's halfbeak	Meia-agulha de Lutke	Ningalare
Hyporhamphus affinis	Insular halfbeak	Meia-agulha affinis	Ningalare
Holocentridae	**Squirrelfishes**	**Esquilos**	
Sargocentrum diadema	Crown squirrel	Esquilo sammara	Dada
Neoniphon sammara	Bloodspot squirrel		Dada
Labridae	**Wrasses**	**Bodioes**	
Anampses caeruleopunctatus	Blue-spotted wrasse		Nsingombe
Cheilinus arenatus	Arenatus wrasse		Nsingombe
Cheilinus bimaculatus	Twospot wrasse		Nsingombe
Cheilinus digrammus	Cheeklined wrasse		Nsingombe
Cheilinus oxycephalus	Snooty wrasse		Nsingombe
Cheilinus trilobatus	Three-lobed wrasse	Bodiao trilobatus	Nsingombe
Cheilinus undulatus	Humphead wrasse	Bodiao napoleao	Nsingombe
Cheilio inermis	Cigar wrasse	Madonoli	Kisuare
Cymolutes praetextatus	Knife razorfish		Nsingombe
Cymolutes torquatus	Finescale razorfish		Nsingombe
Halichoeres hortulanus	Checkerboard wrasse	Bodiao axedrezado	Nsingombe
Halichoeres scapularis	Zigzag wrasse		Nsingombe
Labroides dimidiatus	Bluestreak cleaner wrasse		Nsingombe
Novaculichthys macrolepidotus	Seagrass wrasse		Nsingombe
Novaculichthys taeniourus	Rockmover wrasse	Donzela alguiera	Nsingombe
Oxymolutes marea			Nsingombe
Pteragogus flagellifera	Flagfin wrasse		Nsingombe
Stethojulis albovittata	Blue-lined wrasse		Shingu
Stethojulis bandenensis	Red-shoulder wrasse		Shingu

Stethojulis interrupta	Cutribbon wrasse		Shingu
Stethojulis strigiventer	Three ribbon wrasse		Shingu
Thalassoma fuscum	Christmas wrasse	Peixe-verde de Natal	Nsingombe
Thalassoma purpureum	Surge wrasse	Peixe-verde turquesa	Nsingombe
Xyrichthys pavo	Peacock wrasse	Bodiao pavao	Nsingombe
Xyrichthys pentadactylus	Five finger wrasse	Bodiau ocelado	Nsingombe
Lethrinidae	**Emperors**	**Ladroes/Imperadores**	
Gnathodentex aurolineatus	Yellowspot emperor	Ladrao-imperador	
Lethrinus harak	Thumbprint emperor	Sao Pedro	Njana baka
Lethrinus lentjan	Pink ear emperor	Ladrao de lentejoulas	Njana
Lethrinus mahsena	Sky emperor	Ladrao mahsena	Sangu
Lethrinus mahsenoides	Snubnose emperor		Kilundumasa
Lethrinus microdon	Smalltooth emperor	Ladrao de boca doce	Sunguri
Lethrinus nebulosus	Spangled emperor	Ladrao relampago	Sangu
Lethrinus obsoletus	Yellow-banded emperor	Ladrao de bandas	
Lethrinus olivaceous	Longface emperor		
Lethrinus rubrioperculatus	Redgill emperor	Ladrao maquilhado	Fimbo
Lethrinus variegatus	Variagated emperor	Ladrao moteado	Sololo
Lutjanidae	**Snappers**	**Pargos**	
Aphareus furcatus	Smalltooth jobfish	Pargo de boca doce	
Aprion virescens	Green jobfish	Pargo verde	
Lutjanus bohar	Two spot snapper	Pargo de manchas	
Lutjanus ehrenbergi	Ehrenberg's snapper	Pargo carpa	Kerare
Lutjanus fulviflamma	Blackspot snapper	Pargo tinteiro	Kerare
Lutjanus gibbus	Humpback snapper	Pargo curvado	Numba
Pristopomides multidens	Gold-banded jobfish	Pargo de cauda	
Monacanthidae	**Filefishes**	**Peixes-porco-galhudos**	
Aluterus scriptus	Scribbled leatherjacket	Porco rabiscado	Nanamali
