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Inland fisheries in Mozambique: importance and potential

Final report
18 December 2002

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Executive summary

This summary presents the findings of the brief study by ICLARM (now known as the WorldFish Center) in August 2002 on inland fisheries in Mozambique. The study aims to identify the constraints to the development of inland fisheries to strengthen livelihoods, food security and economic growth, and to identify and propose possible initiatives which could be introduced to enable this development. Most attention was directed to the lacustrine waters in Niassa and Tete Provinces.

Methods

Between 2 and 6 September, the team spent time in Maputo, meeting with key people mainly in IDPPE and IIP, and gathering literature. Between 7 and 11 September, the team visited Lichinga, and a sample of fishing centres on Lake Niassa (southern and central part of Mozambican sector). Between 12 and 19 September, the team visited Tete, and a sample of fishing centres on Lake Cahora Bassa. Interviews were held with some 27 key informants and nine loose focus groups of artisanal fishers. The status of the fishery resource and its use, fishing practices and investments, and the potential for development were assessed.

The literature was scanned and analysed to describe what is known about the inland fisheries and the potential for development. Data from the field interviews were used to develop preliminary financial and economic models of the fishing enterprises involved in Lakes Niassa and Cahora Bassa. Indications were thus derived of the biological, financial and economic state of the fisheries.

Findings

The evidence suggests that there are no large untapped fish resources in the artisanal fisheries of Niassa and Cahora Bassa. Thus, while more specific research is needed on potential yields and current fishing effort, we recommend that development priority should be given to sustaining and, where possible, enhancing the benefits of the existing fisheries through a number of carefully targeted interventions accompanied by continuing investment in improving the information base for management.

Our preliminary economic analyses (which incorporate the benefits of job creation, and generally provide a more accurate measure of the worth of the fishing activity for Mozambican society) indicate that all the inland fishing activities are economically efficient. They all contribute positively to the economy. All the fishing activities analysed are desirable and worthy of promotion. This provides sound motivation for initiatives to enhance financial attractiveness of fishing. It suggests that support to the artisanal fishery enterprises is economically sound.

The lack of appropriate low cost gear and capital is identified as the most important constraint on artisanal fishing. Our preliminary financial and economic analyses of fishing activities indicate low financial profitability, which may reflect this constraint. Profitability is highly sensitive to catch rates, product prices and labour costs. Interventions, which can improve catches and prices, will greatly improve net incomes for fishers.

Artisanal fishers are generally satisfied with their markets, and, except perhaps in the most remote areas, these are not seen as constraining. However, at broader level the market environment is constrained by poor infrastructure, poor product quality, and poor business development. Improvements to these would likely enhance product value, and thus fishing incomes.

There is no evidence to suggest that catch rates are depressed due to excess fishing pressure. However, in all the artisanal fisheries, fisher populations seem to be expanding, and with few

income alternatives and effective open access for fishers, this is likely to continue. Currently, community-based management of fish resources is weak.

In Niassa low yields may hinder further exploitation of offshore pelagic fish resources. Inshore pelagic stocks seem to have higher yields and there may well be potential for enhancement of catches of inshore pelagic resources in Niassa. This needs confirmation. Current thinking is that demersal haplochromines are best left lightly exploited, for example, as high value aquarium fish. A shift of traditional demersal fisheries towards the pelagic resources seems likely to improve catch rates, profits and bio-production, and also contribute to conserve the unique biodiversity of the lake.

The development of tourism related use of inland fish resources is embryonic in Niassa and Cahora Bassa. Considerable expansion of sport-fishing tourism is seen as possible in both lakes. In Niassa some ornamental fish exports, are seen as possible. Artisanal fishing communities lack the skills and capital to use these resources. However, communities can appropriate significant amounts of the economic rents from these developments given territorial rights to the resources in question, and appropriate institutional development

The legislation is designed for the coastal sector, and does not adequately cover the needs of inland fisheries. It requires review, based on sound research. Promulgation of appropriate regulations should follow.

Proposed development priorities

Three development priorities are suggested:

Credit/finance/gear provision

An initiative to relieve the widespread shortage of capital and gear, especially nets and boats, perceived by artisanal fishers, is proposed. This may or may not involve subsidy, and it will likely involve small-scale credit supply, depending on the findings of research. Pilot activities would be on the two large inland lakes, Niassa and Cahora Bassa, but the project could later expand to embrace all inland fisheries.

Development of “concelhos de gestão”

An initiative is proposed to facilitate the development of management bodies among artisanal fishing communities. This would be focussed as a pilot in Lakes Niassa and Cahora Bassa, and could expand later. Community management bodies would enable common property management of the fishing resources. They would also enable communities to develop joint ventures between themselves and other users of local natural resources, for example, sport fishing tourism operators. This in turn would enable communities to appropriate rents from these activities as they develop. Management bodies would also be able to access international donor funds (non-use values), aimed at conservation, and they could also assist in conflict resolution. Existing programmes with experience (IFAD, Tchuma Tchato) would form the basis or design of the programme.

Legislative review

A Maputo-based project is proposed in which the existing fisheries legislation is reviewed, and a set of regulations drafted and promulgated for inland fisheries. These regulations will need to be carefully designed so as to assist in the development of a viable inland fisheries sector, as well as ensuring conservation and sustainability.

Proposed research priorities

Four proposed research priorities, to provide the basis for design of these development initiatives, and to ensure that their impacts are maximised, are proposed.

Census 2003/4

It is recommended that the artisanal fisheries census, already planned for 2003/4 by IDPPE, be carried out. The survey will be structured to provide data directly comparable with that of previous surveys. If resources permit it could incorporate some additional questions relating to gear ownership, and be expanded to embrace a wider area.

Social and economic research

A programme of social and economic research is proposed for artisanal fisheries in two study areas, one in the central part of Lake Niassa (for example, around Metangula) and on the southern shores of Lake Cahora Bassa (for example around Daque). This research will build on the existing IDPPE programme for monitoring product prices and research into the economics of fishing and markets on the coast. It will provide reliable data for fishery enterprise financial and economic models, which enable sound policy development, planning and project design. Financial and economic analyses of fishing activities would be done, to determine the financial attractiveness, economic viability, resilience, and need for subsidies. The research would also embrace financial and economic analysis of fishing households' non-fishing income-earning activities. The research would address concerns related to livelihood, capital formation, and benefit distribution, among communities.

Biological research

In line with the research being planned by IIP, and as with the proposed social and economic programme above, we propose a programme of long term, targeted research, based at the existing laboratory at Metangula in the central part of Lake Niassa, and the southern shores of Lake Cahora Bassa. Research would involve routine sampling to measure catch and effort, and the accurate determination of potential sustainable yields. In Niassa research should also be focussed on inshore waters. In both Niassa and Tete, research should embrace needs, if any, for protection of vulnerable species, the feasibility of sanctuary establishment and the allocation of fish resources between artisanal fisheries and other uses.

Market research

A research project is proposed to examine the broader constraints to development of more durable producer-market relationships in artisanal inland fisheries. This project would specifically examine the complexities of fish marketing in Mozambique and neighbouring countries, as well as markets for inputs to artisanal fishing. It would be a quantitative study, measuring price and other elasticities of demand, and determining financial and economic values. It would identify opportunities for strengthening market and business institutions, and determine needs for infrastructural development (roads, water and land transport).

