Fisheries Resource Accounts for the Maputo Coastal Districts of Mozambique

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Abstract The main purpose of compiling national income accounts is to provide a comprehensive overview of the nation's economy and to facilitate decision-making by policymakers. The most important indicator in national economic accounts is the gross domestic product (GDP). However, GDP ignores the interactions between economic activity and the environment (including natural resources), although these interactions have become increasingly evident. In Mozambique, as a result of population growth, persistent rural poverty and a fast pace of growth and development in the private sector, the degradation of a number of environmental and natural resources has reached such proportions that the economic growth capabilities are already being compromised. However, the economic effects of these trends are not reflected in the traditional GDP based upon which most economic policy decisions are made.

Keywords UN SEEA for fisheries • Management of renewable resources • Fisheries resource rent • Economic sustainability • Mozambique

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1 Introduction

A response to the shortcomings of conventional economic accounts has been the development of environmental accounting. Integrated Environmental and Economic Accounting (SEEA 2003) builds on the existing system of national accounts. It brings together economic and environmental information in a common framework to measure the contribution of the environment/natural resources to the economy and the impact of the economy on the environment/natural resources. It provides policymakers with indicators and descriptive statistics to monitor these interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development (UNSTATS 2005). It generates and systematically assembles data needed to support a set of environmental and resources policies that will be consistent with overall economic sustainability. In Mozambique, policy documents such as the Biodiversity Strategy and Annual Planning for Mozambique recommend including the depletion of natural capital in the analysis of economic growth indicators.

With funding from the Swedish International Development Agency (SIDA), the Centre for Environmental Economics and Policy in Africa (CEEPA) at the University of Pretoria supported implementation of natural resource accounting (NRA) in four countries in Eastern and Southern Africa (Tanzania, Uganda, Ethiopia and Mozambique). In Mozambique, the NRAESA project was implemented on a pilot basis in the fisheries and water sectors. This chapter presents the findings of the pilot project on fisheries resource accounts.

The objective of this study was to initiate a process leading to the institutionalisation of natural resource accounting (NRA) in the fisheries sector. The emphasis was on demonstrating the UN system of environmental and economic accounting for fisheries (SEEAF) methodology and its practical applicability to developing satellite accounts for the sector. Environmental-economic accounts in fisheries can provide measures of the economic value of stocks and changes in volume of the stocks as result of fishing activities and/or other environmental impacts. The expected results will demonstrate how the satellite fisheries NRA can be used to correct the traditional indicators of economic performance provided by the system of national accounts (SNA). This study establishes the classification to be used in constructing marine fisheries accounts for Mozambique and estimating the physical and monetary accounts for the fisheries.

2 The Fishery Sector of Mozambique

Fisheries are important in Mozambique contributing more than 2% of the national gross domestic product (GDP) (INE 2005). However, the sector's potential is not very high, and there is not much room for growth as Mozambique's coastal tropical waters are warm and relatively less productive compared to the waters of other countries off the East African coast. It is estimated that the potential for sustainable catch of all species combined in Mozambique is about 300,000 tons a year, and about half of that is being caught at the moment (DNEP 1994).

The fisheries of Mozambique are classified into artisanal or industrial (also called commercial) depending on the types of fishing boats employed. In general, artisanal fishers do not have formal settings for their business but rather operate under informal schemes. By regulation, they can operate boats up to a maximum of 10 m in length, and when powered, the engines are limited to a maximum of 100 HP (74 KW). Commercial fishers, which include industrial and semi-industrial operators, are obliged by law to register their enterprises. The main difference between industrial and semi-industrial commercial enterprises is the size and engine power of their boats. A semi-industrial boat is typically under 20 m length and fitted with engine not exceeding 350 HP (259 KW) of propulsion power. Industrial boats permitted to fish in the coastal area (within 12 nautical miles) are over 20 m in length but generally not greater than 40 m. By regulation, industrial fishing boats can be fitted with engines not exceeding 1,500 HP (1,110 KW) of propulsion power. Tuna fishing boats, operating in the Exclusive Economic Zone (EEZ), are not subject to the building and construction specifications of the Maritime Fisheries Regulation (2003).

According to the national fisheries policy, artisanal fishing is reserved for national citizens and operated by local communities found concentrated in the so-called fishing centres. The main species for the artisanal fishery, ranked by the quantity of catch, are finfish (e.g. *magumba*), prawn, shark, octopus/squid and crab. The catch of prawn by artisanal fishers is mostly composed of non-penaeid shrimps. Artisanal fisheries represent an important source of cash income and food for coastal communities and employ a significant number of people. Between 70,000 and 100,000 fishermen are estimated to be directly involved in this fishery. According to an IDPPE census (2002), approximately 8,000 additional people are involved in other artisanal fishery-related activities. Commercial fishing in Mozambique is open to foreign direct investment. The observed situation is to have joint ventures between Mozambican and foreign commercial fishing companies, with the foreign partners holding the majority of shares. About 60% of the commercial shrimp fishing business is controlled by three joint venture companies with Spanish majority private capital. Other smaller joint venture companies include firms originating from other European countries, Japan and South Africa. The main species for the industrial and semi-industrial fishery, ranked by the quantity of catch, are kapenta, prawn, tuna, by-catch (small pelagic fish species) and deep-sea fish. With the exception of kapenta, all others are sea fisheries. Kapenta is a freshwater fish from the man-made Cahora Bassa Dam found in the central province of Tete. Whereas artisanal fishing is of key importance for domestic supply of relatively cheap protein with over 60% of fish landings, commercial fishing is an important source of export revenues.

Table 1 shows that over 67% of the fishing catches in Mozambique (2003–2005) are artisanal and less than 35% are industrial or semi-industrial (tuna excluded from the totals as it is fished by foreign fleets). Note from Table 1 that catch data for artisanal fisheries is underestimated due to the fact that over the reported period,

Table 1 Industrial (including semi-industrial) and artisanal fishing catches of Mozambique (tons)

Description (in tons)	2003 Industrial	2003 Artisanal	2003 Total	2004 Industrial	2004 Artisanal	2004 Total	2005 Industrial	2005 Artisanal	2005 Total
Sea crustaceans	9,320	6,191	15,511	9,417	3,985	13,402	10,602	1,932	12,534
Shallow-water prawns	7,690	5,835	13,525	8,106	3,783	11,889	8,520	1,759	10,279
Deep-water prawns	1,425	–	1,425	993	–	993	1,774	–	1,774
Crayfish	124	–	124	132	–	132	149	–	149
Lobster	–	–	–	2	–	2	1	12	13
Crab	81	356	437	184	202	386	158	161	319
Sea fish	1,075	58,188	59,263	484	52,176	52,660	660	50,917	51,577
Pelagic fish	–	57,759	57,759	–	51,908	51,908	–	50,024	50,024
Deep-sea fish	1,075	–	1,075	484	–	484	660	–	660
Tuna fish[a]	*7,450*	–	*7,450*	*14,783*	–	*14,783*	*5,396*	–	*5,396*
Sharks	–	429	429	–	268	268	–	893	893
Freshwater fish	10,978	–	10,978	18,760	–	18,760	12,991	–	12,991
Kapenta	10,978	–	10,978	18,760	–	18,760	12,991	–	12,991
Pende		–	–	–	–	–	–	–	–
Tiger		–	–	–	–	–	–	–	–
Molluscs	131	389	520	195	255	450	165	239	404
Octopus/squid	131	389	520	195	255	450	165	239	404
By-catch	1,608	–	1,608	1,354	–	1,354	1,830	–	1,830
Others	–	2,306	2,306	–	3,962	3,962	–	4,660	4,660
Total	23,112 (26%)	67,074 (74%)	90,186	30,210 (33%)	60,378 (67%)	90,588	26,248 (31%)	57,748 (69%)	83,996

Source: DNEP (Ministry of Fisheries) (2003)

[a]Tuna is fished by foreign fleets, so it should not be included in the national fish production

only five coastal provinces were covered by the fisheries statistics system: Maputo, Inhambane, Sofala, Zambézia and Nampula. No artisanal catch data was available for the remaining two coastal provinces of Gaza and Cabo Delgado and for the entire inland fisheries.