Amanses scopas	Broom filefish		Kokoma
Paluteres prionurus	Blacksaddle mimic		Kipweti
Pseudalutarius nasicornis	Rhinocerous filefish		Kokoma
	Speckled filefish		Kokoma
Mullidae	**Goatfishes**	**Salmonetes**	
Mulloides flavolineatus	Yellowstripe goatfish	S. de estria amarela	Nkundage
Mulloides vanicolensis	Yellowfin goatfish	S. de vanicola	Nkundage
Parupeneus barberinus	Dash-dot goatfish	Salmonete barberino	Nkundage
Parupeneus cinnabarensis	Cinnabar goatfish	Salmonete cinnabar	Nkundage
Parupeneus cyclostomus	Gold saddle goatfish	Salmonete dourado	Nkundage
Parupeneus heptacanthus	Redspot goatfish		Nkundage
Parupeneus macronema	Long-barbel goatfish	S. barba longa	Nkundage
Parupeneus pleurostigma	Sidespot goatfish	Salmonete pastilha	Nkundage
Parupeneus rubescens	Rosy goatfish	Salmonete rosado	Nkundage
Paruupeneus indicus	Indian goatfish	Salmonete do Indico	Nkundage
Upeneus moluccensis	Goldband goatfish	S. de banda dourada	Nkundage
Upeneus taeniopterus	Fin stripe goatfish	Salmonete estriado	Nfionyo
Upeneus tragula	Freckled goatfish	Salmonete sardento	Nfionyo
Upeneus vittatus	Striped goatfish	Salmonete laranjeiro	Nfionyo
Muraenidae	**Moray eels**	**Moreias**	
Siderea picta	Speckled moray	Moreia sideral	
Nemipteridae	**Threadfin breams**	**Bagas, Sizis**	
Scolopsis bimaculatus	Thumbprint spinecheek	Sizi Sao Pedro	
Scolopsis ghanam	Arabian spinecheek	Sizi de Arabia	Abudala
Ostracidae	**Trunkfishes**	**Cofres**	
Lactoria cornuta	Longhorn cowfish		Kilamba
Ostracion cubicus	Yellow boxfish		Kilamba
Pegasidae	**Seamoths**		
Eurypegasus spp.			
Platacidae	**Batfishes**	**Morcegos**	
Platax orbicularis	Batfish	Morcego	Kipukupu
Platycephalidae	**Flatheads**	**Sapateiros**	
Papilloculiceps longiceps	Crocodile flathead	Sapateiro crocodilo	Manzi/Atjari
Thysanophrys arenicola	Broadhead flathead		Manzi/Atjari
Thysanophrys chiltonae	Longsnout flathead		Manzi/Atjari

Plotosidae	**Catfishes**	**Patunas**	
Plotosus lineatus	Striped eel catfish	Patuna raiada	Ngo
Pomacanthidae	**Angelfishes**	**Libres**	**Kipapais**
Centropyge multispinus	Multispined angelfish		
Pomacanthus chrysurus	Ear-spot angelfish	Lebre cauda dourada	
Pomacentridae	**Damselfishes**	**Castanhetas**	**Gugrue**
Abudefduf sparoides	False eye sergeant		
Abudefduf sexfasciatus	Scissortail sergeant		
Abudefduf vaigiensis	Indo-Pacific sergeant		
Amphiprion allardi	Allard's anemonefish		
Chromis opercularis	Doublebar chromis		
Chrysiptera annulata	Footballer demoiselle		
Dascyllus aruanus	Humbug dascyllus		
Dascyllus carneus	Indian dascyllus		
Dascyllus trimaculatus	Three spot dascyllus		
Neoglyphidodon melas	Black damsel		
Neopomacentus fulginosus	African demoiselle		
Priacanthidae	**Bigeyes**	**Fura-vasos**	
Priacanthus cruentatus	Glasseye	Fura-vasos de rochas	Dada
Priacanthus hamrur	Moontail bigeye	Fura-vasos espelhudo	Dada
Rhynchobatidae	**Guitar fishes**	**Peixes cunha**	
Rhynchobatus djeddensis	White spotted guitarfish		Saluware
