Prawn Fisheries

Background

The fisheries sector in Mozambique accounts for about 4% of GDP and 28% of foreign exchange earnings. It is estimated that the population derive 50% of their animal protein intake from fish and fish products (current per capita consumption of fish at 6.9 kg per annum). This figure is significantly increased along the coastal zone where fishing communities rely mostly on daily fish catch for subsistence and animal protein input. The sector provides employment to over 100,000 people as primary activity, and over more than three to four times this number in supporting services. Annual production of fish from marine and inland waters is estimated at around 100,000 tons, but this figure may be under estimated as production from capture fisheries and subsistence marine fisheries operations are not representative of the production output of this extensive sub-sector. The country´s fisheries production is currently around 88,000 tons (2007), of which about 76% comes from small-scale fishing, 22% from the commercial sector and 1% from aquaculture. Exports of aquatic products (prawn, fish, molluscs, sea weeds, etc.) amounted to some US$ 76 million in 2006. emphasis should be given to the prawn industry (shallow water prawn), contributing with 79% of export earnings, Over the last 10 years export earnings have been kept stable and around USD70 million per year, indicating the fisheries sector is not reflecting in an increasing economic contribution to poverty eradication. Marine fishing resources are estimated in 200,000 tons, mostly fish species. Amongst crustaceans marine prawns represent the bulk of stocks both in biomass estimated at 14,000 tons and USD economic value.

Fisheries Policy

The current **Fisheries Sector Policy** establishes as key objectives: (i) increase in domestic supply to reduce food deficit and improve nutrition and rise in living standards; (ii) to increase exports and net foreign earnings. This policy is reflected in the development aims of the Government´s five year development programme (2005-2009) and the Plan for the Reduction of Absolute Poverty (PARPA II) for 2006-09.

The general objectives of **PARPA II** are:

- Improving the living standards of fishing communities;
- Sustainable exploitation of fisheries resources;
- Continue strategies seeking to ensure permanent access to the international market for national fisheries produce, acting to guarantee quality through consolidating the fisheries produce inspection service, as well as in strengthening competitiveness and in diversifying national fisheries produce for export;
- Quality control measures through consolidating the fisheries inspection service, as well as in strengthening competitiveness and in diversifying national fisheries output for export; and

- Adequate measures to promote environmental sustainability through integrated management of marine and coastal environments and fisheries resources, and that protects important ecosystems (mangroves, corals and coastal wetlands).

While the State secures the long-term sustainability of resource exploitation, the private sector has the role of creating businesses and brings economic development.

The fisheries policy resumes on development of semi-industrial prawn fisheries and onshore processing while managing the current industrial fisheries. This as a mean to increase by-catch landings, will require upgrading and develop onshore processing, and new regulatory measures which will create the necessary opportunity for change.

The **Fisheries Master Plan 1995-2005 (PDP)**, currently under new formulation, has the following general objectives:

- Enhance domestic supply of fish products to cover the country's protein and food deficit;
- Boost the net foreign exchange revenue generated by the sector, and
- Improve the living standards of small-scale fishing communities.

Although the envisaged restructuring of the commercial shrimp fisheries, through strengthening the relative weight of the semi-industrial fishery compared with the industrial fishery in the Sofala Bank, did not happen due to an increase in the fishing effort in the industrial fishery, and although the results of the desired diversification of industrial and semi-industrial fisheries production were modest, in everything else the PDP achieved important results, particularly with regard to the withdrawal of the state from the productive sector, and the consequent reform of the public administration and increase in the role of private initiative as the engine of development, improvement in the well-being of the communities of small-scale fishermen, and the continued development of human resources.

The **Small-Scale Fisheries Strategic Plan** 2007-2011 (PESPA) has the broad aim to improve living standards of coastal fishing communities through:

- Support to fishing activities based on traditional gear and methods corresponding to their potential, and development of more advanced forms of fishing, particularly on open sea in favourable areas, providing added results;

- Provision of better health, education and water services in a framework of strengthened community capacity;

- Expansion of networks for marketing fish products and fishing gear, aiming a securing long-term sustainability and development of small-scale fishing, both in its subsistence and its commercial forms;

- Development and improvement of financial services targeting fisheries and associated community based activities;

- Strengthening of fisheries administration competence in support of small-scale fisheries.

Institutional Framework

The fisheries Administration of Mozambique centres on the Ministry of Fisheries and its respective provincial fisheries bodies, and the autonomous national institutions and their local representatives.

The fisheries sector in Mozambique is formed by four main integrated sub-systems that include ***policy making***, ***fisheries administration & management***, ***development***, and the ***industry***.

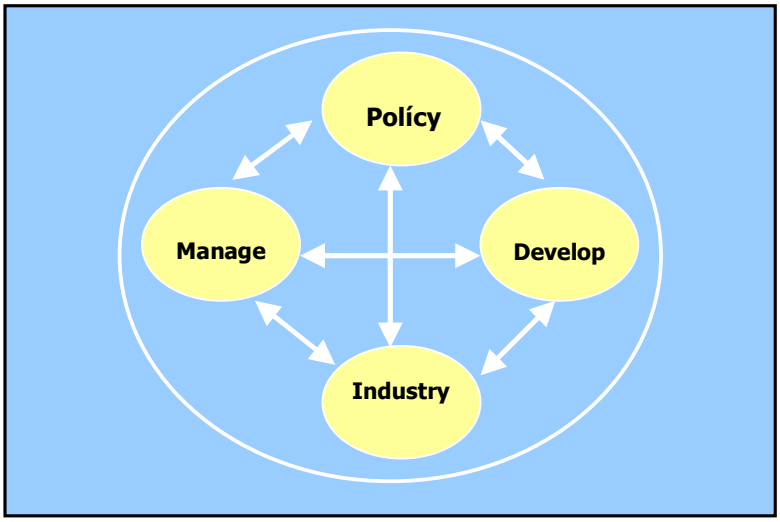

Figure x Sub-system partition of the fisheries sector in Mozambique. (Adapted from Tenreiro, 2006).