In the central and northern provinces of Mozambique where richer fishing grounds can be found, fisheries play an even bigger role in the economy than in Maputo province. Fishing from the central provinces is especially important in supplying Maputo city markets. To satisfy internal demand especially in the main urban areas, Mozambique also imports fish, for example, mackerel from Namibia and Angola, estimated at 15,000–20,000 metric tons per year (*author's estimates*). As the demand for fish is huge in Maputo city, additional fish and prawns are imported from Inhambane and Gaza provinces.

Table 2 shows the commercial value of fish exports for the period 2000–2005. Note from the table that shallow-water and aquaculture shrimp accounts for 85% of the total value of exports. Gamba and kapenta are the second and third most important export species, with 7 and 4% of export value, respectively. Table 2 does not include exports of fish from artisanal production. No substantial catch from artisanal fish suppliers reaches official export markets. Exports from artisanal fishers are to a great extent channelled to regional markets informally. Although some of the artisanal fish production is sold to local fish processors, most of these processors do not meet the international standards for quality assurance, meaning that a negligible portion of the output from these contribute to export volume.

The aquaculture industry in Mozambique is recent with the first commercial production recorded in 2002. The potential for aquaculture development is estimated at over 30,000 ha of readily available land for marine shrimp culture and over 258,000 ha for the culture of freshwater species (DNEP 1994). So far, slightly over 2,500 ha of marine shrimp culture have commercially been developed with the highest harvest of 1,106 tons of prawns recorded in 2005. Sea algae culture was another successful commercial undertaking in aquaculture development, but at the moment, there is a decline in production (Table 3).

Freshwater fish culture is developing at the household level in almost all provinces, with Manica and Tete provinces taking the lead. The production is essentially for self-consumption, but there is one entrepreneurial operation in Manica province, producing freshwater fish at commercial scale and with prospects to enter the export market.

In 1995, the government adopted a fisheries policy whose main objective is sustainable development of fishing activities, enhancement of the economic value of small-scale fisheries production and development of commercial aquaculture with special attention to boosting fisheries exports. The fisheries policy emphasises the increase of fish availability for domestic supply through adoption of small-scale production technologies with potential for reducing postharvest losses, augmenting fish landings and ensuring that more fish reaches consumer markets.

The main management tool in the fisheries sector is licensing. Up to 1990, the management and regulation of fishing licences was governed by the Marine Fishery Regulations 1971, the Shrimp Fishery Regulations 1971 (Ministry of Fisheries 1971a, b)

Table 2 Mozambique fish exports (2000–2005)

Description	Annual exports (in thousand US$)							
	2000	2001	2002	2003	2004	2005	Total	(%)
Lobsters	1,122.00	220.0	1,100.0	230.0	334.4	69.8	3,076.2	1
Crabs	234.0	306.0	330.0	1,301.0	575.4	360.1	3,106.5	1
Gamba (deep-sea prawns)	8,077.0	10,471.0	7,500.0	5,061.0	4,519.6	3,163.2	38,791.8	7
Finfish	1,563.0	2,163.0	1,250.0	1,113.0	1,516.5	460.1	8,065.6	2
Shallow-water shrimp	87,561.0	83,979.0	72,800.0	71,665.0	72,671.0	44,070.8	432,746.9	83
Aquaculture shrimp	–	–	–	3,915.0	1,285.8	3,223.9	8,424.7	2
Subtotal shrimp	87,561.0	83,979.0	72,800.0	75,580.0	73,956.8	47,294.8	441,171.6	85
Cray fish	940.0	1,160.0	700.0	1,275.0	1,165.0	432.0	5,672.0	1
Octopus/squid	150.0	205.0	250.0	212.0	506.3	122.7	1,446.0	0
Kapenta	4,576.0	2,066.0	2,441.0	3,309.0	6,179.3	1,856.2	20,427.4	4
Marine algal-aquaculture	–	–	–	–	110.4	43.0	153.4	0
Other	3.0	10.0	10.0	4.0	0.0	0.2	27.2	0
Total	104,226.0	100,580.0	86,381.0	88,085.0	88,863.7	53,802.0	521,937.7	100

Table 3 Commercial aquaculture production in Mozambique 2002–2006 (in tons)

	2002	2003	2004	2005	2006
Shrimp (tons)	600	329	450	1,106	613
Algae (tons)	155	523	129	20	15

and the Inland Waters Fishery Regulations (Ministry of Fisheries 1960). With the promulgation of the Fisheries Law in 1990 which established the Ministry of Fisheries, existing licensing powers were revoked, and the issuing of fishing licences and licences for aquaculture was made the exclusive responsibility of the new ministry. As from 1997, new Marine Fishery Regulations took effect which laid down licensing procedures and also defined the types of fishing techniques that may be used (DNEP 1997). In 2003, a new Maritime Fisheries Regulation replaced the one of 1997. Inland fishing still lacks specific regulations so that its management still relies on the 1990 law (Ministry of Fisheries 1990) and the Marine Fisheries Regulation of 2003 (Ministry of Fisheries 2003). Aquaculture Regulation was adopted in 2001, which establishes extensive and semi-intensive production systems for marine shrimp culture, whereas artisanal production is limited to extensive systems only (Ministry of Fisheries 2001).

With the exception of subsistence activities, all fishing and aquaculture activities are subject to licensing. The issuing of a fishing licence is subject to payment of an annual fee, the amount of which is fixed by a joint dispatch from the Minister of Fisheries and the Minister of Finance. The fees are applied according to the type of fishing (industrial, semi-industrial and artisanal), and within each type of fishing, they vary according to the commercial value of the resource being caught. Every year, the total allowable catch (TAC) and quotas for each of the industrial species are established. For fisheries regarded as non-excedentary[1] (such as the shallow-water shrimp, gamba and large demersals, i.e. line fish), the quotas granted refer to the maximum allowable catch per vessel or series of vessels per company. Semi-industrial fishing (specifically with boats without freezing on-board capacity) is not subject to quota limits, even when fishing the same non-excedentary species mentioned above. The economic agents operating in the fisheries sector, mainly the industrial and semi-industrial fishing companies or groups of artisanal fishermen, participate in decision-making on matters concerning fisheries management especially on matters concerning the establishment of TAC's, fishing quotas and the number of vessels to be licenced per fishery, among other issues. This consultation takes place through the fishery administration commission (CAP), which is a consultative body that brings together representatives of the fisheries administration and of the fishing industry through the industry's associations or fishermen's associations. The Minister of Fisheries takes his final decision on TAC's and quotas after listening to the opinion of the fishery administration commission. Whereas for artisanal and semi-industrial fishing the tax is paid upon issuing of a fishing licence for each boat, industrial fishing is taxed on the basis of quotas allocated for the fishing season.

[1] Non-excedentary is a terminology utilized in fisheries literature to mean low stock relatively to catching capacity, therefore requiring rather restrictive management measures.

All fishing, except for subsistence, requires licensing. Quotas and number of vessels per individual company are the main control measures, and fees are subject to quota. For industrial shrimp trawlers, gamba trawlers and industrial line fishers, there are fees per individual quota. For the rest, there are annual fees per fishing licence. In commercial shrimp fishery, there are fishing rights granted to traditional operators, as the fishery was declared closed for new comers as from 2000. On this basis, a maximum of 78 freezer trawlers are licenced every year.