1. Introduction

1.1 Background

This document is the report for a brief study on inland fisheries in Mozambique. It aims to identify the important elements of and the potential for development of the inland fisheries resources. The National Institute for Small Scale Fisheries Development (IDPPE), which is part of the Ministry of Fisheries, has the mandate to study and develop artisanal fisheries along the coast, as well as inland for the whole of Mozambique. Until now, the IDPPE has concentrated its efforts mainly on the promotion and sustainable development of coastal artisanal fisheries. Currently a number of on-going projects and studies are being implemented to improve the knowledge and understanding of the status of these resources and the design of systems for their sustainable management.

In relation to inland fisheries the information available is less, the potential for investment and development is less well understood, and appropriate strategies are lacking. Therefore, the IDPPE, with the support of ICLARM (now known as the WorldFish Center) agreed to conduct a study identifying the importance and potential of these inland water resources upon which future strategies of intervention could be based. Of particular importance in this study is the need for a better understanding of the contribution of these resources for the socio-economic well-being of the communities living in the interior, the importance of inland fisheries for food security, and the importance of the fisheries for economic development.

The Republic of Mozambique is situated on the southeast coast of Africa, approximately between latitudes 10^o and 27^o south. It is bounded in the north by Tanzania, on the west by Malawi, Zambia, Zimbabwe, and Swaziland, and on the west and south by South Africa. The climate is tropical, ranging from humid to semi arid, warm in winter and hot in summer. Relatively small differences in average temperatures are accounted for by the small variation in altitude, as well as the effect of a warm Indian Ocean current which flows south along the coast. Rain falls mostly in summer, and in winter cold fronts can reduce temperature in the southern parts of the country. The country is some 799,000 km^2 in extent, including about 13,000 km^2 of inland surface waters.

1.2 Acknowledgements

We would like to thank Simeão Lopes (Director, IDPPE) and Maria Ascensão Ribeiro Pinto (Diretor Adjunta, IDPPE) for the strong support given to this study from IDPPE. The team was accompanied on their field visit to the Niassa and Tete Provinces by Maria Ascensão Pinto and Maria Eulália Vales (Bióloga e Chefe, Departamento de Cooperação, IDPPE), respectively. Without the guidance and essential inputs of these two, useful field visits would have been impossible. In their travels the team was also skillfully guided and assisted by Maria Cunhete Chingoma (Chefe dos Serviços, Ministério de Pesca, Província de Tete), Argentina Trausene (Extensionista, Direcçao dos Serviços, Ministério de Pesca, Província de Tete) and Fernando Aualo (Chefe da Estação, IDPPE, Metangula, Província de Niassa). In Zumbo, Pedro Fazenda Sarange (Diretor, Direcção de Educação, Distrito de Zumbo) assisted the team logistically. The team also wishes to thank the very competent drivers, Ambrósio Afonso Tembe (in Niassa), and Carlos Diago Carvalho (in Tete), for their attentive services. The funding for the study has been provided by ICLARM. The participation of JI Barnes in this study was contributed by the Environmental Economics Unit, Directorate of Environmental Affairs, Namibia, and funded by the Government of Sweden, through Sida.

1.3 Objectives

The general objective of the study is to produce a comprehensive description of the current status of inland fisheries and make recommendations for the potential improvement of the use of these resources, as well as to identify areas of particular importance or concern.

The specific objectives are to provide and analyse currently available information on inland fisheries, and to use this information to address specific questions in three inter-related areas:

(i) the status of the fishery resource and its use;
(ii) fishing practices and investments; and
(iii) the potential for development.

More specifically, the status of the fishery resource was to be studied to:

- Identify priority inland fishery resources and fishing areas;
- Collect basic socio-economic data on these priority areas, including;
- current resource management systems;
- existing or potential sources of conflict;
- Assess current catch rates;
- Where possible estimate MSY (maximum sustainable yield);

The fishing practices and investments were studied to:

- Assess fishing gear and fishing methods used;
- Evaluate the availability of fishing gears;
- Assess fish processing methods used;
- Evaluate available infrastructure;
- Assess market access;
- Identify existing areas of private investment in artisanal fisheries;

The potential for development was studied to:

- Assess the potential of inland fisheries in relation to food security and sustainable livelihoods;
- Identify actions, which could be taken to develop this potential;
- Identify other issues which need to be addressed in order to support the future development of inland fisheries resources;
- Identify potential constraints, which could affect future investment and development of these resources.

The terms of reference for this study are provided in Annex A.

2. Methods

2.1 Data gathering

A team of two, comprising a resource economist, Dr Jonathan Barnes, and a fisheries biologist, Mr Jørgen Meisfjord, was deployed, and these two held a series of meetings and discussions in Maputo during the week of 2 – 6 September 2002. During the first three days, the team was joined by ICLARM representatives and fisheries specialists, Drs Patrick Dugan and Daniel Jamu. A list of all persons consulted in the study is provided in Annex B. Many of those consulted were from the Ministry of Fisheries, notably the IDPPE and the IIP, which two agencies have a direct interest in the study. A review of the available literature was made at the same time. All references consulted are listed in section 7 of this report.

Between the 7th and the 11th of September, the team paid a reconnaissance visit to Niassa Province and a sample of fishing centres along the shores of Lake Niassa.. Nine key people, including government officials, NGO staff members and community leaders were interviewed. Focus group discussions were held with groups of artisanal fishers in Meponda, Nonga, Metangula, Micala and Chiuanga. Four key informants for the artisanal fishery were identified and interviewed. Transport difficulties and time constraints precluded visits to Lakes Amaramba, Chiúte, and Chilwe. Staff members of some key NGOs, involved in assisting artisanal fishers, were unavailable and could not be interviewed.

This was followed, between the 12th and 19th of September, by a reconnaissance visit to Tete Province, and a sample of fishing centres along the shores of Lake Cahora Bassa. Sites visited included Zumbo-Sede and Bawa in the west, and Songo, Mágoè, Chipalapala, Daque, Cassindire, and Cadzewe, as well as a fishing camp at Camahuku. Some nine key persons were interviewed in the province. Focus group discussions were held with artisanal fisher groups in Zumbo, Chipalapala, Cassindire, and Camahuku. Some six key informants were interviewed to get information specific to the artisanal fishery and the semi-industrial "kapenta" fishery.

During the fieldwork, as much data as possible was collected on the fishing systems and their physical and economic characteristics. Thus information was sought on the types of gear used, the scale of operations, catch and effort, employment, the capital investments made by fishers, the costs of operation, products and prices, and the markets. Particular attention was paid to the constraints affecting artisanal fishery activities. Due to the rapid nature of the study this information was, of necessity, only indicative. Data from other work, notably the very useful studies of Muchave (2001), IFAD (2001e), Wilson *et al*. (1996), Falcão (2000), Falcão & Gervásio (2001) Turpie *et al*. (1999), and Bukali *et al*. (1995), were used to corroborate some of the findings.

2.2 Analysis of fishing and potential

A detailed analysis of the literature was made to describe research findings on the fish resources, current fishing practices, potential yields, and possibilities for expansion, in Lakes Niassa and Cahora Bassa. The team did not develop any models to this end but simply attempted to evaluate and combine findings from other studies.

2.3 Financial and economic enterprise models

The basic field data was used to construct three preliminary financial and economic models for typical artisanal fishery enterprises on Lakes Niassa and Cahora Bassa, as well as one for a semi-industrial "kapenta" enterprise. These preliminary models have two functions. The first is to illustrate the type of model that could be usefully employed to further analyse the artisanal activities, providing details on private incentives, economic efficiency, and assisting with policy decisions. The second is to provide indicative numbers to assist in formulation of recommendations for future interventions in the inland fisheries sector.