Central Level: The Fisheries administration includes the components that are represented below. The Ministry of Fisheries (MF) is the political body, and constitutes the political sub-system that coordinates the fisheries administration system. The main responsibilities of the MF concerns the establishment of fishing development policies, their expression in development plans, as well as the coordination of their implementation through performance control of the various sub-systems.

The **fisheries management sub-system** consists of the following institutions:

- **National Fisheries Research Institute** (**IIP**), whose tasks is to conduct stocks assessment, provide management recommendations and ensure that exploitation of fishing resources takes place on sustainable basis;
- **National Fisheries Administration Directorate** *(***DNAP***),* which is an integral part of the MF. Its objective is to define the conditions based on which fishing operators may have access to fisheries resources and, the fisheries inspection which seeks to ensure that the activities of the fishing operators takes place in accordance with the laws and regulations on the above-mentioned conditions of access to fisheries resources, and
- **National Fisheries Inspection Institute** *(***INIP***),* the objective of which is to ensure that the quality of the fish products, produce, exported or imported for national consumption are in accordance with the health conditions stipulated in national legislation and international provisions.

The **fisheries development promotion sub-system** consists of the following institutions:

- **National Small Scale Fisheries Development Institute** *(***IDPPE***),* which seeks to promote the development of small scale fishing, with particular attention to reducing levels of poverty and promoting well-being in the communities of small-scale fishermen;
- **Fisheries Development Fund** (**FFP**), which has the objective of controlling the financial resources used in fisheries public investments and granting of credit intended for fisheries development;
- **National Institute for Aquaculture** (**INAQUA**), which as the objective of promoting aquaculture development;
- **Fisheries School** (**EP**), which provides training at basic and medium level, to fulfil the needs of the fishing industry.

Local Level: The fisheries administration exists locally in the provinces and districts. At levels lower than district (administrative posts and locality) any power in terms of fisheries administration is exercised by the delegate of the District Administrator.

The administration of the semi-industrial and industrial fishing is exercised by the provincial body of the fisheries administration, currently integrated into the Provincial Fisheries Directorates (DPPs). In any case, the legislation always prevails (the law, regulations and management measures in force).

The administration of small-scale fishing in terms of issuing fishing licences and collecting fees, inspection and fines, is in power of the district Administrator since 1st October 2006.
The central institutions of the fisheries administration – the IDPPE, FFP, INIP and IIP – possess provincial delegations.

Coastal Environment Systems

Taking into account the characteristics of the coast, the continental shelf and the also the marine ecosystems it can be considered that there exist three dominant types of coastline, relatively homogenous in term of the continental shelf and the sea, which identify large units of fishery management, in which ecological and physical conditions are similar:

- The northern coast, with a rocky and coral-bearing sea bed, and a narrow continental shelf, with sheltered islands and bays, covering Cabo Delgado province and the northern and central districts of of Nampula province (about 700 Km);

- The sandy central cost, facing the Sofala Bank, influenced by the numerous rivers and channels and mangrove forest that provide sheltered estuarines areas, and some coastal islands, extending from the more southerly districts of Nampula province to Govuro district, in Inhambane province (about 980 Km);

- The southern coast, with sea beds sown with coral and rocks, sandy in some areas, exposed to strong winds, particularly from southern Inhambane, facing in its central region the deep water Boa Paz bank, with some sheltered bays, going from Govuro district, in Inhambane province to the extreme south of Maputo province (about 950 Km).

The different physical, ecological and hydro biological conditions in the three types of coast condition the occurrence of prawn stocks and the fishing operations undertaken. The main to refer in terms of marine prawns include:

- The *Sofala Bank*, extends over 45,000 km^2 (accounts to 64% of the national continental shelf) in centre-north Mozambique between parallels 15º 38' and 21º30' South, with a maximum breadth of 60 nautical miles in front of the Pungué River in Sofala province and depth down to 200 m;

- The Maputo bay in the South (26º) to which five important rivers discharge and important mangrove resources provides the nursing ground for prawn larvae and post larvae development;

- The *Boa Paz Bank*, between the coordinates 24º 30' South and 35º 30' East to 26º 30' South and 33º 00' East, with the discharge of Limpopo River; and

- The Rovuma River Bank at north frontier of Mozambique with Tanzania.

Fishing Industry

The shallow water shrimp fishery is the most valuable fishery in Mozambique as the country long coastline possesses important commercially exploited prawn stocks. The main fishing activity is in the Sofala Bank and the Maputo Bay with the former representing 95% of total commercial production. The industrial production in 2000 accounted to 8755 Mt export worth USD76.6 million. Although catch of industrial fishery in 2000 correspond to 35% increase of 1990's catch, this was partly due to an increase in fishing effort in reaction to the management measures introduced (mesh size and closed seasons).

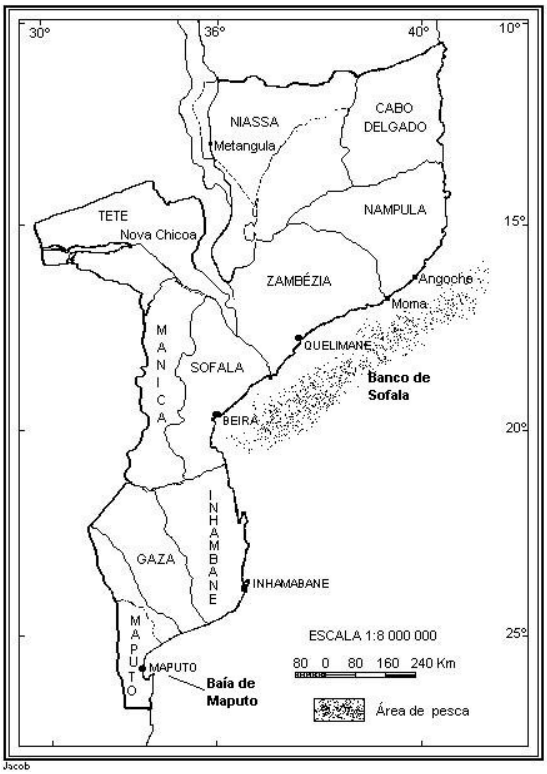

Figure x The coastline of Mozambique and location of the two most important prawn fishing grounds, the Sofala Bank (centre-north) and the Maputo Bay in the South.