3 The Maputo Province Case Study

This case study is limited to the coastal districts of Maputo province: Manhiça, Marracuene, Maputo City and Matutuine district. These administrative units constitute the working definition of the coastal zone in Mozambique. This area was chosen to embrace a clearly defined zone in an area that is well accessible. Maputo province, with an area of 26,358 km^2, had a population of 2,152,000 in 2003 (INE 2004). The majority of people live in the coastal districts. In general, the Mozambican population tends to concentrate around 50 km from the sea maximising the use of water, marine and terrestrial resources. The Mozambican coastal resources include fish stocks, coral reefs, land, beach, mangrove forests, flora, fauna, water and air. The main species for artisanal fishing in the province, ranked by captured amounts, are finfish (small pelagic species such as horse mackerel), prawn, crab and octopus/squid (Table4).

Most of the available statistical information on fisheries currently exists either at the national or provincial levels, but it is not disaggregated to the district level. It was therefore necessary to assume in this study that no significant inland fishing activity takes place in Maputo province. This allowed the research team to collect primary fisheries data only from coastal areas. There was also the likelihood that existing secondary statistical information was incomplete or incorrect. This meant that all information collected from primary sources was closely scrutinised before being used in this study.

A total of 5,458 persons were involved in fisheries activities in 2002 in the province; they were working as sailors, fishermen without vessels, in fish processing activities and in boat repairing among others (IDPPE 2002). The fisheries sector consists not only of fishermen and sailors but also of fish vendors who buy fish from fishermen and then sell it at the markets. This means that the number of people involved in fisheries is much higher than those operating in the boats. The IDPPE study also showed that there were 532 fishing boats counted in 2002 with an estimated 2,218 fishers. According to the IDPPE study, there were 34 fishing centres in the province in 2002. A fishing centre is the landing site for artisanal fishers, where the catch is unloaded and sold to local vendors and where the fishing boats and gear are regularly checked. It is maintained by the fishermen themselves, and it functions as a kind of informal association of the fishermen. They select a leader who has the contact with the Ministry and manages the centre.

Table 4 Captured amounts of the main artisanal fishing species in Maputo province (tons)

Year	Prawn	Finfish	Crab	Octopus/squid	Other	Total
2004 (tons)	445	3,705	4	0	261	4,415
2005 (tons)	451	2,755	9	3	188	3,406

Source: IIP – Fisheries Research Institute (2005)

Table 5 Fish catch by kind of fishing gear in Maputo province in 2004 (in tons)

Gear type	Gillnet	Line fishing	Beach seines	Total
Fish caught (tons)	3,276 (92.2%)	92 (2.59%)	185 (5.21%)	3,553 (100%)

Source: IIP – Fisheries Research Institute (2005)

Table 6 Classification of fisheries accounts for the study area

Species	Gamba rosa	Magumba	Marreco
Fishing operator	Industrial fishing	Artisanal fishing	Artisanal fishing, semi-industrial fishing
Fishing vessel	Industrial vessels	Artisanal boats (motorised and nonmotorised)	Artisanal boats (motorised and nonmotorised)
Fishing gear	Bottom trawl	Gillnet	Line

In these centres, there are people with carpenter or mechanical skills to build, maintain and repair boats and engines.

Industrial fishing in the province is only for the gamba fishery (deep-sea prawns) which is almost 100% based in Maputo. Additionally, a few semi-industrial ships are operating in the waters off Maputo Bay, mainly for prawns and some line-fishing vessels. The vessels used in the province for artisanal fishing are flatboats, round boats and boats made of fibreglass. Approximately 13% of the vessels are motorised, mostly with outboard motors. The other vessels work with helms or sails.

According to the IDPPE (2002) census, the province had a total of 560 fishing gears in 2002 distributed as follows: gillnets (206 units), beach seines (200 units) and hand lines (115 units) (Table 5).

The fisheries in Maputo province are classified according to species, fishing operator and fishing vessels or gear (Table 6):

Species: magumba, marreco, bamba rosa, shrimp and squid
Fishing operator: artisanal, semi-industrial and industrial
Fishing vessels/gear: artisanal boats (motorised and nonmotorised), industrial vessels, line and gillnet

4 Methodology and Data

Economic information on fisheries (e.g. production, manufacturing and consumption of fish products) is compiled in the SNA mostly in monetary terms. Physical information on fish stocks, catches and physical flows of fish and fish products is often compiled by fisheries ministries according to concepts, definitions and classifications which respond to specific regulatory or administrative purposes and often are not consistent with economic statistics. The National Institute for Statistics (INE) in Mozambique has a branch responsible for compilation of economic statistics, including that of fisheries, whereas the Ministry of Fisheries compiles physical statistics. There is an ongoing process of harmonisation, and one of the first outputs is a manual of concepts and definitions, to be approved by a Decree, providing classification for a number of economic sectors, including fisheries. The main challenge for this study is attempting to integrate the physical fisheries data with the economic data in an accounting framework in order to obtain a consistent data set, which can be used for the derivation of a coherent set of indicators and for performing more in-depth analysis of the impact of fishery policies on the economy and environment and economic policies on the fisheries sector. The SEEAF handbook provides guidelines for this purpose, and in this report, we attempt to implement the SEEAF methodology in Mozambique.

Based on the classification suggested, the study identified data needs according to the SEEAF methodology, including biomass data, catch statistics and economic data. Data sources included the statistics branch of the Ministry of Fisheries, the Fisheries Research Institute, the Small-Scale Fisheries Development Institute, the Maputo Provincial Department of the Ministry of Fisheries, selected private fishing companies and some fisheries input suppliers. Secondary data in the form of available publications was also considered, especially the IDPPE census of 2002, INE publications and written reports from relevant institutions. The research team held two workshops with relevant stakeholders and a number of separate technical meetings with relevant institutions and individual information sources. The work of the fisheries NRA team was guided by the process flow chart shown in Fig. 1.

4.1 The SEEA Framework for Fisheries Resources Accounting

Fish resource accounts are based on the SEEA (UN 2003b) and the specialised Integrated Environmental and Economic Accounting for Fisheries, SEEAF (UN & FAO 2003a). Fisheries accounts are constructed in physical and monetary terms.

4.1.1 Physical Accounts

As with all asset accounts, fish accounts are constructed for opening stocks, changes that occur during the accounting period and the closing stock. Changes that occur

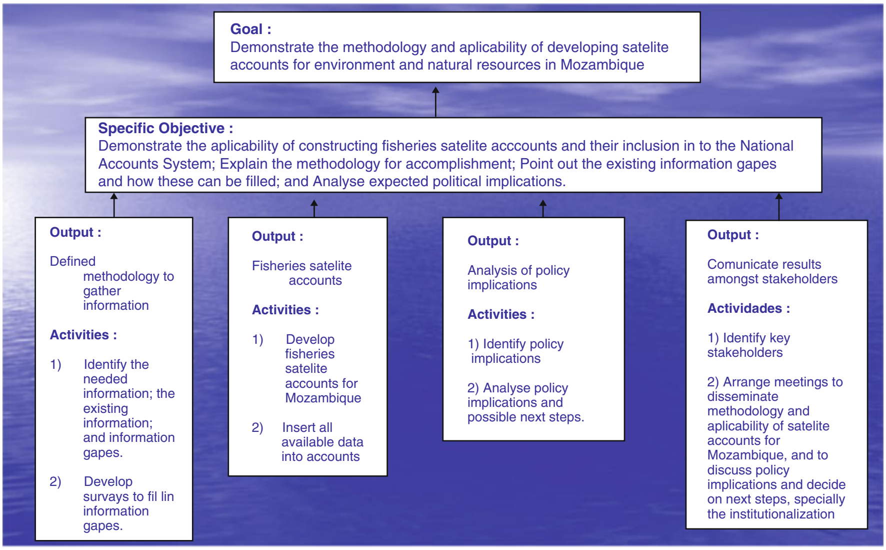

Fig. 1 Process flow chart

during the year consist of catch, recruitment, mortality and other volume changes. Other volume changes can include factors such as the migration of fish stocks out of the country's territorial waters due to environmental events. In practice, there is not enough information to quantify all the different sources of change so that changes are collapsed into two categories: "Catch" and "Other Volume Changes" (Lange 2003a, b). For long-lived species, it would also be useful to construct accounts by age class, as is done for forestry (Hassan 2000).