The models consist of static budget, and dynamic cost-benefit profiles for typical enterprises. They measure *private profitability* (annual net income, financial rate of return, financial net present value) from the point of view of the user or investor (the enterprise owner, "armador" or "patrão"). They also measure *economic efficiency* (annual contribution to gross and net national income, economic rate of return, economic net present value) in economic (or shadow) prices, from the point of view of Mozambican society.

The budget models measure annual financial returns at full production after deduction of all capital and recurrent financial costs, including interest and amortisation, from output. Both marketed and consumed private values are included in the financial measures. The cost-benefit models measure financial and economic returns over five- and 10-year investment periods. Interest and inflation are excluded, and cost and benefit flows are in constant prices and discounted over time. A real discount rate of 6% is assumed for both private and economic analyses, but a 2% risk premium is added to the financial discount rate. All capital expenditures are included and depreciation is accounted for through the residual value of assets in the final year of analysis.

The economic budget models provide measures of *gross* and *net national income* (GNI and NNI) generated by the enterprise. These are the returns in gross and net value added to the factors of production in the enterprises owned by Mozambican nationals. NNI is GNI minus annual capital asset depreciation. GNI is the "*rendimento nacional bruto*", and NNI is the "*rendimento nacional líquido*" in the Mozambican national accounts (INE, 2000a). In the economic models the economic cost, or benefit, to society, of using or producing a resource, is taken to be its opportunity cost (the value of its best alternative use). The economic data are based on financial transactions, but where opportunity cost differs significantly from financial prices, then shadow pricing is applied. These national income measures thus gauge economic efficiency, unlike the statistical measures presented in national accounts.

Standard criteria for shadow pricing in Mozambique are not available, so preliminary ones were developed. Thus, the following adjustments are made in the economic enterprise models. Domestic transfers such as taxes, and subsidies, are eliminated as costs or benefits. A general shadow price for unskilled labour of 0.15 of the market price is applied to reflect general unemployment and social pressure for higher wages. A foreign exchange premium of 10% is added to the prices of all tradable items in the economic models, to account for excess demand for traded and tradable goods and services. Inflows from, and outflows to, non-nationals are treated as benefits and costs, respectively. An opportunity cost of capital of 6% is deducted.

The models are subjected to sensitivity analysis, by varying key assumptions to determine the extent to which conclusions can be drawn from the results. Differences between financial and economic returns provide an indication of the influence of policy and/or market imperfections, on the enterprises.

Aggregate estimates of financial and economic fishery values were made using the model results and the results from the censuses undertaken in Niassa and Tete (IDPPE, 1993; 1996; 2001b). Here, the estimates of fisher and boat numbers made in 1993 and 1995 were extrapolated to the present (2002) using data on population growth from INE (1999; 2000b; 2001) and Gaspar (2002a; 2002b), and then multiplied by the relevant enterprise values. To reduce the potential for compounded error, aggregates were calculated using various different assumptions and then a mean of the results was taken.

Where monetary values are given in this report they are in Mozambican Meticais (Mt), or in United States Dollars (US$), where in 2002, US$ 1.00 was equal to Mt 22,000. In places, for brevity, Meticais are presented in Contos or units of a thousand (Cts).

3. The resource base

3.1 Primary areas

The inland fishing areas of Mozambique were divided into four categories according to their specific characteristics, national importance, and the likely interventions required for their development. These are:

(i) Lake Niassa, with lakes Amaramba, Chiúte, and Chilwe in Niassa Province
(ii) Lake Cahora Bassa in Tete Province
(iii) The three most expansive and populous river basin/floodplain systems (Zambeze, Limpopo and Pungwe/Busi),
(iv) Other river systems.

i) Lake Niassa, the Mozambican part of Lake Malawi/Niassa/Nyasa, is characterised by being very remote within Mozambique. It has significant artisanal fish production, some potential for expanded fish utlisation (some of it possibly commercial and involving tourism), a limited market in Niassa, a larger potential market in adjacent Malawi, and very high biological diversity and biodiversity value. The smaller, shallower lakes to the south, on the Malawi border, Amaramba, Chiúte, and Chilwe are also included in this division. A significant amount of research has been conducted here, on the broader lake (e.g., FAO, 1982; Fisheries Development Ltd, 1986; Menz, 1995; Turner, 1997a and others) and also locally (Massinga, 1988; Massinga, 2000; Bernacsek *et al*. 1983; Bukali *et al*. 1995; Halafo 2000, and others) and the results of this are reviewed below. There have also been some interventions by the Ministry of Fisheries, and others, aimed at support of fisheries.

ii) Lake Cahora Bassa is a large body of dammed water, characterised by being remotely situated in the Western Tete Province, by having a highly productive sardine fishery ("kapenta"), by having potential for expansion of the artisanal gill-net fishery, and by having limited markets to the north and south in Zambia and Zimbabwe respectively, as well in the Tete area. A fairly significant amount of research has been conducted here, (Jackson, 1975; Jackson & Rogers, 1976; Bernacsek & Lopes, 1983; Vostradovsky, 1984; Marshall, 1995; Falcão, 2000, and others). The results are reviewed below. There have also been some interventions by the Ministry of Fisheries, and others, aimed at support of fisheries.

iii) The three larger river basin systems are characterised by having some artisanal fisheries associated with their river and floodplain areas or small lakes/dams, having sizeable human populations, which could provide some market potential. Some isolated studies have described the fisheries of these systems, (Turpie *et al*., 1999; G. Pierconti, 2002, pers. comm.) and some interventions have been introduced aimed at fisheries rehabilitation (Massingire Dam). The systems tend to have been degraded by upstream dam construction (Davies, 1997).

iv) The other river systems consist of many linear rivers, lacking in floodplains or large surface areas, their production potential is small, but many, where associated with human populations, are utilised for artisanal fishing. A dam (Chicamba Dam) and an aquaculture intervention (around Chimoio) are associated with this category. Very little data is available and very little is known of these fisheries.

Given the small amount of information on the river and floodplain systems (iii and iv), these will only be referred to briefly throughout this report, which is focussed on the two big lakes and their fisheries (i and ii). Their physical characteristics are described below.

3.1.1 *Lake Niassa*

Lake Niassa, in the western arm of the East African Great Rift Valley, is the 6th largest lake in the world covering some 30 000 km^2. It is also one of the deepest lakes in the world and holds about 7% of the accessible world supply of freshwater. The principal characteristics of the lake are presented in Table 1. Eighty percent of the water loss is through evaporation and flushing time is high, at 750 years. The lake is meromictic (permanently stratified) with a consistent barrier to vertical mixing occurring at about 230 meters depth, a depth that also approximates to the oxic-anoxic boundary layer (Patterson & Katchinjika, 1995).

Table 1: Principal physical and physico-chemical characteristics of Lake Niassa. More than one figure indicates either the extremes of natural range, as in temperature, or extremes in estimates by different sources of information (from Ribbink 2001).