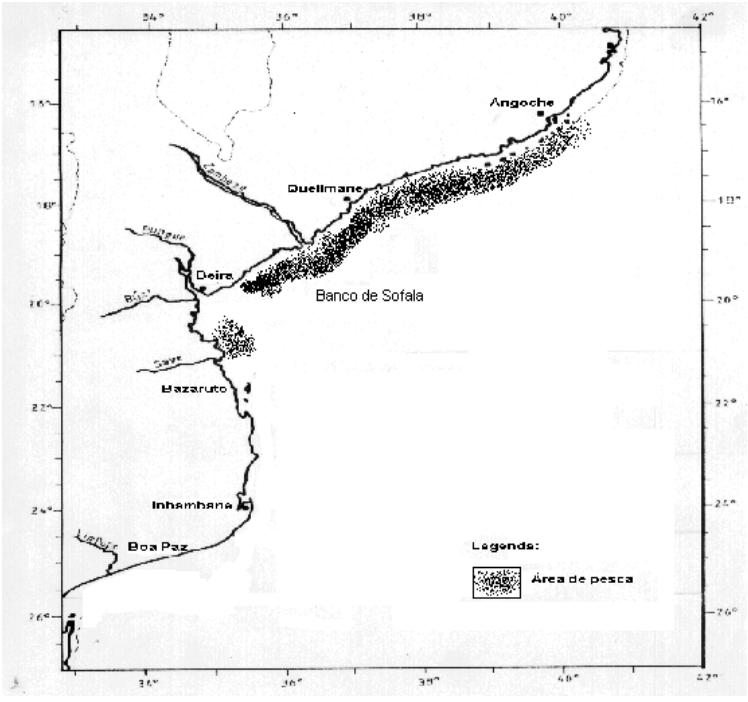

Figure x Lay-out of the Sofala Bank and location of main fishing grounds on the south end (Chiloane) and north of Beira.

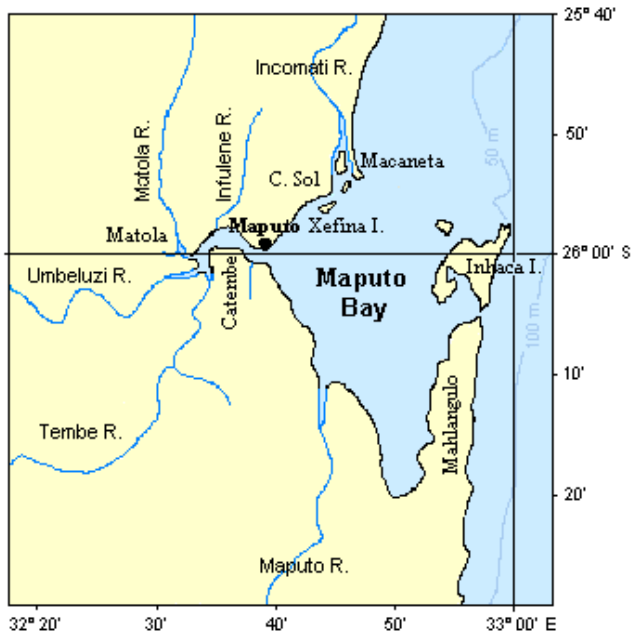

Figure xx Maputo bay were the second most important prawn fisheries is based.

The prawn fisheries in Mozambique are categorized into three sub-sectors, *viz:* small-scale, semi-industrial and industrial fisheries. These categories, apart from other considerations, are mainly based on the size of the vessels.

The small-scale fisheries are the largest of the three categories by volume as it incorporate the subsistence fisheries. This category operates vessels of less than 10 metres, and fishing along the entire coastline and inland waters with shore based operations. From a strategic perspective this fishery is also the most important with respect to employment, income, job creation, food security and maintaining the current per capita consumption of fish (6.9 kg per annum). The product is mainly for local market and home consumption.

The semi-industrial fishery which employs ice and freezer vessels between 10 to 20 metres, focus primarily on shallow water shrimp south of the Sofala Bank, Maputo Bay, Rovuma Bank and The Boa Paz Bank.

The industrial fisheries with vessel over 20 metres long is mainly export oriented. It is mainly centred on the Sofala Bank.

The majority of the shrimp trawlers, both semi-industrial and industrial are based in Maputo, Beira and Quelimane where the land based export infrastructure is well developed and the industry is well developed.

Currently there is over capacity in the shallow shrimp fishery and, it is fully exploited.

There are three types of fisheries participating on the shallow water prawn fishery at Sofala Bank in Mozambique: the small-scale represented mostly by the coastal fishing communities

subsistence fishing as the basis for living economic source, commercial semi-industrial and industrial fisheries represented by Mozambican fishing companies. However it should be recognized that trends in the small-scale and semi-industrial fleet may affect the stock assessment of the industrial fleet as they are essentially fishing the same stock.

The number of industrial vessels in 2000 was reduced to 58 from 66 and 67 for 1998 and 1999, respectively. In 1997 the catch from 2 vessels of 19.9 m (194 t) of the 'semi-industrial' (with freezer) fleet was added to the industrial fleet because their fishing ability was generally similar to the industrial fleet. The number of these semi-industrial freezer vessels added to the industrial fleet increased significantly in 1998 and 1999 with 18 and 27 vessels, respectively, and again 27 in 2000. The relative catch of these semi-industrial freezer vessels in the industrial fishery was 683 t. (9%), 1143 t. (14%) and 1295 t. (15%) in 1998 to 2000, respectively.

The catch of the industrial fishery (including the semi-industrial freezer vessels) in 1998 to 2000 was 7859, 8114 and 8755 tonnes, respectively, compared to 8419 tonnes in 1997. The 2000 catch represents an 8 % increase on the 1999 catch and the highest catch since 1981. The catch estimate of *Penaeus indicus* of 4846 tonnes for 2000 was 26% higher than 1999 and the highest since 1980 when reliable total catch estimates were available. The catch estimate of *Metapenaeus monoceros* of 2058 tonnes were 21% lower than the catch 2605 t. in 1999. The catch of other species (*P. japonicus, P. latisulcatus* and *P. monodon*) has increased from about 10% of the catch in the 1980's to about 20% of the catch since 1992 as a result of increased fishing at night.