In this study, physical accounts were constructed for two species, *Haliporoides triarthrus* (gamba pink or gamba rosa), which represents about 70% of the commercial catch in deep-water shrimp, and *Hilsa kelee* (magumba), a small pelagic species caught by artisanal fishers. The fisheries research institute estimates the stock size for each species using the Schaefer production model (IIP 2005). The model requires a time series corresponding to an observed commercial abundance index and catch representative of the whole stock. Because it is a non-linear model, it requires the pre-estimation of two stock parameters: r (intrinsic rate of growth) and K (carrying capacity) (Conrad 2010). Catch is essential to calculating stock abundance of the following year. Analysis of commercial landings for catch and effort and on-board biological sampling programmes provided additional information for the analysis. There are a number of limitations to the empirical application of this method. First, the stock estimates are only based on data provided by commercial fishing boats. However, only a well-designed biomass survey can provide a more reliable estimate of the overall fish biomass. There is also a need for ecological studies in which the present state of health of the ecosystem is determined and the availability of stock flows ascertained. This issue is particularly important in that it provides information on the state of exploitation or health of the fishery.

4.1.2 Monetary Accounts

The value of fish, like any other asset, is the net present value of the stream of income (rent) it is expected to generate in the future. Constructing monetary accounts has two components: (1) defining how rent is to be calculated and (2) making projections about the future rent a fishery is likely to generate. Both components raise unique challenges for fisheries.

Rent is defined as the value of production minus the marginal exploitation costs. When markets are lacking, rent is often measured with the residual approach (see Lange 2003a). However, for fisheries managed under an individually tradable quota (ITQ) system such as Iceland and New Zealand, a market for quotas may develop that, under the right circumstances, reflects the rent. The resource rent formula is

$$\mathrm{RR} = \mathrm{TR} - (\mathrm{IC} + \mathrm{CE})$$

where RR is resource rent, TR is total rent, IC is intermediate consumption and CE is compensation of employees. In actual implementation of rent calculations, average cost is used rather than marginal cost because data about marginal cost are generally not available.

As mentioned above, the value of each fish stock is the net present value of the rent it will generate in the future. The present value calculations require projections of future prices, technology, costs of production, fish stock levels and resource exploitation paths. Future stock levels depend partly on fisheries policies and partly on environmental conditions and their impacts on fish stocks, which are difficult to forecast. In the absence of alternative information, common practice has been to assume that the current year's prices, technology and production costs remain constant in the future. The calculation then relies on the remaining variables: levels of stock and exploitation.

Prediction of future stock levels is much more difficult with marine capture fisheries than with other renewable resources, like forests, because there is a high degree of uncertainty resulting from poorly understood dynamics of many fish populations and of large marine ecosystems. In some relatively well-understood fisheries, a bio-economic model can be used to assess the likely future stocks, costs of fishing and rent under different management regimes. If government is clear about its management objectives, the model can be used to assess the value of the fish stock with reasonable accuracy. Such a model was used, for example, to assess the value of Iceland's fisheries (Danielsson 2000).

In principle, given a harvest regime and a stock size, a stock of fish has the biological potential to either increase, remain constant or decline in the long run. Each of these possibilities has different implications for future rent and the value of the asset. If fish stocks remain constant, then rent and asset value will remain constant. If there is a recovery from depletion and fish stocks increase, then rent will increase over time, and the present value of the asset is much higher than under the constant stocks assumption. If, on the other hand, fish stocks decline, then the asset value will be much lower. Assuming a fishery is currently efficiently managed, one could further assume that the stocks have stabilised at current levels and will generate the same rent in the future. Under this assumption, the net present value formula takes the following form:

$$V_t^i = \frac{\text{Rent}_t^i}{r}$$

where

V^i the value of the resource stock at the close of period
Rent^i total rent
r the discount rate

For each fishery, i and t is time.

4.2 *The Primary Data*

4.2.1 Species Included in the Survey

Prior to consulting the relevant sources of information, the project team internally discussed the terms of reference and decided to consider some changes in the classification to be adopted for the fisheries NRA work. Since there are many species exploited by fishers, the team decided to include only a few in the accounts selected on the basis of data availability and economic value as discussed below:

For the artisanal fishing, the following classes were considered:

Shrimps: two main species were to be considered, *Fenneropenaeus indicus and Metapenaeus monoceros. The two represent over 60% of the mean catch*
Large demersals: cachucho, marreco, robalo and magumba

For the semi-industrial fishing, the following were the considerations:

Large demersal species: the concern was that this fishery not only operates in Maputo Bay and the surrounding coastal areas but also further up in the north. The problem then was to allocate the catch between that obtained within and that obtained outside the waters of Maputo province. After checking the vessels' logbooks at the provincial department, it was not possible to make this allocation. Consequently, large demersal species were excluded from the fisheries NRA.
Shrimp: after discussions with the fisheries research institute in Maputo, the team concluded that information on biomass was unavailable and thus shrimps were excluded from the fisheries NRA.

In short, this case study does not include any semi-industrial fishers in the NRA. However, fish species such as large demersals covered in the accounts for artisanal line fisheries are the same ones fished by the semi-industrial fishers.

For industrial fishing, only the gamba fishery (gamba rosa) was considered. This type of fishing occurs not only in Maputo Bay and the surrounding coastal areas, but also further in the north. The issue again was to determine how many of the fishers leave the case study area and how much of their catch is obtained outside of Maputo province. Checking the logbooks was the answer, and these were usable compared to the ones for the semi-industrial fleet. Another concern was that the statistics had to be checked carefully as fishers often care more for the by-catch than for gamba itself, as the former is more valuable. The main by-catch species, ranked in order of importance, include crayfish, deep-sea crabs, lobsters, a variety of deep-water finfish species and cephalopods. Crayfish and lobsters are of much higher commercial value than gamba, and there is a ready export market for them. In the gamba fishery, fishers are allowed to land crabs, all types of finfish and cephalopods as by-catch, but these are of low commercial value and can be sold in the local market. Company owners will normally distribute a huge amount of this type of fish to their employees, as a social benefit. No clear policy is currently in place for the management of the crayfish fishery. The absence of scientific information on the resource base can be considered as the main reason for the precautionary approach to management currently being observed, consisting of not licensing any exploitation. Exploitation of the lobster fishery was banned in 1997/1998 due to stock depletion, and about 9 years down the road, this management measure is yet to be revised.

Recreational and sport fisheries activities are mainly done in Ponta d'Ouro and Maputo Bay. Information on the main species for this fishery (i.e. the large pelagic species) is obtained from the provincial directorate. It has been realised that a programme for monitoring this activity had just been launched, and there was insufficient data readily available to construct the accounts for this activity at present. Consequently, these fisheries were not included in the Mozambique fisheries NRA. Inland fishery was also excluded from the NRA due to lack of data in spite of its importance, especially tilapia-dominating local markets.

It can thus be seen that adequate information could only be obtained for gamba and magumba making the team concentrate on these two species in constructing the accounts. For gamba, stock and catch data was obtained from 1995 to 2005, and for magumba, stock and catch data was obtained from 1992 to 2006. In constructing the physical accounts, the team could not estimate the magnitude of illegal catch as there was insufficient data available within the project time frame. There are no statistics at all on production costs, particularly in the artisanal fishery, and hence, the study made the assumption of constant base cost for this time period. The constant base cost being the one derived from the case study survey for the year 2006.

In summary, the fish stocks of interest in this study (magumba and gamba) are not confined to the study area giving rise to the question of whether the study area was well defined.