Extent	28800-30800 km^2	Major inflowing rivers	9
Max depth	704-785 m	Outflowing rivers	1
Mean depth	290-426 m	Inflow	29 km^3 y^{-1}
Depth of oxic water	170-210 m	Precipitation over lake	41 km^3 y^{-1}
Altitude	471 m	Inflow Malawi	43%
Proportion below sea level	230 m	Inflow Mozambique	4%
Shoreline	1500 km	Inflow Tanzania (%)	53%
Max. lake length	505/603 km	Outflow	12 km^3 y^{-1} ca 20%
Max. lake width	87 km	Evaporation	54 km^3 y^{-1} ca 80%
Mean width	50/60 km	Annual amplitude	0.4-1.8 m
Secci disk transparency	12-20 m	Proportion of worlds total available surface freshwater	7%
pH surface	7.9-9.1	Flushing time	750 y
pH 300 m	7.8	Residence time	140 y
Conductivity surface	215-225 mS cm^{-1}	Age	ca 2 million y
Conductivity 300 m	200-230 mS cm^{-1}	Number of lake basins	1
Primary production	252 g cm^{-2} y^{-1}	Wet season southern part	Nov.-Mar.
Total catchment	126 500 km^2	Wet season northern part	Dec.-May
Land catchment	97 750 km^2	South easterly winds (Mwera)	May-Sep.
Hypolimnion	Below 230 m	Northerly winds (Mpoto)	Nov.-Mar.
Metalimnion	125-230 m	Fish landings	60 000 t y^{-1}
Epilimnion	0-125 m	Temperature hypolimnion	22.1-22.75°C
Volume of hypolimnion	ca 2800 km^3	Temperature metalimnion	22.5-23.5°C
Volume of metalimnion	ca 2600 km^3	Temperature epilimnion	23.0-29.5°C
Volume of epilimnion	ca 3000 km^3		
Volume	ca 8400 km^3		

Because of the lack of turnover in the lake, nutrients are trapped in high concentrations in the hypolimnion (Ribbink, 2001). Still, nutrients are loaded to the surface waters from the metalimnion during the seasonal south-east trade winds, which cause weakening of the vertical density boundaries in the epi- and meta-limnion, and cause a seasonal increase in production (Patterson & Katchinjika, 1995). Surveys of primary production in 1992-1993 indicated that the lake can be considered oligotrophic or mesotrophic depending on the criteria (Patterson & Katchinjika, 1995). An understanding of the factors dictating variation in phytoplankton production, and thus a basis for understanding variation in stocks of planktivore fish, is still lacking.

About 20% (6,400 km^2) of the lake, with a shoreline of about 250 km, belongs to Mozambique (Vanden Bossche & Bernacsek, 1990). The Mozambican shoreline is mostly rocky (44%) and sandy (43%) and the bottom falls steeply to the 100 metre depth contour which, on average, is only 1.2 km wide and occupies a total of only some 300 km^2 (Bernacsek *et al*., 1983).

3.1.2 Lake Cahora Bassa

Cahora Bassa is, with its 2,665 km^2 surface area, one of Africa's largest reservoirs. As a lake, it is very different from Lake Niassa in all respects (topography, water residence time, fish fauna, fisheries and, presumably, productivity). It can be much more readily compared with the Lake Kariba reservoir, 300 km upstream, which holds the same fish fauna, and is one of the most studied freshwater reservoirs in Africa (Karenge & Kolding, 1995). The principal differences between the two are that Cahora Bassa has lower water residence time, higher nutrient load, periodically high clay load (possibly causing a temporary decrease in primary production) and a narrower euphotic zone (Table 2).

Table 2: Summary of data relating to physical, physico-chemical and biological characteristics of Lake Cahora Bassa (based on a water level of 326 m a.m.s.l.) compared with Lake Kariba (based on a water level of 485 m a.m.s.l.). References and data are found in Bernacsek & Lopes (1983), Kolding *et al.* (1993) and Marshall (1995).

	Cahora Bassa	Lake Kariba
Length	246 km	320 km
Width, mean	11 km	19 km
Width, max.	40 km	40 km
Surface area	2665 km^2	5360 km^2
Shoreline length	1775 km	-
Volume	55 km^3	157 km^3
Inflow, mean	98 km^3y^{-1}	60 km^3yr^{-1}
Mean water residence time	0.61 y	-
Depth, mean	21 m	29 m
Depth, max.	156 m	120 m
Depth zone 0-15 m	38 % of surf. area	29 % of surf. Area
Depth zone 0-20 m	48 % of surf. area	38 % of surf. Area
Catchment area	1074600 km^2	664000 km^2
Height a.m.s.l	320 ± 7 m	482 ± 5 m
Euphotic zone[a]	2-3 m	12 m
Conductivity ≈ nutrient load [a,b]		
Bernacsek & Lopes (1983)	117 ~S cm^{-1}	80 ~S cm^{-1}
Marshall (1995)	143 ~S cm^{-1}	99 ~S cm^{-1}
Primary productivity[a]	2.3 gC m^{-2} d^{-1}	1.4 gC m^{-2} d^{-1}

[a] Given the great variability in water transparency both in time and space, this single figure for the Cahora Bassa euphotic zone should be interpreted with caution.

[b] Conductivity (C) is proportional to the concentration of dissolved solids ($TDS_{mg/l}$=0.722*C+6.07; Dr. H. Silva, Hidroeléctrica de Cahora Bassa, 2002, pers. comm.) and is taken as a measure of nutrient load.

Gliwicz (1984) described hydrological aspects and their impact on production on the exotic clupeid, *Limnothrissa miodon* ("kapenta"). The drastic seasonal increase in water turbidity, caused by increased clay load (still of unknown origin), was identified as an important regulatory factor for primary, secondary and, eventually, *L. miodon* production.

It should be noted that the study by Gliwicz (1984), like many others biological studies on Cahora Bassa, is based mainly on research in the most accessible eastern end of the lake, in particular, the smallest and deepest, Garganta, basin. ”Kapenta” fishers, although their camps lie near the Garganta basin, only occasionally go there to fish because catches are generally low. Thus the representativness of this basin for the lake as a whole is questionable and results obtained there should not be extrapolated uncritically to the rest of the lake. However, the dramatic periodical increase in turbidity described by Gliwicz (1984) is a lake-wide phenomenon, occurring first in the rainy season in the western end of the Lake, then expanding progressively eastwards to reach the Chicoa and Garganta basins many weeks (or months) later. The duration and timing of this varies considerably between years, and it may not reach the eastern parts, or even occur at all. Also, it is possible that the turbidity in the eastern region (e.g. the Chicoa basin) is not as high as that further west (unpublished data). It is probable that the increase in turbidity carries with it a loading of nutrients that are exploited by phytoplankton once the clay particles drop and the depth of the euphotic zone increases. When the water clears, this also seems to happen progressively from the west (anecdotal evidence from “kapenta” fishers). Outside the rainy season, bays under influence of inflowing rivers normally clear earlier than offshore waters. Water turbidity may have a great influence on the production, and perhaps the mortality, of the planktivore “kapenta”. However, its immediate impact on the other, long-lived species that do not depend directly upon the zooplankton production could be much less dramatic.

Only a very limited area of the now submerged area was cleared of vegetation before the reservoir started filling in 1975. The submerged vegetation serves as substratum for invertebrates, especially insect larvae and oligochaetes, and is favorable for fish production. It imposes, however, restrictions on the type and quality of fishing gear that can be used on the lake, as well as on motorised lacustrine transport.

3.2 Social and economic setting

The country of Mozambique is one of the poorest in the world. Some nation-wide statistics drawn from INE (2001) and Sida (2001) illustrate this point. GDP per capita in 1999 was some US$ 230. Out of its total 1999 population of 17.3 million, 70 % live on less than US$0.40 per day. For every 1000 live births, the infant mortality rate is around 131, and the child mortality to age 5 is 203. Literacy rate is 59% among men and 28% among women. Only 24% of the population have access to clean drinking water, and some 15% of adults are infected with the HIV.