An assessment of the small-scale beach seine prawn fishery in the Angoche and Moma regions during 1997 to 1999 showed that the catch of adult penaeids which is an incidental catch of the fishery varied from 291 t in 1997 to 62 t in 1999, which represented 1 to 3 % of the industrial fleet's total catch. In 1999 the juvenile penaeids catch was 16 t, resulting in a total small-scale beach seine catch in these two regions of 78 t compared to a catch of only 144 t. for the industrial catch for these regions. There is also an small-scale fishery using drag nets (quinia) which is currently being evaluated and the use of trammel nets is also being encouraged. The small-scale fishery is being evaluated in the region further south (17-18^{o} S) since 1998.

There is also a semi-industrial fleet (using ice rather than freezers) based at Beira to the south of where the industrial fleet operate. There were 23 boats in 1998 to 2000 catching 136, 140 and 154 t. in 1998 to 2000, respectively, which represents less than 2% of the industrial catch.

Prawn Stocks

Since 1989 the catch rate and fishing effort has been affected by the closed season and the subsequent move to night fishing. Standardizing the effort into day-time effort units for 2000, results in a decline in the 2000 effort by 19% due to the reduced number of vessels and the delayed start to the season. At current levels of effort, one cannot expect to increase the catches by increasing effort. However the high effort, increasing efficiency, and the move to night fishing may continue to decrease the breeding stock, particularly the spring spawning stock in October-November which may lead to over fishing.

The recruitment survey of 2000 showed an increase in the *P. indicus* catch rate and a decline in the *M. monoceros* catch rate for 2000 compared to 1999. This trend was reflected in the industrial catches of these two species. Unfortunately the 2001 catch rate for *P. indicus* appears as a significant outlier compared to previous years and may not be a reliable predictor of the catch in 2001. The data for 2001 requires further examination. Floods may have also affected the survey this year.

The catch data for 2001 from some vessels indicate that the catch rate was below average for March and April, probably partly as a result of lower recruitment and the earlier start of the season on 1 March. Comparison of the grade categories in March between 2000 and 2001 show that there were smaller prawns during March 2001 probably due to the start of the season on 1 March in 2001 compared to 13 March in 2000.

The differences in the closed season prior to the opening of the fishery also appear to be reflected in the mean sizes caught at the start of the season in 1997 and 2000. The mean size was greater for the 3-month closure up to 12 March in 2000 and was 18% and 29% higher for *P. indicus* and *M. monoceros*, respectively, than the 2-month closure of January-February in 1997. The increase in revenue would even be greater due to the higher prices achieved for the larger sizes and reduced costs of fishing. Any potential loss due to the mortality of small prawns by a delayed start to the season would be offset by the increase in size and value of product caught.

While the mean sizes in March and December are generally similar, the numbers of prawn are considerably greater in March, particularly for *P. indicus*, and hence a short delay to the start of the season has an immediate benefit in increased size for a significant part of the recruitment.

Fisheries Management

Prawn fisheries management centres on licensing, and establishment of fishing quotas based on TAC's (Total Allowable Catch), and closed season indicated by stock assessment

conducted by the Fisheries Research Institute. All fishing activities are subjected to regulative registration and licensing, except for small-scale fisheries.

More recently, new measures to limit the fishing effort have resulted in the closure of the prawn fisheries to new applications for licensing. The new maritime fisheries regulations aim at up-dating and contemplate new regulatory measures. Further work on prawn fisheries management is being pursued with implementation of a satellite monitoring control and surveillance system, and assessment of social and economic sustainability.

Industrial Fisheries

The number of industrial vessels in 2000 was reduced to 58 from 66 and 67 for 1998 and 1999, respectively. In 1997 the catch from 2 vessels of 19.9 m (194 t) of the 'semi-industrial' fleet was added to the industrial fleet because their fishing ability was generally similar to the industrial fleet. That is, despite being less than 20 m, they had freezers, fished away from port, and fished in the same area as the industrial fleet.

The number of these semi-industrial freezer vessels added to the industrial fleet increased significantly in 1998 and 1999 with 18 and 27 vessels, respectively, and again 27 in 2000 (Fig. 1). The relative catch of these semi-industrial vessels in the industrial fishery was 683 t. (9%), 1143 t. (14%) and 1295 t. (15%) in 1998 to 2000, respectively (see Fig. 2).

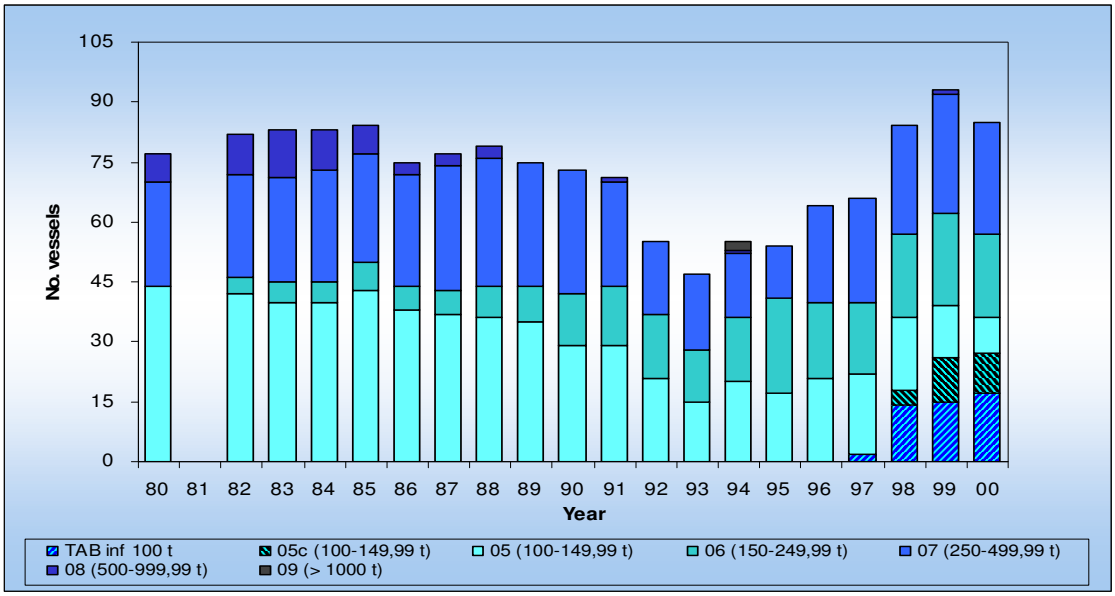

Figure Composition of the fleet by Gross registered Tonnage (GRT) for the period 1980-2000.