It was not possible to know from the operator's logbooks (industrial and semi-industrial) how many of them operate outside the study area and how much of their catch is obtained from outside. It was therefore decided to consider two case study areas for the different species of interest: (1) Maputo Bay for the magumba accounts and (2) a wider area, off Maputo Bay and extending to the south of parallel 21°S for the gamba accounts.

It was also concluded that it would not be possible to use any logbook information for the semi-industrial shrimp and line fishing (e.g. marreco).

Lack of reliable data was the main reason for this study to concentrate on a few species. The information database that fisheries sector institutions are collecting are limited to catch statistics and fishing effort and generally does not include other socio-economic attributes. By law, industrial companies are required to submit copies of their annual accounts, but this practice is not being regularly observed by most companies. The National Census of Artisanal Fisheries, conducted by IDPPE in 2002, did not attempt to collect any economic data. Therefore, for the purpose of developing the monetary accounts, we decided to design and implement primary data surveys with commercial and artisanal fishers. The residual approach was used in measuring the resource rent. The survey covered commercial and artisanal operators (including fish vendors).

4.2.2 The Survey of Commercial Fishing Operators

All 11 commercial firms that were active in the gamba fishery in 2006 were surveyed via mail questionnaires. Only 3 of the 11 companies approached responded to the questionnaires. These three companies however were representative of the fishery given that they produce over 50% of the total catch of gamba (in 2005 they produced 58% of the total gamba catch). Of the three companies that responded, one dedicates over 80% of its effort to gamba fishing and the other 20% to shallow-water shrimp fishing. The other two companies are mainly shrimp fishers dedicating over 50–70% of their effort to shallow-water shrimp fishing.

The accounting structure of all the companies is aggregated without providing a clear separation between gamba and magumba operations. This means that for the calculation of resource rent, we had to use the allocation of effort between gamba and magumba to determine how much of the total costs should be imputed to gamba operations and how much should be imputed to magumba operations. The 11 companies operated a total of 27 boats in 2006, of which only 4 were owned by one of the companies, and 23 were charter boats. There is some level of reluctance to invest (owning of gamba boats) due to the high market uncertainty involved in this business (commercial risk). So, only four boats operating in the gamba fishery are Mozambican, and rest are chartered from abroad. Thus, the issue of capital invested in the fishery was neglected, and all capital cost-related variables of the resource rent formula were assumed to be equal to zero. Furthermore, companies are not required by law to provide this information, so the study had to rely on the goodwill and cooperation of companies.

4.2.3 The Survey of Artisanal Fishers and Vendors

Unlike the survey of commercial firms, the survey of artisanal fishers and fish vendors was rather complex, both for questionnaire development and survey implementation, which consisted of deploying groups of enumerators to the fishing centres to collect information. The questionnaire was developed by the project team and would have benefited from a wider participation in a focus group. However, there was not sufficient time to allow for such participation.

Five university students and one fisheries officer were recruited and trained as enumerators to carry out the surveys of artisanal fishers and vendors. The training consisted of two sessions of about 2 h each and was probably too short, since none of the enumerators had any previous experience with surveys. The surveys were carried out over five working days, and each survey team member was expected to interview five persons (both fishers and fish vendors) per day. In total, they were expected to cover a sample of 150, but they managed to provide only 103 responses distributed as follows:

39 responses for magumba
48 responses for line fish
16 responses for fish vendors

The data resulting from the survey of artisanal fishers was generally poor, with lots of unanswered questions and or inconsistent answers. The short training of enumerators, inexperience and lack of ability to deal with "rather defensive" fishermen can be pointed out as the main reasons for this poor outcome. The survey team also subsequently learnt that questions such as frequency of fishing trips, amounts of catch, etc. should be asked on weekly basis because fishermen can hardly remember their total catch or the number of days they went out fishing, for longer periods like 1 month or a season or a year.

After the survey of artisanal fishers, the project team analyzed individual questionnaires, took note of the types of problems in the answers and then held a briefing with the survey teams to get clarifications on the questionnaires. From this briefing, the research team observed that after less than 2 weeks, the students could not quite remember how they arrived at a number of answers. As a consequence, not much improvement (data cleaning) could be made to the database. From this experience, the research team learnt that much greater supervision of the survey was required, and briefing sessions with the enumerators should be carried out on daily basis at the end of each daily survey campaign in order to revise the questionnaire and provide additional clarification to the enumerators. Consequently, the information collected from fish vendors was not utilised for the accounts. The team realised that, apart from having a limited number of answers from vendors, it would become more complex (and probably irrelevant) to attempt to reflect in the accounts the vendor's sale price of fish because that would also imply aggregating vendor's costs in the calculation of the rent.

5 Results and Discussion

NRA have been constructed for three species: gamba rosa, magumba and line fish. However, due to the lack of biomass and growth information for line fish, it is only the accounts for gamba rosa and magumba that can be considered complete.

5.1 The Gamba Rosa NRA

5.1.1 Physical Accounts

Gamba is the third most important export species for Mozambique after shallow-water shrimp and kapenta. It is a migratory species and companies fish for the species in the whole area south of parallel 21°S. There are 11 fishing companies registered in gamba fishery operations, and with the exception of one, all are based in Maputo fishing port. Management of the gamba fishery is based on fishing licences, TAC and the quota system. The gamba fishery is multi-species, operated by bottom trawl nets, and the by-catch includes crayfish, lobster, squid, demersal finfish and crab, among others. Most of the by-catch often earns higher sales value than the gamba itself, which makes the fishery quite complex to manage as fishers tend to target the by-catch rather than gamba. Quotas for the authorised by-catch are set as a percentage of the target species, and fishers are prohibited from landing non-authorised by-catch species, such as deep-sea lobsters. From 1994 to 2004, the TAC for the whole gamba fishery was set at 5,000 tons; after that, it was reduced to 3,000 tons. However, the total catch per year has never reached 2,000 tons probably because the majority of licenced vessels only fish gamba in periods when the catch rates of shallow-water shrimp are low or during the closed season of the shrimp fishery (December–March).

There is more than one gamba species although the main one is *Haliporoides triarthrus* (commonly known by gamba rosa), representing over 80% of the targeted catch. The fisheries research institute (IIP) is running a specific monitoring and stock assessment programme for gamba rosa using the Schaefer model for stock predictions. For data sources, IIP is using logbook statistics, on-board sampling and surveys. Table 7 (physical stock accounts for gamba rosa) was constructed based on the IIP stock assessment data. Note that data on "observed catch" corresponds to total gamba species (including red gamba that represents 20% of the total gamba catch). By reducing 20% of the "observed catch", one is able to construct the physical stock accounts for gamba rosa.

The information used for compilation of Table 7 was based on:

Species: Haliporoides triarthrus (gamba rosa)
Type of fishing and gear: industrial fishing, bottom trawling
Extent of fishing zone: whole distribution zone including Maputo and Sofala provinces
Source of data: IIP logbooks statistics, on-board sampling and surveys
Model of stock prediction: the Schaefer model (general production model)
Data quality: 88% fit
Margin of error: 12%
Observed catch: the total catch, including pink (gamba rosa, 20%) and red gamba (80%)
A multispecies fishery whose by-catch includes crayfish, lobster, squid, large demersal finfish, crab and other gamba species.
Gamba rosa is a migratory species.

Table 7 Physical accounts for gamba rosa species (in tons)

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Opening stock		3,112	2,061	2,108	1,819	1,974	2,153	2,247	2,324	2,335	2,465	2,561
Changes in stock	Total	−1,051		−289	155	179	93	96	−8	130	96	196
	Observed catch	1,690	1,128	1,457	1,035	1,006	1,066	1,040	1,115	979	964	820
	Estimated illegal catch											
	Net natural growth	639	1,175	1,168	1,190	1,185	1,159	1,136	1,107	1,109	1,060	1,051
Closing stock		2,061	2,108	1,819	1,974	2,153	2,247	2,342	2,335	2,465	2,561	2,756

Catch variation is quite consistent with variation in effort, that is, catch goes down as effort goes down. Effort is based on the total number of fishing days of the operating boats. Due to its low commercial appeal, the fishery has not been attracting much investment, and most (almost all) gamba fishers are not specialising in this fishery but rather, they are doing combined fishery, with shallow-water shrimp fishery. Other reported types of management problems include underreporting and filling of logbooks on land rather than while fishing.