Scaridae	**Parrotfishes**	**Papagaios**	
Calotomus carolinus	Carolines parrotfish	P. das Carolinas	Bonju
Calotomus spinidens	Spinytooth parrotfish	P. dentuco	Bonju
Hipposcarus harid	Indian Ocean longnose parrot	P. candelamoa	Mono
Leptoscarus vaigiensis	Seagrass parrotfish	Papagaio manchado	Bonju
Scarus ghobban	Blue barred parrotfish	P.de escamas amarelas	Mono
Scarus japanensis	Palecheek parrotfish	P. rosto palido	Mono
Scarus psitticas	Common parrotfish	Papagaio vulgar	Mono
Scarus sordidus	Daisy parrotfish	Papagaio margarida	Mono
Scarus viridifucatus	Round head parrotfish	P. cabeca redonda	Mono
Scorpaenidae	**Scorpionfish**	**Galinhas**	
Pterois miles	Lionfish	Peixe-fogo diabo	Namatanga
Scorpaenopsis spp.	Scorpiuon fish	Rascasso	Kindwani
Serranidae	**Groupers**	**Garoupas**	**Kushaywa**
Cephalopholis argus	Peacock grouper	Garoupa pavao	Kushaywa
Siganidae	**Rabbitfishes**	**Coelhos**	
Siganus argenteus	Streamlined spinefoot		Safi
Siganus stellatus	Stellate rabbit	Coelho margarida	Safi manga
Siganus sutor	African whitespotted rabbit	Coelho sapatiro	Safi
Sphyraenidae	**Barracudas**		
Sphyraena barracuda	Great barracuda	Barracuda bicuda	Luluva
Sphyraena flavicauda	Yellowtail barracuda	B. de rabo amarelo	Luluva
Sphyraena forsteri	Bigeye barracuda	B. de forsteri	Luluva
Sphyraena putnamie	Sawtooth barracuda	Barracuda serrote	Luluva
Syngnathidae	**Pipefishes and Seahorses**		
Corythoichthys haemopterus	Scuptured pipefish		
	Greenpipefish		
Corythoichthys schultzi	Guilded pipefish		
Hippocampus spp.	Spiky seahorse		
Synodontidae	**Lizardfishes**	**Peixes-banana**	
Saurida gracilis	Gracile lizardfish	Peixe-banana gracioso	
Synodus variegatus	Variegated lizardfish	P-b matizado	
Teraponidae	**Terapons**	**Peixes zebra**	**Oo-ee**
Pelates quadrilineatus	Four-lined terapon	Peixe-zebra aurora	Ngungungu
Tetraodontidae	**Pufferfishes**	**Peixes-bola**	**Kipweti**
Arothron hispidus	Whitespotted puffer		
Arothron immaculatus	Immaculate puffer		
Arothron mappa	Map puffer		
Arothron meleagris	Guineafowl puffer		

Arothron nigropunctatus	Black-spotted puffer		
Arothron stellatus	Star puffer		
Canthigaster bennetti	Bennett's toby		
Canthigaster solandri	Spotted toby		
Canthigaster valentini	Black-saddled toby		
Diodon liturosus	Blackblotched porcupine		
Tetrarogidae	**Waspfishes**		
Ablabys binotatus	Redskinfish		Kindwani
Triglidae	**Gurnards**	**Ruivos**	**Manzi**
Chelidonichthys kumu	Bluefin gurnard		

[i] Fish species caught in the Quirimba seagrass fishery and their scientific, common and local names. Where Kimwani names are omitted they were either not known by the fishermen as the species appeared rarely in the catch or in a few cases the specific local name was not determined. In a limited number of cases the same name was used for all members of a family. (English and Portuguese names from FAO 1990, Lieske and Myers 1996, and Smith and Heemstra 1995).