The catch of the industrial fishery in 1998 to 2000 was 7859, 8114 and 8755 tonnes, respectively, compared to 8419 tonnes in 1997. The 2000 catch represents an 8 % increase on the 1999 catch and the highest catch since 1981.

The catch estimate of *Penaeus indicus* of 4846 tonnes for 2000 was 26% higher than 1999 and the highest since 1980 when reliable estimates of total catch were available. The catch estimate of *Metapenaeus monoceros* of 2058 tonnes were 21% lower than the catch 2605 t. in 1999. It should be recognised that the catch split of *P. indicus* and *M. monoceros* of some vessels have been estimated using biological sampling of landed catch. The catch of other species (*P. japonicus, P. latisulcatus* and *P. monodon*) has increased from about 10% of the catch in the 1980's to about 20% of the catch since 1992 (Fig. 2) as a result of increased fishing at night. Until the early 1990's fishing was focused during the day on the two main target species.

An assessment of the catch of the small-scale prawn fishery has been undertaken in the Angoche and Moma regions during 1997 to 1999 (Masquine *et al*. 2000). This study is part of the Project for Development of Small-scale Fisheries at Nampula Province. The catch of adult penaeids is an incidental catch of the beach seine fishery with its catch varying from 291 t. in 1997 to 62 t. in 1999, which represented 1 to 3 % of the industrial fleet's total catch. In the estimate of the juvenile penaeids was 16 t resulting in an small-scale catch in these two regions of 78 t. This compares to a catch of only 144 t. for the industrial catch in 1999 for these regions as it is not an important part of the industrial fishery.

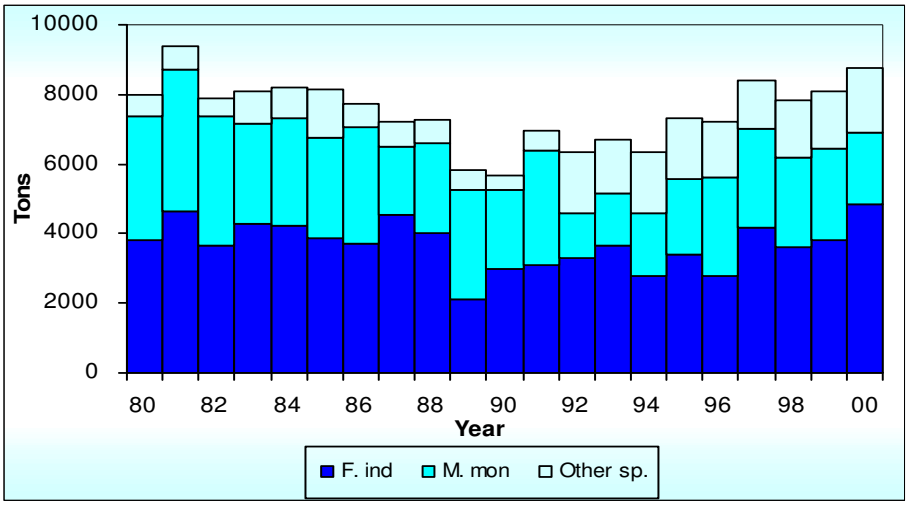

Figure Catch by species for the period 1980-2000.

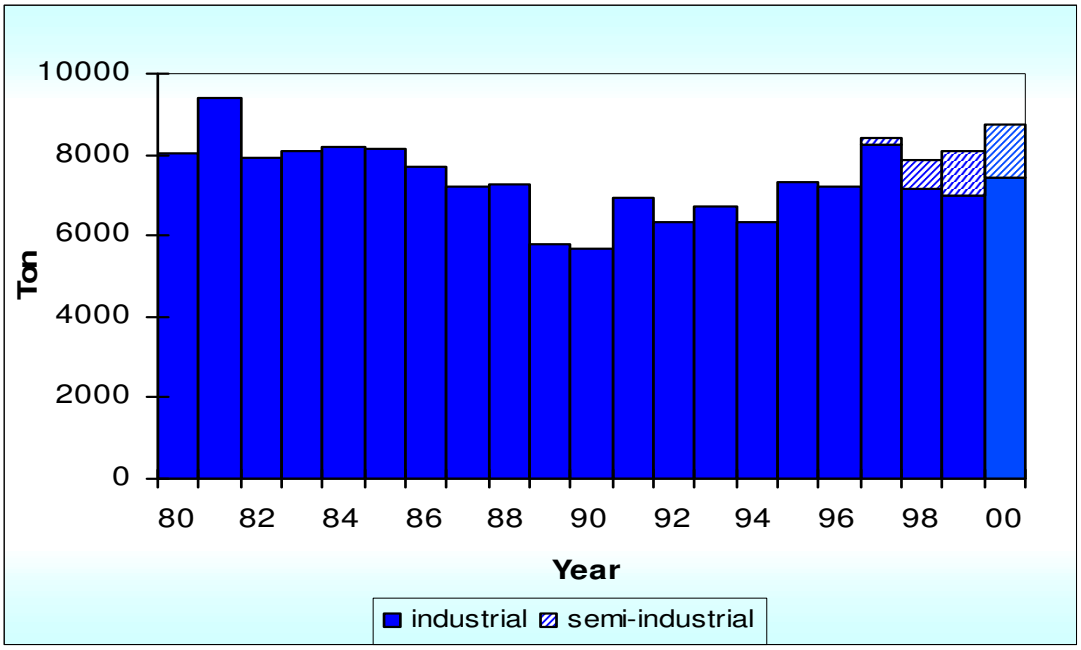

Figure Catch by industrial and semi-industrial fisheries period 1980-2000.