5.1.2 Monetary Accounts

Only 3 of 11 active gamba fishers in 2006 did respond to the primary survey, and contrary to the legislated requirements, the Ministry of Fisheries did not keep any copies of the companies' books of accounts. Therefore, only data from the three commercial companies was analyzed, and the accounts reflect one single year of operation rather than an average taken from a series of years as was originally intended. All the three companies studied are involved in gamba and shrimp operations and they keep aggregate rather than separate accounts per type of operation (fishery). However, one of them is more gamba oriented and keeps a specific fishing fleet for gamba and a separate boat for shrimp trawling, but still, the accounting of this company is aggregate.

For the gamba-oriented company, the team assumed that 80% of total costs are gamba related (four out of five boats) and 20% are from the shrimp operations. The second company is using the same boats for both fisheries, and the shifts from one fishery to another are done along the year, based on the season's catch rates and quota criteria, that is during shrimp high season (March, April and May), and while shrimp quotas are not exhausted, the whole fleet will be used for shrimp trawling. Thereafter, when shrimp season is low or shrimp quotas are reached, the fleet shifts to gamba fishery. We analyzed the behaviour of this fleet over the period of years 2000–2004 and concluded that they are doing about 50% of the time in each fishery. Therefore, we assumed that 50% of total costs can be imputed to gamba and neglected the fact that trawling for gamba costs relatively more as bottom trawling of over 300–650 m depth requires higher power engines and the consequent higher fuel consumption. The trawl system is also relatively more costly as an intermediate input, as compared to the gears for shallow-water trawling. The third company is mostly shrimp fishery oriented, and when in season, it will use the entire fleet on the shrimp fishery. When the shrimp season is over, a smaller part and not the whole fleet will shift to gamba operations and remain there until quotas are reached or the year closure. On the basis of time and fleet allocation per fishery, we have assumed that 20% of the total costs can be imputed to gamba.

Resource rent calculations for the three companies is presented in Table 8 where it is calculated as total revenue less labour costs, intermediate inputs and financial costs.

The structure and management setting of the three analyzed companies are completely different, which renders their accounts to be poorly comparable. Therefore, the monetary accounts can be built on the basis of net revenues of company 1, which

Table 8 Gamba resource rent calculation (US$1 = MZN18.900)

Structure	Comp 1	Comp 2	Comp 3	Total
Revenues				
Annual production (tons)	500	235	293	1,028
Production value (10^3 MTn)	62,020,000	28,209,094	23,255,600	113,484,694
Costs				
Labour costs (10^3 MTn)	3,813,201	5,641,839	1,130,409	10,585,449
Intermediate inputs (10^3 MTn)	217,481	26,117,493	469,521	26,804,495
Financial costs (10^3 MTn)	30,353,813	26,254,243	25,001,359	81,609,415
Capital costs (10^3 MTn)	0	n.a.	n.a.	
Net revenues				
Net revenue (10^3 MTn)	27,635,504	−29,804,481	−3,345,689	−5,514,665
Capital opportunity cost (10^3 MTn)				
Profit	27,635,504	−29,804,481	−3,345,689	−5,514,665
Average rent (on each unit "ton of fish") (10^3 MTn)	55,271	−126,828	−11,419	−5,364

is specialising in gamba fishery, rather than an average taken from the three companies. Otherwise, the mean net revenue derived for the three companies is negative (−5,364 MTn). If capital costs were included in the calculations, the net revenue would be even more negative. However, it should be noted that the production value of by-catch has not been included in the calculations and that it would have a contrary effect and work as buffer to the negative rent of gamba.

As our exercise was based on a sample rather than the whole fishery, we have derived an average rent (per each unit "ton of fish") which is (−5,364.00 MTn) under current exploitation using the average of all three companies and 55,271 MTn if we will apply the "ideal" value using the unit rent from company 1. If we were to apply the scenario of average rent of the three companies, which is negative, the asset value would be negative. When asset value is negative because of negative resource rents, the value of asset is reported as zero. Thus, we have chosen to build the accounts on the basis of the "ideal" scenario, using the unit rent of company 1.

5.1.3 Asset Valuation

SEEAF defines the value of each stock as the net present value of the rent it will generate in the future. The present value calculations require projections of future prices, technology, costs of production, fish stock levels and resource exploitation paths. Future stock levels depend partly on fisheries policies and partly on environmental conditions and their impact on fish stocks, which are difficult to forecast. In the absence of alternative information, common practice has been to assume that the current year's prices, technology and production costs remain constant in the future. The calculations of Table 9 below have relied on the remaining variables: levels of stock and exploitation, as given in the physical accounts of Table 8, and assumed all other variables are constant.

For the resource rent of 55,271 MTn per each ton of fish caught, company 1 paid in 2005 an average of 2,436 MTn per ton as licence fee corresponding to 4% of the rent. This percentage of rent recovery can be much lower if we consider the production value of the by-catch which has not been accounted for. One may want to discuss whether this is a fair pay for the recovery of rent by the State, but this requires further investigation. On the other hand, as derived from the total labour costs and the number of local employees in the company, the average salary paid (month/man) in 2005 was 4,965.11 MTn which is 3.5 times as much as the minimum wage.

5.2 Magumba Fishery NRA

5.2.1 Physical Accounts

Magumba (*Hilsa kelee*) can be considered the most important artisanal fishery species in Maputo Bay given that it is fished by 37% (206 gillnets) of the 560 units of fishing effort (IDPPE National Census 2002). It is the most abundant fish in the local markets, and the landings are much higher compared to the catch of other fish species. Because of its very low market price, it is the most accessible source of protein for the low-income consumers.

The stock of magumba is composed of a unique species that is highly concentrated around Maputo Bay making its monitoring and stock assessment relatively easy. A similar stock is located in the waters of Sofala Bay, off the coast of Beira. The main management measures consist of access by fishing licence and mesh size regulation. However, this fishery can be considered to be an open access for two main reasons: (1) there are no limits to the number of licences issued to fish (anyone can get a licence to fish magumba); (2) due to the poor capacity for monitoring and enforcement, most of the fishers are operating without fishing licences. For instance, in the primary survey we have carried for the study, only few respondents answered the question related to payment of licence fees. The Fisheries Research Institute (IIP) is running a specific monitoring programme of the magumba fishery, which includes compilations of landing statistics, and a data series is available for the period from 1992 to 2005. According to IIP, the process of data collection and processing varied throughout the time, and it can be divided overall in two main periods: the period from 1992 to 1997 and the period post 1999 when a new system of data sampling came into practice for the artisanal fisheries. The physical stock accounts for magumba are reported in Table 10.