The conditions in the remote rural settings where the majority of artisanal fishing communities are found are generally even poorer. This is true for the inland fishers, and communities such as that at Zumbo, in the extreme western end of Lake Cahora Bassa, are some of the most marginalised in the country. The fish resources, and the economic activity of fishing, play a role in ameliorating the plight of these communities. Whether this role can be enhanced is a primary focus of this report. Communities in these areas are heavily dependent on the natural resources for their livelihoods. Small scale, low input, risk averse systems of crop production are important. Natural resources are used through harvesting (fish, and plant products such as reeds grass, wood, etc.), and in Tete province, grazing is used for small-scale livestock keeping. Wherever possible household members earn cash in employment nearly always away from the home, but such opportunities are few.

Mozambique is celebrating ten years of democratically secured peace, following a protracted period of civil war. The period has been positive characterised by high economic growth, albeit from a very low base. GDP has grown at an average rate of 7.7%, between 1998 and 2000 (Sida

2001, INE 2000a). The last ten years have also seen fairly significant investments by international donors, aimed at capitalising on these positive developments. The setting is thus positive for the development of projects aimed at enhancing the contribution of fisheries to livelihoods and development.

3.3 Fisheries resources and sustainable yields in Lake Niassa

With at least 800 fish species, most of them endemic, Lake Niassa has the most diverse fish fauna of any lake in the world and it has attracted great international scientific interest. Biodiversity conservation has thus been given considerable attention in fisheries research activities (Turner, 1997a, 1997b; Ribbink, 2001). The most vulnerable species are found among the demersal haplochromines and the potamodromous species (cyprinids reproducing in rivers and spending their adult life in the lake), the first group because many of them have very narrow distributions and low population numbers, the second because they are subject to a particularly high fishing pressure as they congregate in river mouths prior to spawning. In contrast, pelagic species have generally higher population numbers, wider geographical distributions and do not, to anyone's knowledge, congregate in breeding aggregations in restricted areas.

3.3.1 Ornamental species

In Malawi, the ornamental fish ("mbuna") trade provides employment to some 200 people (Ribbink, 2001). In the Mozambican sector, reports by fishermen suggest that there is considerable species diversity of ornamental fishes (Thomás & Abdula, 1997) and some new species have recently been documented (Konings, 1995, cited by Thomás & Abdula, 1997). Eichler (1981), records past exports of ornamental fish from Metangula in Mozambique and the 1995 census of artisanal fisheries in Niassa province, recorded 693 artisanal divers, who "catch, among others, species for aquariums" (IDPPE, 1996). Our field investigations failed to detect any trade in ornamental fish.

Eichler (1981) investigated the feasibility of exporting ornamental fish from Mozambique in the context of the world market for East African ornamental cichlids. The following points emerged:

- In Malawi, 56 species of demersal haplochromines, some with numerous local colour forms, and 17 pelagic haplochromines of the genus *Copadichromis* (formerly *Haplochromis*) are of commercial interest.
- New colour forms (and especially new species) generally fetch high prices.
- Rift Valley cichlids are traded in low numbers but their prices are high and stable
- Trade channels are intricate.
- Lake Niassa water quality is favourable for post-harvest survival.
- European and American dealers expressed enthusiasm about the prospect of supply (new colour forms, new species) from the Mozambican waters of the lake.

It seems likely that a well-planned exploitation of ornamental fish on the Mozambican sector of Lake Niassa could be financially attractive.

3.3.2 Potamodromous species[1]

The potamodromous species (Cyprinidae) may be demersal or pelagic but are treated as a group because they are subject to a rather intensive fishing pressure when they congregate in river mouths prior to their spawning runs up river in the rainy season. Historically, these species have

[1] lacustrine in adult life, and reproducing in rivers

been a major constituent of the Lake Niassa catches, but stocks in Malawi have now collapsed. It is not clear whether it is overfishing or river degradation (or the two acting together) that has caused the critical situation of the Malawian stocks. In Tanzania where the general fishing pressure is low the potamodromous stocks appear to be in a good shape, yet the authorities are on the alert due to an ever-increasing demand for this popular fish even from distant urban centres (Ngatunga *et al.*, 1997). In Mozambique, it seems as if the stocks of "n'chila" (*Labeo mesops*) and "sanjika" (*Opsaridium microcephalus*) may still generate good yields (Halafo, 2000). However, according to fishermen in the Metangula area, catches of "mpasa" or lake salmon (*Opsaridium microlepis*) had decreased in the late 1990s and this species was not reported in catches from the river mouths in the 1998-99 rainy season (Halafo, 2000). The lake salmon prefers rather large rivers for its spawning runs (Ribbink, 2001) so the species may not be common in the Mozambican part of the lake. However, the Malawian experience, where the lake salmon has been decimated, must be taken seriously. Currently, of all the Lake Niassa fish resources, the potamodromous species appear to be most in danger of being over-exploited.

3.3.3 Demersal resources

In spite of the narrow inhabitable area of the lake bottom, the shallow demersal zone houses the majority of Lake Niassa's exceptional biodiversity. Among the species found here is the group of the rather small demersal haplochromines (demersal "utaka"), counting hundreds of species with 99.9% endemicity. Among these are many species with extremely narrow distribution, low population sizes and low numbers of offspring (Ribbink 2001), characteristics that make them exceptionally vulnerable to intensive fishing. The unique evolutionary process that has taken place in the lake means that local overfishing can, potentially, lead to extinction at the species level. Compared to the other resources, the status of the demersal haplochromines, and the level of fishing pressure they are subject to, are the most difficult to evaluate. The exploratory gill netting conducted by Bernacsek *et al.* (1983) lacked the mesh sizes necessary to sample the demersal haplochromines representatively.

Generally low catch rates in bottom-set gill nets lead Bernacsek *et al.* (1983) to believe that a demersal gill net fishery (presumably excluding the rainy season river mouth fishery) could not be economically viable without also targeting the demersal haplochromines. In numbers, bottom-set gill nets were the predominant gear type in the Mozambican sector both in 1983 (Massinga & Contreras, 1983) and 1995 (IDPPE, 1996), but mesh size composition has not been recorded. Based on existing data, it is hard to distinguish the fishing effort directed at demersal haplochromines from that directed at larger demersal fish and the potamodromous species. The level of fishing pressure can not be estimated. In general, the status of the resources in the Mozambican sector would probably be more comparable to that in Tanzania than that in Malawi. Ngatunga *et al.* (1997) expressed little concern over the demersal resources in the Tanzanian sector, partly due to low fishing pressure, but, importantly, also because there has been a marked shift of fishing effort towards deeper waters and away from the shallows.

The only other gears that might have an impact on the demersal haplochromines are the seines (chilimilas used in shallow water, and beach seines). Beach seines are fished on sandy bottom and chilimilas on rocky bottom so it appears as if most demersal haplochromines would be affected. However, in the survey by Halafo (2000), the demersal haplochromines constituted less than 5% of both chilimila and beach seine catches, thus the fishing pressure from these gears seems modest.

From a biodiversity conservation perspective, optimizing yields of demersal haplochromines would be a development in the wrong direction, and research to estimate potential yields should not be priority.

The large catfishes (*Bathyclarias* spp.), the "kampango" (*Bagrus* spp.) and the popular table fishes in the "chambo" group (*Oreochromis* spp.) constitute the most important non-haplochromine demersal species. They have all been subject to rather heavy exploitation in Malawi. Although they seem rather resilient to fishing pressure, there is some concern regarding the conservation status of "chambo", which has been overexploited by trawlers in south east of the lake in Malawi and in Lake Malombe (Ribbink 2001). Since there is no trawl fishery in Mozambique these stocks are unlikely to be overexploited except, possibly, in areas with high numbers of beach seines.