The 1999 small-scale prawn catch was estimated to have caught 100 t. of the small prawn, *Acetes erythraeus*, which is caught but not retained of the industrial catch.

There is also an small-scale fishery using drag nets (quinia) which is currently being evaluated in these two regions and the use of trammel nets is being encouraged in the small-scale fishery. The small-scale fishery is also being evaluated in the region further south (17-18^{o} S) since 1998 as part of an ongoing evaluation by IIP (Baloi et al 1999).

There is also a semi-industrial fleet (using ice rather than freezers) based at Beira to the south of where the industrial fleet operates. There were 23 boats in 1998 to 2000, catching 136, 140 and 154 t. in 1998 to 2000, respectively, which represents less than 2% of the industrial catch.

State of the stock

The yearly average catch per hour and the yearly total effort for the industrial fleet are shown in Figures 3 and 4 respectively. In order to be comparable over time, the catch rate and effort are expressed in standardised units, representing the performance of the VEGA-type of vessels with the previously used two-net trawl.

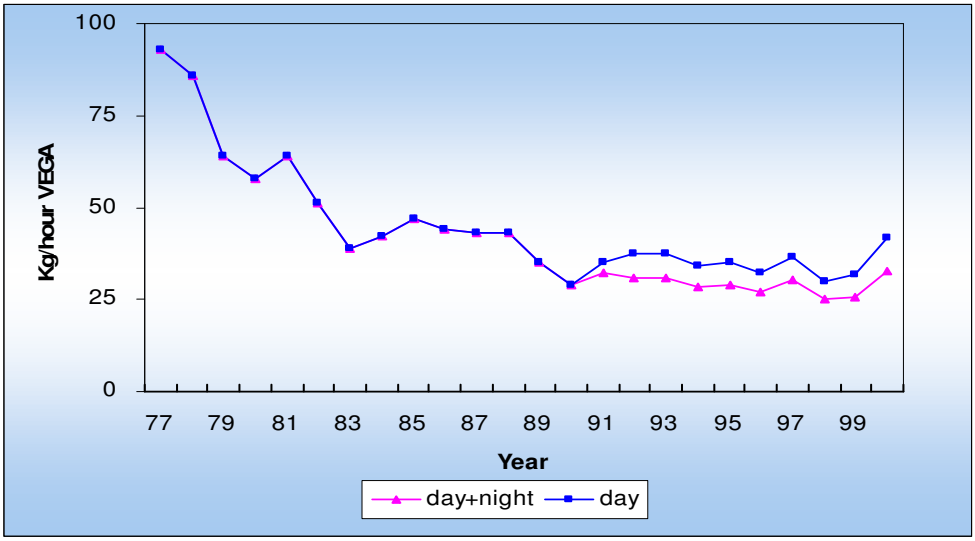

Figure Yearly average catch per hour for the period 1977-2000.

The analysis of catch rates for day and time fishing has been possible since 2000 with the development of a new database with catch by species and fishing effort available for each trawl. This analysis is important as it takes into account the lower catch rates for the prawns, *P. indicus* and *M. monoceros,* at night mainly in water depths greater than 20 m. These data have been used to further standardize catch rates and fishing effort since the advent of night fishing in the early 1990's in equivalent day-time effort units for Vega-type vessels (Figures 3 and 4).

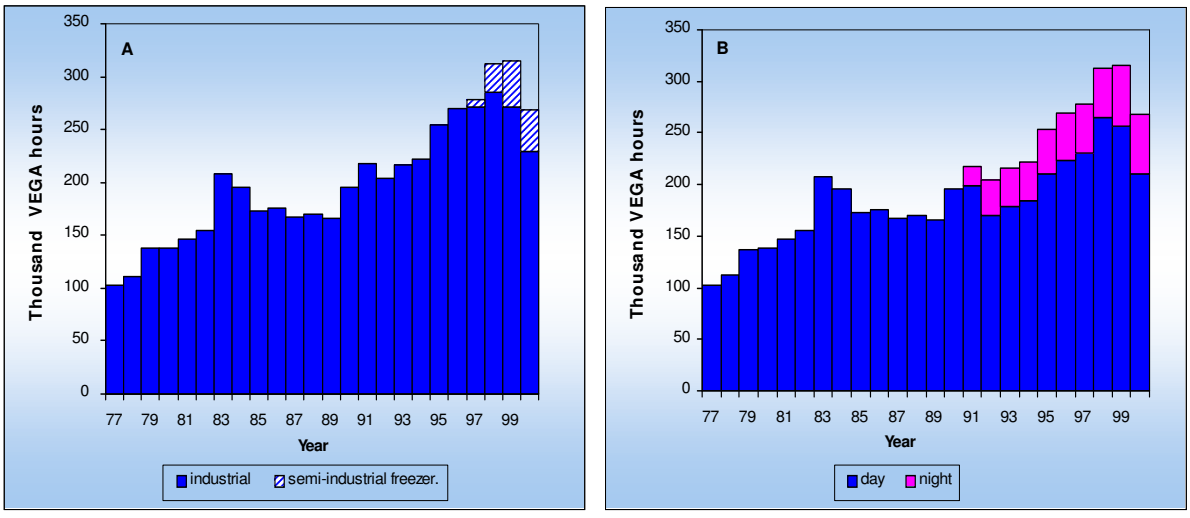

Figure Yearly total effort for the period 1977-2000. **A** Industrial and semi-industrial freezers; **B** Day and night fishing.

The estimates of the catch-per-hour for combined day and night has increased in 2000 compared to 1999 as a result of improved recruitment. The standardised fishing effort in total hours fished has decreased by 19% mainly as a result of the reduced number of vessels and delayed start to the season (Fig. 4). Accordingly, fishing mortality has declined compared to 1998 and 1999 but still significantly higher than the 1980's. Since 1989 the catch rate and fishing effort has been affected by the closed season and the subsequent move to night fishing.