Table 9 Monetary accounts for gamba rosa (in 10^6 MTn)

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Opening stock		1,720	1,139	1,165	1,005	1,091	1,190	1,242	1,294	1,291	1,362	1,416	1,523
Changes in stock	Total	−581	26	−160	86	99	51	53	−4	72	53	108	
	Observed catch	934	623	805	572	556	589	575	616	541	533	453	805
	Estimated illegal catch												
	Net natural growth	353	649	646	658	655	641	628	612	613	586	561	
Closing stock		1,139	1,165	1,005	1,091	1,190	1,241	1,295	1,290	1,362	1,416	1,523	

Table 10 Physical stock accounts for magumba (in tons)

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Opening stock		168	1,627	2,232	2,809	3,574	4,723	6,440	15,457	10,137	9,820	8,757	7,816
Changes in stock	Total	−61	605	577	765	1,149	1,717	9,017	−5,320	−317	−1,063	−941	661
	Observed catch	1,401	691	1,132	1,304	1,346	1,304	3,528	6,809	4,024	4,811	4,755	3,115
	Estimated illegal catch												
	Net natural growth	1,339	1,296	1,709	2,069	2,494	3,021	12,545	1,489	3,707	3,748	3,814	3,776
Closing stock		1,627	2,232	2,809	3,574	4,723	6,440	15,457	10,137	9,820	8,757	7,816	8,477

The information used for compilation of Table 10 was based on the following:

Species: Hilsa kelee (magumba)
Type of fishing and gear: artisanal, gillnet
Extent of fishing zone: Maputo Bay, 70% of catch from Costa do Sol
Source of data: IIP data base
Model of stock prediction: Schaefer Model (general production model)
Data quality: 99% fit
Margin of error: 1%
Observed catch: sampling estimations
Type of management: no TAC's or quotas established, control through licensing of boats, mesh size of nets determined with 2¼ in., but no regular enforcement

The CPUE was derived based on the assumption that there has been no significant changes in the fishing effort over the study period so that the 206 fishing units (gillnets) captured in the IDPPE census (2002) remained constant. Since there has only been one national census of artisanal fisheries ever conducted so far, there is no basis for assessing trends in these fisheries.

A very drastic rise in CPUE has been observed between 1999 and 2000, and thereafter, it remained very high (compared to earlier years). The dramatic change in the estimated biomass and catch, and consequently the CPUE, can be attributed to the earlier mentioned change in data collection systems. While acknowledging this fact, the Fisheries Research Institute has attributed this trend primarily to unexpected environment modification in Maputo Bay as a consequence of a massive flood which affected the inshore primary production of the southern Mozambican coastal zones, and as an instant response, the stocks increased significantly. Our primary survey of artisanal fisheries collected catch data, which upon analysis produced an estimate of 7,250 kg for CPUE. As the figures on fish catch from IIP for the period 2001–2005 are unlikely too high, we decided on one scenario from IIP figures which are consistent with our primary survey, and the physical accounts were developed on this basis. Until 1999, we had just a normal variation in catch data, and it is within a range that is consistent with the estimate derived from our case study survey (7,250 kg). For our analysis, we have excluded data from the period 2000 to 2005, that is, we have utilised available data only for the period between 1992 and 1999.

5.2.2 Monetary Accounts

Data for the construction of monetary accounts was collected through primary surveys as described in earlier sections of this document. The outcome of the surveys was so poor that we had to select best cases that could be utilised for the accounts. Of 39 responses received for magumba, only four could be used in the analysis. The results from these cases were cross checked with IIP catch statistics and with information collected from suppliers before being used in the analysis. The analysis derived average net revenue received for the four selected cases of 36,824.12 MTn. This net revenue is inclusive of revenue received by boat owner (or fishing gear owner), labour costs and opportunity cost of capital so that the actual

Table 11 Magumba fishery resource rent calculations

Structure	Case 1	Case 2	Case 3	Case 4	Average
Revenues					
Estimated annual production (kg/fishing unit)	7,250.0	7,250.0	7,250.0	7,250.0	7,250.0
Production value (MTn)–at prices from the survey	54,375.00	72,500.00	65,250.00	67,664.25	64,947.31
Costs					
Labour costs (MTn)	7,100.00	24,350.00	6,000.00	17,750.00	13,800.00
Intermediate inputs (MTn)	12,000.00	10,800.00	8,400.00	4,080.00	8,820.00
Estimate financial costs (MTn)	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00
Capital costs (MTn)	435.0	2,000.00	577.78	3,000.00	1,503.19
Net revenues (MTn)					
Net revenues (MTn)	30,840.00	31,350.00	46,272.22	38,834.25	36,824.12
Estimate owner's labour cost (minimum wage) (MTn)	18,000.00	18,000.00	18,000.00	18,000.00	18,000.00
Capital opportunity cost (10%) (MTn)	543.75	1,500.00	520.00	1,500.00	1,015.94
Profit (MTn)	12,296.25	11,850.00	27,752.22	19,334.25	17,808.18
Average rent (on each unit "kg of fish") (MTn)	1.70	1.63	3.83	2.67	2.46

Table 12 Monetary stock accounts for magumba (in 10^6 MTn)

		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Opening stock		49	41	42	40	55	69	88	116	158	380	249	241	215	192
Changes in stock	Total	−8	1	−2	15	14	19	28	42	222	−131	−8	−26	−23	16
	Observed catch	46	32	34	17	28	32	33	32	87	167	99	118	117	77
	Estimated illegal catch														
	Net natural growth	38	33	33	32	42	51	61	74	308	37	91	92	94	93
Closing stock		41	42	40	55	69	88	116	158	380	249	241	215	192	208

net profit on capital is 17,808.18 MTn, which is about the current national minimum wage. The calculation of production value was based on the first sale price (fisherman's price). In calculating the financial costs, we included estimates of asset depreciation based on individually declared lifespan of the boats, and then an average of the four cases was taken. We assumed 10% rate of capital opportunity cost. Results of resource rent calculation for the magumba fishery are given in Table 11.

5.2.3 Asset Values

The asset value of magumba fishery was calculated by applying the average unit rent of the four cases, 2,46.00 MTn/kg of fish (Table 11). The calculations of Table 12 used the physical data of Table 10.

Table 12 shows that the magumba fishery is a reasonable source of income for the boat owners as it provides an average of 17,808.12 MTn of profit. For this level of profit, each boat owner has paid 394 MTn of licence fee, according to survey data, representing 2% of rent recovery. This can be considered a very good level of rent recovery by the State taking into consideration the social objective pursued in this fishery, which is to secure a sustainable source of income for the poor fishermen. Nonetheless, it should be noted that the officially applying licence fee for magumba is 245 MTn for boats with outboard engine, which represents only 1% of rent recovery from this fishery. This is not consistent with the declared amount in the survey. However, the fishermen working for the boat owners are very poorly paid, and this can be a big challenge to the sustainability of the fishery. The average number of paid labour is two fishermen per boat. The labour costs are estimated at 13,800 MTn per year which correspond to a monthly pay of 575 MTn per fisherman – less than half the national minimum wage. Given that this fishery is of open access, these working conditions can be an incentive for the individual fishermen to attempt to have their own fishing boat and gear so as to better their individual income level. The immediate implication of this would be an increase in fishing effort. The Government pursues a development promotional policy based on soft credit schemes for the fishermen. This is a great opportunity for more and more fishermen to become self-employed boat owners. While this is good for poverty alleviation, it requires strong capacity for monitoring the resource exploitation so as to keep it within sustainable levels.

5.3 Line Fish NRA

5.3.1 Physical Accounts

Line fishing is the third most important type of artisanal fishing gear in Maputo Bay, accounting for a total of 115 units of artisanal fishing effort according to the IDPPE census of 2002. Total catch recorded in 2004 for the artisanal fishers was 92 tons. The fishery is operated mainly by semi-industrial boats, with a mean annual catch

Table 13 Physical stock accounts for Marreco (in tons)

		1998	1999	2000	2001	2002	2003	2004	2005
Opening stock									
Changes in stock	Total								
	Observed catch	18	n.a.	60	66	18	28	66	n.a.
	Estimated illegal catch								
	Net natural growth (e.g. birth, recruitment, death)								
Closing stock									

varying between 350 and 400 tons. The main concentration of semi-industrial fishing effort is at the south of Save River, along the coast of Maputo, Gaza and Inhambane provinces. Unlike magumba which has very localised stocks in Maputo and Sofala Bays, the stock of line fish is distributed through a much wider area across the southern provinces, and other stocks are recognised to occur in the central and northern provinces.