Bernacsek *et al.* (1983), based on catch rates for the medium and large mesh sizes (catching 85% non-haplochromine species), reached a tentative conclusion that bottom gill net CPUE was lower in Mozambican waters than the average for the rest of the lake. However, the comparison was described as "limited and not exactly equivalent". On the other hand, the study suggested a positive correlation between rocky bottom and bottom gill net CPUE. In the Mozambican sector, some 45% of the shoreline is rocky (Bernacsek *et al.*, 1983; Massinga & Contreras, 1988), which is 50% higher than the average for the lake (Ribbink, 2001). This contradicts the assumption of demersal fish being scarcer in the Mozambican sector than in other, comparable parts of the lake.

3.3.4 Pelagic resources

In contrast to the demersal zone, the pelagic environment houses a relatively low number of species, each with generally high population numbers and, compared to some of their demersal counterparts, a broad geographical distribution (Thompson *et al.*, 1995a; Ribbink, 2001). These species can be overfished in an economic sense of the term, but from a biodiversity conservation perspective they are less vulnerable than the demersal haplochromines. No mass spawning aggregations could be detected for offshore pelagic species during intensive surveying in 1992-94 (Thompson *et al.*, 1995b; Menz *et al.*, 1995), thus they seem less vulnerable than the potamodromous species to be over-exploited in the breeding season.

It is important to make the distinction between inshore and offshore pelagic resources since they differ significantly both in fish density, species composition and accessibility to artisanal fishermen. However, the concepts of "inshore" and "offshore" are not used in a consistent manner in the literature on the lake. The ODA/SADC Pelagic Fish Resource Assessment Project had as a mandate to survey offshore pelagic fish stocks. In one of their studies, what are designated "inshore-offshore transects" started 5 km off the coast (Thompson *et al.*, 1995a), yet in many parts of the lake, the acoustic surveys seemingly passed 1 km from the shore (Menz *et al.*, 1995). The project seems to have operated with a lake surface area of 28,800 km^2 (Patterson & Katchinjika, 1995). The relationship between estimated biomass and density (Menz *et al.*, 1995) imply that an area of about 24, 000 km^2 has been considered offshore waters, which again implies the concept of an inshore-offshore border some 4-5 km from the shore. This concept is corroborated by Turner (1982a) who found that the influence of the coast (as measured by purse seine CPUE) extended to about 5 km off the shore at Nkhata Bay, Malawi. The lakebed at Nkhata Bay shelves quickly to 200 m depth, somewhat more steeply than is the case along the Mozambican coast. Pending direct observations, it seems as a reasonable approximation to set the limit of the inshore waters in the Mozambican sector to 5 km from the shore.

<u>Offshore pelagics</u>

The ODA/SADC Pelagic Fish Resource Assessment Project is the most comprehensive study of the offshore pelagic environment of Lake Niassa to date, describing various aspects of its limnology and ecology. Fisheries resources were the focal point of the project and 11 acoustic cruises and 11 fishing cruises were conducted (between March 1992 and January 1994) to survey fish biomass, species composition and variation of these over time and space. The main findings were:

- Mean offshore fish biomass over all cruises was estimated at 168,400 tonnes with a mean density of 70 kg ha^{-1} (Table 3).
- The biomass spatial density showed no statistically significant variation over space and time during the survey period, although there was a tendency for higher fish densities to occur in the northern and southern third of the lake (Menz *et al.*, 1995). There was generally no east-to-west trend in densities. The *volume* density was significantly higher in the south where the lake is shallower. It is not explained, though, if the shallow areas in the south hold higher volume densities than shallow waters elsewhere on the lake.
- On average 88% of the offshore fish biomass was made up by cichlids (Thompson *et al.*, 1995a; Menz *et al.*, 1995). This strongly contradicted earlier belief (Turner 1982b) that "usipa" (*E. sardella*) is the only true pelagic species in the lake. Indeed, in the species composition below (from Menz *et al.*, 1995), "usipa" was estimated to constitute only 3% of the offshore virgin stock biomass at the time of the surveys;

Diplotaxodon 'elongate'	52%
Diplotaxodon 'bigeye'	19%
Ramphochromis longiceps	7%
Copadichromis quadrimaculatus	5%
Other *Ramphochromis* spp.	3%
Other cichlids	2%
Non-cichlid species;	
Synodontis njassae (small catfish[2])	8%
Engraulicypris sardella (Cyprinidae)	3%
Opsaridium spp. (Cyprinidae)	1%

- In contrast to most pelagic planktivores, the Lake Niassa pelagic cichlids are all *k*-selected with low fecundity (288-730 eggs kg^{-1}, or, in absolute numbers, 15-24 eggs per ripe female of the dominant offshore species; Thompson *et al.*, 1995b). This implies that the stock is unable to rapidly replace large numbers of fish taken out by fishing. The opposite effect is predicted for the *r*-selected "usipa" (*E. sardella*) with its high fecundity, apparently continuous reproduction and short life span (Thompson *et al.*, 1995a; 1995b).
- Given a fishery using trawl cod-end mesh size of 38 mm (1.5"), which is the mesh size currently employed in trawling in Lake Niassa, Thompson (1995) estimated that only 19% of the virgin biomass of pelagic cichlids can sustainably be taken out on a yearly basis (Table 3). The estimated Y/B_0 ratio of "usipa" was considerably higher but, if the offshore biomass is as scarce as indicated, the potential yield is low (Table 3).
- The density stability in time and space was taken as evidence that mass spawning migrations (especially in an inshore direction) did not take place.
- In the deep waters that dominate the pelagic zone of the lake, fish biomass had a wide vertical distribution (0-250 m). Catch rates suggested a tendency for biomass to concentrate in the upper half of this distribution range at night (Thompson *et al.*, 1995) but this did not seem to be corroborated by acoustic recordings (Menz *et al.*, 1995).

The low estimates of offshore *E. sardella* biomass should be treated with some caution. First, the contribution of each species to the total pelagic biomass (as estimated by hydro-acoustic techniques; Menz *et al.* 1995), was done by experimental gillnetting and trawling (Thompson *et al.,* 1995a). It was admitted that *E. sardella*, being small and very slender, was not well sampled

[2] Mochokidae

by gill nets. It can be deduced from the description of the trawls that the large, commercial midwater trawl (probably the best one for many purposes) had a cod-end lining mesh of 1.5 inches (38 mm), whereas the mesh sizes used and recommended by fishermen interviewed during our field mission were only one third or one sixth of this (i.e. half inch and quarter inch). There is thus reason to question the efficiency of this trawl to retain "usipa". The second trawl, although having an adequate 4-mm-mesh liner in the cod-end, had an opening of only some 14 m^2 which caused concern with respect to its adequacy (Thompson *et al.*, 1995a).

Table 3: Yield estimates (Y) of pelagic fish in offshore Lake Niassa based on virgin biomass (B_0), Y/B_0 ratio and an offshore area of 23 900 km^2. Based on Menz *et al.* (1995), Thompson *et al.* (1995a) and Thompson (1995).