Prediction on Catch and Biomass and Recommendations for Management

Prediction is made using a length based yield-per-recruit and a biomass-per-recruit according to the Beverton approximation. As catches depend largely on the recruitment, the predictions are given for 3 different levels of recruitment for *F. indicus* and *M. monoceros*. The 'poor', 'average' and 'good' recruitment levels use the lowest, average and highest values of recruitment respectively, during the last 5 years. For each of these scenarios, catch and biomass estimates are presented at the current level of effort, and at fishing mortalities that would give the same average biomass observed during 1982-87, a period when the fishery was more stable.

It is recommended that the long-term level of effort be continued to be reduced to 180 000 standardised hours, which represents about a 14% reduction of the effort in 2000. The main objective is to bring the effort down to a level where a higher average catch with a higher mean size (which is generally more valuable) can be expected. This is also safer with respect to sustaining the stocks. As in previous years, the situation in mid 1980's (1982-87) is suggested as an appropriate target. This is not necessarily the optimum with respect to long-term yield, but represents a period where the recruitment and the catches were generally better than in the 1990's, and the levels of stock biomass and recruitment were quite stable.

It is recommended that the long-term level of effort be continued to be reduced to 180 000 standardised hours, which represents about a 14% reduction of the effort in 2000. In 2001 the number of vessels is similar to the previous year but the fishery commenced on the 1 March so that the effective effort is expected to increase. The main objective is to bring the effort down to a level where a higher average catch with a higher mean size (which is generally more valuable) can be expected. This is also safer with respect to sustaining the stocks. As in previous years, the situation in the mid 1980's (1982-87) is suggested as an appropriate target. This is not necessarily the optimum with respect to long-term yield, but represents a period where the recruitment and the catches were generally better than in the 1990's, and the levels of stock biomass and recruitment were quite stable.

More specifically, a balance between recruitment and biomass corresponding to the average recruitment and biomass in the years 1982 - 1987 would require a fishing mortality of 2, which corresponds to the recommended effort level of 180 000 standardised hours. This fishing mortality is also close to the $F_{0.1}$ of 2.16. The average biomass during 1982-87 was

about 24% higher than in 2000. Based on the relationship between stock biomass and recruitment (Fig. 9), this increased biomass would result in an average recruitment and catch comparable to that of 1982-87 unless there are other factors which have lead to the generally lower recruitment in the 1990's.

If the effort was reduced to 180 000 standardized hours in 2002 and assuming a similar range of recruitment, the loss in catch in 2002 would be expected to be about 5% (Table 3), and part of this catch would be available the following year at a larger size. The gain in average biomass is expected to be about 19%.

The effect of reducing effort, using combinations of closed season and reduced fishing effort, on catch and average biomass, are compared to that estimated in 2000 (Table 4). These calculations were done assuming the same recruitment as in 2000, and therefore show only the immediate effect of these measures.

The scenarios show the effects of a 15% effort reduction and different combinations of a 3-month closed season during December to March. Closing in December has very little effect in reducing the current fishing effort as it is a low catch rate month and some vessels stop fishing because they reach their quota. However it does protect the commencement of the recruitment that occurs in December. Clearly closing March has a major impact in protecting the high abundance of recruiting prawns, particularly *P. indicus*. This allows the prawns to grow for an additional period before capture and reduces the overlap with the small-scale fishery. The beneficial effect of a March closure was demonstrated in 2000 as the good recruitment combined with a delayed start to the season resulted in a very good catch of *P. indicus*.

Another variation on this March closure option is to close the recruitment grounds close to the coast (say less than 15m) during March that allows some fishing in March on the larger prawns in deeper water but allows additional opportunity for the smaller prawns emerging from the rivers and coastal areas to grow to a more valuable size. It also reduces the overlap with the small-scale fishery. The assessment of the mean size from the grade categories for 2000 by month, depth and location highlights the increasing size by month and depth. Also, the introduction of the VMS to monitor effectively the fishing position of vessels would be useful.

Table 4. Different scenarios using as a basis 2000 data (same recruitment and effort)

		Catch *P.ind+M.mon* (t)	(%)	Biomass *P.ind+M.mon* (t)	(%)	Average weight in the catch (g)	(%)	Total Catch (t)
Recruitment and effort 2000 (211 thousand h) Closed season - 16 Dec - 12 Mar		7422	0.0	3627	0.0	22.6	0.0	9350
Effort (2000) - 211 thousand h	Closed season - J-M	7053	-5.0	4032	11.2	23.2	2.7	8885
Effort - 180 thousand h	Closed season - J-M	6716	-9.5	4342	19.7	23.7	5.1	8461
Effort - 180 thousand h	Closed season - D-M	7127	-4.0	3931	8.4	23.2	2.6	8978
Effort - 180 thousand h	Closed season - 15 D-15 M	6938	-6.5	4124	13.7	23.5	3.8	8740

The overall management of this fishery is by a combination of effort control (ie number of vessels, closed season) with some control on catch quota. However in many years the catch quota is not achieved. When companies easily achieve their quota they are generally provided with additional quota. This indicates that effort control, rather than quota control, is the effective controlling mechanism for this fishery.

With fisheries whose catch is generally based on each year's recruitment, ie basically a 1-year life cycle, it is difficult to use quota as an effective management tool. If the quota is set too low and there is good recruitment then the full benefit of the good recruitment is not achieved or the quota needs to be increased as occurred in 1997, for example. More serious is the scenario when the quota is set high and a poor recruitment occurs. If the fleet has the capacity to increase its effort in an attempt to achieve its quota, it will result in a severely depleted breeding stock and subsequent low recruitment. On the other hand, effort control in a fishery with a short life cycle usually results in similar proportion of the stock being taken each year. Thus if effort controls are set at proper levels and there is not the ability to greatly increase effort (ie high level of latent effort) then the fleet does not have the ability to take a high catch in a year of low recruitment.