Line fishing is a multispecies fishery, and the respective catch statistics are reported with no discrimination by individual species. However, the existing stock assessment programme, run by the Fisheries Research Institute, is only for Marreco *Chrysoblephus puniceus*, considered to be the most important species in the catch composition. For this reason, we were unable to build complete physical accounts for this fishery. The physical accounts for Marreco are given in Table 13.

The information used for compilation of Table 13 was based on:

Species: Chrysoblephus puniceus (Marreco)
Source of data: IIP

5.3.2 Monetary Accounts

The primary survey collected 48 responses from fish operators, but due to data quality, only four of these were selected for further analysis. The annual catch data estimated from these four units ranged from 1.9 to 7.8 tons per unit, giving a total of between 218.5 and 897.0 tons of artisanal fish production for the 115 fishing units. These figures are not consistent with and are far beyond the estimated catch reported by the Fisheries Research Institute, which estimated the annual catch in 2004 at 92 tons. In Table 14, we compute the net benefits to the individual fishing unit based on the survey data and complementary information from suppliers. We generally conclude that with the exception of case 1 which recorded negative net revenue (−7,113.00 MTn), the line fishery is generally profitable.

The column of averages in Table 14 shows that line fish fishery is much more profitable than the magumba fishery, which is consistent with the observed reality. According to the primary survey data, line fishermen paid an average of 303.5 MTn

Table 14 Line fishery resource rent calculation

Structure	Case 1	Case 2	Case 3	Case 4	Average
Revenues					
Estimated annual production (kg/fishing unit)	1,935	4,380	7,200	7,840	5,339
Production value (MTn) – at prices from the survey	98,100	226,800	360,000	470,400	288,825
Costs					
Labour costs (MTn)	41,400	68,040	108,000	84,000	75,360
Intermediate inputs and financial costs (MTn)	63,398	12,300	18,000	104,400	49,524
Capital costs (MTn)	415	30,000	6,000	3,200	9,904
Net revenues (MTn)					
Net revenues (MTn)	−7,113	116,460	228,000	278,800	154,037
Estimate owner's labour cost (minimum wage) (MTn)	18,000	18,000	18,000	18,000	18,000
Capital opportunity cost (10%) (MTn)	510	4,500	3,000	1,600	2,402
Profit (MTn)	−11,397	93,960	207,000	259,200	133,635
Average rent (on each unit "kg of fish") (MTn)	−5.89	21.45	28.75	33.06	25.03

for licence fee. Relative to the average net revenues of 154,037 MTn (Table 14), this represents a meagre 0.20% of rent recovery. Based on these findings, one could consider revisiting the present taxation policy. Considering that each fishing unit employs on average four paid labourers, it is estimated that salaries in this fishery are just as much as the minimum wage in Mozambique. However, the rent generated in the line fishery suggests that there is potential for paying better salaries and this study hypothesises that this is not happening because of excess labour supply in the fishery.

6 Conclusions and Policy Implications

It is our conclusion that constructing fisheries NRA in Mozambique is feasible for all commercially fished species but rather complex for most artisanal fisheries. For the industrial shrimp fishery, gamba and kapenta, the routine for calculating physical and monetary accounts can be established in a quite straightforward way. It will require revisiting existing legislation on statistics reporting and ensuring effective enforcement for non-compliance, which can be combined with education campaigns for the industry.

For the semi-industrial shrimp and line fish fisheries, there is need to enhance capacities, enabling the Fisheries Research Institute to perform the existing stock assessment programmes. The Fisheries Provincial Directorates should be enabled to utilise the logbook information collected from the fishing boats and produce relevant reports that will be the source of information for development of fisheries accounts.

Changes should be considered in collecting and processing catch statistics in order to identify separately at least the most relevant fish species.

Artisanal fishing is rather complex, and one may consider different options for the classification of the accounts, depending on specific characteristics of the fishery concerned. The magumba fishery, which consists of a unique fish species and is fished with a rather selective gillnet, appears to be an exception in the complexity of developing artisanal fisheries accounts. Magumba accounts can be developed in a quite straightforward way provided that required improvements in primary data collection methodologies are in place.

Other main artisanal fisheries are operated by none or less selective types of fishing gears, such as beach seines (nonselective at all) and hand lines (selectively used for finfish species), among others. The species captured with these fishing gears are generally of the same stocks as those fished by the semi-industrial and industrial boats, and this will require a special attention in the classification of the accounts and on the methods of information gathering and aggregation.

We have concluded that the system of fisheries statistics needs to be revisited, and appropriate adjustments are required, specifically for the artisanal fisheries, in order to improve quality of the data. The 5-year national census on artisanal fisheries should also capture economic data rather than being limited to catch and effort statistics, and in the interim periods between national censuses, regular surveys should be conducted in order to build up a robust reference database. A critical aspect to be taken care of in conducting the census and surveys is the design of questionnaires and training and supervision of survey teams. Institutional development and relevant investments should be considered in capacity building, including human resources and adequate equipment.

In the revision of the fisheries statistics system, the role of fisheries institutions and coordination matters should be considered very carefully as it appears that roles and competences of each partaking institution are not very well established, and some institutions are "forced" to perform others' roles. For instance, the Fisheries Research Institute has been charged with responsibilities to provide catch statistics for artisanal fisheries, and for performing this task, there is less time available for scientific tasks such as fish biology sampling and analysis.

Environmental accounts generate information that is useful and crucial for both enlightenment and effective management measures. For instance, issues like setting appropriate levels of taxes and levies for the industry, specific sector labour polices, among others, can be supported by this type of NRA studies.

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References

Conrad JM (2010) Resource Economics, 2nd edn. Cambridge University Press

Danielsson A (2000) Integrated Environmental and Economic Accounting for Commercial Exploitation of Wild Fish Stocks. National Economic Institute and Economics Department, University of Iceland, Unpublished Paper

DNEP (Ministry of Fisheries) (1960) Inland waters fisheries regulations 1960. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (1971a) Marine fisheries regulations 1971. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (1971b) Shrimp fisheries regulations 1971. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (1990) Fisheries Law 1990. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (1994) Fisheries and fishery master plan 1994. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (1997) Maritime fisheries regulations 1997. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (2001) Aquaculture regulations 2001. Government of Mozambique, Maputo

DNEP (Ministry of Fisheries) (2003) Maritime fisheries regulations 2003. Government of Mozambique, Maputo

Hassan RM (2000) Improved measure of the contribution of cultivated forests to national income and wealth in South Africa. Environ Develop Econ 5:157–176

Hassan R, Mungatana E (2005) Environmental economics and policy analysis in Eastern, Central and Southern Africa: assessment of existing capacity, training programs and needs for future investments. Assessment of existing capacity. The Centre for Environmental Economics and Policy on Africa, University of Pretoria, Pretoria

IIP (Fisheries Research Institute) (2005) Government of Mozambique, Department of Aquaculture, Maputo

IDPPE (2002) Censo Nacional da Pesca Artesanal em Águas Marítimas. IDPPE, Maputo, p 76

INE (National Institute of Statistics) (2004) Anuário Estatístico 2003. INE, Maputo

INE (National Institute of Statistics) (2005) Anuário Estatístico 2004. INE, Maputo

Lange GM (2003a) The value of Namibia's commercial fisheries DEA research discussion paper number 54, February 2003, Directorate of Environmental Affairs, Ministry of Environment and Tourism, Windhoek, Namibia

Lange GM (2003b) Fisheries accounts: management of a recovering fishery. In: Environmental accounting in action, case studies from southern Africa. Edward Elgar Publishing, Cheltenham

UN FAO (2003) Handbook of national accounting: integrated environmental and economic accounting for fisheries, SEEAF, final draft. Food and Agriculture Organization of the United Nations (UN FAO), Rome

UN (2003b) Handbook of National Accounting, Integrated Environmental and Economic Accounting. Southeast Energy Efficiency Alliance (SEEA), Atlanta