Species Group	Y/B_0	Offshore B_0 (t)	Offshore Density (kg ha^{-1})	P (kg ha^{-1} y^{-1})	Y (t y^{-1})
Cichlids	0.19	148,200	62.0	11.5	27,500
"Usipa"	0.63	5,100	2.1	1.3	3,200
Others [1]	0.17	15,100	6.3	1.1	2,600
Total	-	168,400	70.4	13.9	33,300

[1] 90% being constituted by the small catfish *Synodontis njassae*

For other species, the selectivity by the small trawl could be established by comparison with the larger trawl but this would not have been possible for the "usipa" (see above)). Second, it should be noted that the sampling for species composition was not carried out along the hydro-acoustic transects (as is customary) but in the centre of the lake during separate fishing surveys. Certainly, biomass estimates of species exhibiting an inshore-offshore density gradient would be biased. Thompson *et al.* (1995a) concluded that the "usipa" (as one of only two of the pelagic species) were significantly more abundant in the south than in the rest of the lake. It is noteworthy that the two sampling stations at which the highest "usipa" CPUE were obtained were also the two stations that were closest to the shore, raising speculation as to whether these higher densities were related to latitude, bottom depth or distance from shore (or any combination of these).

The offshore fish stocks do not seem adequate to support fisheries (Anon., 1982; Thompson, 1995). The cichlids are too vertically dispersed and can not be aggregated near the surface due to the physoclist (closed) nature of their swimbladder preventing them from undertaking rapid and extensive upward migration. Light could be used to attract "usipa" from considerable depths since its swimbladder is physostome (open). However, if existing biomass estimates (Rufli & Vitullo, 1982; Thompson, 1995) are accurate, catch rates in offshore waters would still be low.

Inshore pelagics

In contrast to offshore waters, the near shore zone holds reasonably high densities of pelagic fish. Two small planktivore species (groups) dominate: Pelagic "utaka"[3] (*Copadichromis* spp.[4], perhaps particularly *C. quadrimaculatus*) and, periodically, "usipa" (*Engraulicypris sardella*). Less abundant but popular table fishes are the "n'chene" (*Ramphochromis* spp.), lightly exploited

[3] Numerous local names exist for this group, probably reflecting different species and life stages (Halafo, 2000: Appendix C)

[4] *Copadichromis* was formerly *Haplochromis*

pelagic predatory cichlids with highest densities deep (60-100 m) in the water column (Ribbink, 2001; Thompson *et al.*, 1995a).

At Nkhata Bay, Malawi, with latitude and topography comparable to the Mozambican coast, Turner (1982a) recorded purse seine CPUE four times higher within 2 km of the coast than offshore (>5 km). A similar biomass distribution pattern was observed during brief hydro-acoustic surveys in Metangula Bay, Mozambique, in February 1983 (Lindem, 1983). Dense daytime schooling was observed near shore. The night fish density was very high near the shore (4000+ fish ha^{-1}) and it declined steeply to 200-300 fish ha^{-1} "a few hundred metres from the shore" where the water depth exceeded 100 metres (at Metangula Bay, the 100 m depth contour is actually found about 1700 m from the shore; Bernacsek *et al.*, 1983). The mean weight of inshore pelagic haplochromines caught by Bernacsek *et al.* (1983) could be used to convert the density by numbers into density by weight, although the mean weight based on their data is likely to biased. At a mean individual weight of 50.4 g, a fish density of 4000 fish ha^{-1} would correspond to a biomass density of 202 kg ha^{-1} and 250 fish ha^{-1} would correspond to a biomass density of 13 kg ha^{-1}. These density figures assume that the "very small" fish, observed by Lindem (1983), were all pelagic haplochromines, which is unlikely. "Usipa" was probably present too, and at a mean weight <10 g, the biomass density estimates above are probably positively biased.

The differences in purse seine CPUE off Nkhata Bay were mainly explained by the offshore-inshore density gradient of one species, namely, the pelagic haplochromine *Copadichromis quadrimaculatus* which is found throughout the lake (Thompson *et al*., 1995a). The dominant pelagic genera, *Copadichromis* and *Diplotaxodon*, are present both in- and offshore but with inverse prevalence (Table 4).

Table 4: Offshore and inshore species composition of the dominant cichlid (haplochromine) genera, *Copadichromis* and *Diplotaxodon,* in Lake Niassa. From Menz *et al.* (1995), Halafo (2000).

Genus	Offshore (whole lake)	Inshore (central, east)
Diplotaxodon	71%	5-10%
Copadichromis	5%	90%

The breeding biology of *C. quadrimaculatus* (and presumably other *Copadichromis* spp.) is comparable to that of the offshore haplochromines in that it is *k*-selected with low fecundity. This makes it less resilient in the face of exploitation than is usual for pelagic planktivores. However, *C. quadrimaculatus* has a lake-wide distribution and, until an offshore fishery of any scale develops (if ever), there will be a considerable fraction of the stock that is not exploited (some 8 000 tonnes according to Menz *et al.*, 1995). Other *Copadichromis* spp. are likely to be more vulnerable since they are, practically, not found offshore and may actually have narrower distribution ranges (Ribbink, 2001). A paper by Iles (1971) deals with growth of Lake Niassa cichlids in general and a few *Copadichromis* (*Haplochromis*) species in particular. It also contains a reference list to early fish research on the lake.

Bernacsek *et al.* (1983), conducted exploratory gill netting within 1 km of the shore in 1983, and reported highest CPUE for pelagics (including haplochromines) in the rainy season when using surface-set gill nets of 44 and 54 mm stretched mesh (Table 5). The difference was apparently not statistically tested, however. The authors attribute the difference in CPUE between rainy and dry season to difference in biomass. Yet, assuming higher water turbidity and more overcast weather in the rainy season, at least some of the increase in CPUE could be ascribed to increased gill net efficiency. Other studies indicate that the inshore haplochromines generally stay inshore throughout the year (Eichler, 1981; Ribbink, 2001) and that the few species found offshore only occur there in low densities without marked seasonal variation (Menz *et al.*, 1995). Any real peak in biomass during the rainy season, could be the result of either recruitment, increased individual growth, or mass migration into the Mozambican sector from other inshore areas (or some combination of these factors). Catch data suggest that the first hypothesis is unlikely to be valid (see Table 5), and the others cannot be evaluated for lack of suitable data.

Table 5: Catch rates of haplochromines using different mesh sizes (in kg per 100 m surface-set gill net), in dry season and rainy season. Figures are computed from data in Bernacsek *et al.* (1983: Tables 8, 11 & 12)

Season	Survey period	Mesh size 44 mm	Mesh size 54 mm
Dry	August 1981	5.7	6.3
Rainy	February-March 1982	14.9	15.0
Dry	May 1983	8.6	5.0

The limited range of mesh sizes introduced a serious bias into the results of Bernacsek *et al.* (1983). The work may serve as a reference point for the state of a segment of the pelagic stock but, unless it is followed up by routine gill netting using the same (and other) mesh sizes, it is difficult to evaluate its usefulness in assessing the resources (as indicated by Kolding *et al.*, 1993). Nevertheless, the study presents some useful data on biological profiles of several important species.

Year-to-year variations in biomass and CPUE of pelagic haplochromines (*Copadichromis* spp.) will follow variations in plankton production etc. However, due to their low fecundity, variations are likely to be moderate compared to that seen in most small pelagic planktivores. Some comparative population parameters are shown in Table 6.

Table 6: Some population parameters in the important inshore pelagic species *Copadichromis quadrimaculatus* and *Engraulicypris sardella* (from Iles, 1971; Thompson *et al.*, 1995a, 1995b; Thompson, 1995).