Effort controls also require a need to assess the changes in efficiency of the fleet as an increase in fishing effort may not only be due to vessels fishing more days per month or more hours per day but it can also result from vessels becoming more efficient in catching prawns. This can occur through the use of larger or modern vessels, increasing horsepower of engines, using four nets and wider head rope lengths, using electronic searching equipment such as satellite navigation systems (global positioning systems), increased knowledge of distribution of species abundance and migration, enabling better targeting of

species. It is important that information is maintained about the trends in vessel characteristics, gear and equipment so that increases in efficiencies are taken into account when assessing the status of the stocks.

Of these factors affecting efficiency, head rope length is probably the most important and management should obtain this information on their form to license vessels. The availability of historical data should also be examined. Thus a system of not only stipulating the number of vessels allowed to fish but also specifying the total head rope length allowed for the companies should be examined. Companies may then be allowed to choose the configuration of head rope length between the vessels in its fleet.

Fisheries become vulnerable to overfishing when there is a high level of exploitation and recruitment for a given year that happens to be low, possibly due to environmental conditions. The combination of high exploitation with low recruitment can be a recipe for severe depletion of a stock that may take many years to recover. The multi-species nature of this fishery means that it may be economical in the short-term to fish in an area even when catch rates of a given species are severely depleted as there are other species to fish; this continued fishing prevents the recovery of a depleted stock. Due to the high turnover rate in the stock this reduction may come rapidly. If an attempt is made to compensate for this lower catch rate by increasing effort further, the reduction of the stock may become quite severe.
In conclusion, it is important that the fishing effort in this fishery is tightly controlled as the fishery is fully exploited and every attempt should be made to reduce the effort to ensure its long-term viability under different environmental conditions. The control of fishing effort should not only be based on the number of vessels and seasonal closures but should also be focused on the head rope length. The options for effort reduction discussed above generally involve a small short-term catch reduction and result in a more-valuable size of prawns combined with a reduction in costs and hence there should be little or no loss of income.

Recommendations for Future Research

Some recommendations for future research that will assist in the stock assessment process include:

- Further examination of the logbook data may be useful in the following areas:
    - The fishing power of the Antares fleet is about 20-30% greater the Vega fleet. This approach may enable the use of more vessels in the assessment of the fishery as recommended by Caputi et al. (1998) and in the review by Nance (1999). This would allow a better assessment of southern part of the fishery not regularly fished by Efripel but covered by Pescamar.

- Some vessels do not provide species breakdown for *P. indicus* and *M. monoceros* which is fundamental to the stock assessment. There is currently a sampling programme undertaken to provide this estimate of species breakdown and other biological data, however, further means to improve this species breakdown should be investigated.

- Comparison of day-night catch rates by species and depth highlight the differences in catchability between species during day and night and variation in abundance by depth (Caputi et al. 2000). The seasonal and annual variation as well as interactions such as month-depth would also be useful.

- Statistical analyses of 1999 production data enabled a comparison of the fishing power of all vessels based on catch per day over all species (Caputi et al. 2000). This information can then be compared to vessel, gear and equipment characteristics (eg vessel length, head rope length, HP, GPS) that affect the fishing effectiveness of vessels. Examination of data over a number of years will show trends in efficiency.

- The biological sampling data collected by IIP enables an assessment of the size at maturity and monthly variation in the percent of spawning females. These data based on 1998-99 data indicate that spawning occurs for most of the year but with two periods of increased spawning - about April and September for *P. indicus*, and June and October for *M. monoceros* (Caputi et al. 2000). Thus the closed season provides some protection to prawn stocks prior to the April-May spawning. However the low catch rates at the end of the fishing season, October-November, may result in a very low spring spawning stock. This biological information can also be used to develop an alternative estimate to monitor the breeding stock based on catch rates from logbook data. Information on the location and depth of fishing may be available in recent years by linking this data with the logbook and this would assist in refining breeding stock index.

- Comparison of recruitment research surveys from February 1991-1995 and from 1998 onwards. A preliminary relationship between catch, effort and the recruitment survey abundance has been developed (Appendix 1) which should be tested with more years of data.

- Continue research surveys with industry vessels to monitor breeding stock in Oct-Nov and recruitment in Feb (and March if possible). Use of standardised recruitment and spawning research surveys should be considered annually to better understand the annual variation in recruitment and spawning. This can be done in a cost-neutral way by allowing the catch to be kept by fishers or compensating them by some other way eg additional quota. This avoids the continual problem of trying to interpret catch rate information when there are changes in fishing efficiency, targeting practices, gear, vessel, market price, etc.

- Understanding environmental effects on the recruitment of the key species will assist in understanding of variation and trends in recruitment eg whether they are due to the environmental changes or due to the spawning stock. Collection of key environmental data, eg rainfall, river run-off, sea-surface temperature from satellite data, should be obtained.

- A greater participation in the logbook programme should be encouraged as this would give a wider coverage of the area fished and provide further information on the relative fishing efficiency between vessel types.

- Understanding of the trends in the small-scale and semi-industrial fleet should continue as this also helps assist the stock assessment of the industrial fleet as fisheries cover the same stocks. An increasing or decreasing trend in one of these fleets may affect the subsequent catch of industrial fleet.

- The study of the small-scale fishery for prawns also enables a study of the relationship between juvenile prawns inshore and adults in the offshore commercial catch which may enable a prediction of the catch.

Prawn Processing and Quality Control

Prawns from the industrial fleet are processed, packed and frozen on board while the semi-industrial fleet process the catches in onshore facilities, except for some vessels with freezing capacity inboard. Most of production of the small-scale sector is marketed locally on ice or exported frozen to the region.

The main markets for frozen products are the EU, Japan and South Africa, the two first being the most important and attractive. However these are also with the highest quality certification requirements.

A quality control system is being developed to ensure that prawn products can meet the import requirements of the major markets. This is being applied strictly in respect to the EU

market. The prawn exports is taking place based on EU certification that enables the fisheries authorities to certify products from processing plants which operate accordingly to sanitary fisheries inspection and quality control regulations.

Laboratories to monitor prawn processing, quality control and certification for export are being built in the three major fishing ports of Maputo, Beira and Quelimane, and are expected to be in operation in 2002.

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