Species	M (yr^{-1})	L_∞ (mm)	K (yr^{-1})	t_0 (yr)	Fecundity (eggs kg^{-1})	Length at Maturity (mm)	ln(a)[1]	B[1]	Y/B_0[2]
C. quadrim.	0.5	190	0.65	-	649	160	-1.96	2.12	0.19
E. sardella	2.5	113	1.31	0.21	-	70-80	-5.78	3.30	0.63

1 Least square regression estimates of parameters to the equation: $\ln(W)=\ln(a)+b*\ln(L)$
2 See text

The range of surface-set gill net mesh sizes available to the Bernacsek *et al.* (1983) was narrow, and not adequate for very small fish such as "usipa" (*E. sardella*) and medium to large sized fish (tilapiines and the endemic catfishes *Bathyclarias* spp.). Pelagic "utaka" (haplochromines) made up 50% of the catches and 40% of the specimens were classified as sexually mature although data were not given separately for the two mesh sizes. Three cyprinids made up another 40% of the catches: "sanjika" (*Opsaridium microcephalus*), the short-barbelled Lake Malawi yellowfish, "kuyo" (*Barbus jonstonii = Varicorhinus nyassensis*) and "n'chila" (*Labeo mesops*). These are all potamodromous species (see above).

The importance of the sardine-like "usipa" (*E. sardella*) as a pelagic resource is somewhat enigmatic. This is mostly because research efforts have lacked appropriate gear, and duration, and because data from the artisanal fishery is inadequate. Catch statistics on "usipa" must be interpreted with caution. Lewis & Tweddle (undated) set out to validate the catch statistics on "usipa" by sampling the quantity of marketed dried product. Based on these data they estimated the lake-wide Malawian "usipa" catch during 11 months in 1985-1986 at 50-100,000 tonnes. This contrasted with the official estimate of 5,500 tonnes for the same period. The under-estimate by the fisheries statistical recording system was explained by the fact that *E. sardella* is mainly caught and landed at night, while beach recorders only worked at day. It could be noted that the Malawi Fisheries Department's estimates of total annual yield in Malawi (all species) ranged from 17,000 to 33,000 tonnes for 1980-1991 (Thompson, 1995). Thus, it is possible that, in good years, the yield of "usipa" could be twice as high as all other species combined.

Some characteristics of "usipa" biology have been established. Turner (1982a) reported significantly higher purse seine catches in the near shore region than in the open lake during surveys off Nkhata Bay, indicating a preference for inshore waters. The assumption of independence between recruitment and parent stock biomass, seems likely to be valid. This is since statistics from Malawian trawl catches show that a year with very low "usipa" catches can be followed by a year of exceptionally good ones (Turner, 1982b). As with *C. quadrimaculatus*, "usipa" has a lake-wide distribution and, since the development of a full-scale offshore fishery is unlikely, the open waters will act as a refuge for a significant stock of spawners.

Bukali *et al.* (1995) reported over-fishing of "usipa" in the Metangula-Mecuio-Messumba area. Although possible, it seems unlikely that an *r*-selected species with a lake-wide distribution like *E. sardella* would suffer overfishing from a local, artisanal fishery. The explanation seems more likely to be in the great natural variations in biomass (see above).

3.3.4 Sustainable yields for Lake Niassa

Empirical methods such as the morphoendaphic index (MEI) and primary production models are sometimes useful in estimating potential fish yields. In these models, estimated potential yields are negatively correlated with bottom depth. Compared to the lakes that have been studied to establish the empirical methods, Lakes Tanganyika and Niassa take extreme values of mean bottom depth. Thompson (1995) suspects that the models do not apply to lakes where bottom depths deviate this much from the depth range of the reference lakes and he refers to several works in Lake Tanganyika where empirical models have been believed to under-estimate potential fish yields. He therefore advised against using such models for Lake Niassa.

Rufli & Vitullo (1982) estimated the potential *whole-lake* yield at 45 kg ha^{-1} y^{-1} while the potential *offshore* yield was estimated at 14 kg ha^{-1} y^{-1} by Thompson (1995). Assuming an offshore area of 23 900 km^2 and an inshore area of 4,900 km^2 (see above), the prediction for the yield potential for inshore waters alone would actually be 200 kg ha^{-1} y^{-1}. It is evident that this estimate is based on insufficient evidence, but no studies appear to have aimed at producing a separate estimate of the inshore potential yield in Lake Niassa. Our estimate of the total potential sustainable annual yield of the Mozambican section of Lake Niassa is 25,000 tonnes. This conforms with the estimate of between 19,000 and 25,000 tonnes, made by Kolding *et al*. (1993), and that of 20,000 tonnes, made by Bernacsek and Contreras (1998). These potential yield estimates are discussed in relation to estimates of actual yields under "fishing pressure" (4.1.6, below).

3.4 Fisheries resources and sustainable yields in Lake Cahora Bassa

3.4.1 Current harvesting

The artisanal fishers in Cahora Bassa exploit the table fish resource. Species such as "pende" (*Oreochromis mortimeri*), the "m'cheni" (*Hydrocynus vittatus*), "maramba" (*Clarias gariepinus*), "chenga" (*Distichodus schenga*), "mucupe" (*Mormyrus longirostris*), and "mpumbu" (*Labeo altivelis*) make up the bulk of the catches (Bernacsek & Lopes, 1983; Vostradovsky, 1984; Marshall, 1995). The prolific clupeid *Limnothrissa miodon* ("kapenta"), is exclusively exploited by the Lake's semi-industrial fleet and an artisanal fishery for this resource is unlikely to develop (see below). Another planktivore, the small characid *Brycinus imberi*, has been studied in some detail but does not appear to have great commercial potential (Marshall, 1995). It thus seems as if the resources available to the artisanal fisheries sector are the various table fish of riverine origin. Keeping in mind that the reservoir area was not deforested before it was filled, it is an open question how efficiently the demersal species are exploited (see below).

3.4.2 Sustainable yields for Lake Cahora Bassa

Based on comparison between Lakes Cahora Bassa and Kariba, with respect to the contribution of the productive littoral zone to the total reservoir area, actual yield, actual exploitation levels, and a morphoendaphic index (MEI) developed for African reservoirs, Bernacsek & Lopes (1983) estimated the sustainable annual catch of table fish in Lake Cahora Bassa at 6,700 tonnes, more than twice that for Lake Kariba. Vostradovsky (1984) estimated that the figure could be no higher than 4,000 tonnes but this is lower than the actual yield of 4,343 tonnes estimated for 1982 by Bernacsek & Lopes (1983). One study on this topic was carried out during or just after the filling phase. Since this should have been an atypically productive period (Petr, 1975; Marshall, 1995), those estimates on biomass densities and potential yields cannot be considered valid for the current environment. Kolding *et al*. (1993), estimated the total potential sustainable annual yield for Lake Cahora Bassa at 19,000 tonnes, of which 15,000 tonnes was offshore (mostly "kapenta") and 4000 tonnes inshore (mostly demersal species). These potential yield estimates are discussed in relation to estimates of actual yields under "fishing pressure" (4.2.6, below).

4 Fishing practices and investments

4.1 Current fishing practices and catches in Lake Niassa

Censuses of the artisanal fisheries in the Mozambican part of lake Niassa have been carried out in 1983 (Massinga & Contreras, 1988) and in 1995 (IDPPE, 1996). With respect to gear composition, the first census recorded the *number of boats involved in each gear category*, while in the second census, number of boats and number of gears were obtained independently. Thus, the estimates of the number of gears for the two surveys cannot be compared. Estimates of the number of boats, however, can be compared, and these were virtually the same in the two surveys (Table 7). Halafo (2000) conducted a localised census in the Metangula area in 1998-99 and found a significant increase in numbers of boats compared with 1995 (Table 7) but the recent survey was carried out in the rainy season when catches (and probably fishing effort) are generally higher than the yearly average (Bernacsek *et al.*, 1983; Massinga & Contreras, 1988). The fishery in the Mozambican sector is exclusively artisanal and near-shore. At least 95% of fishing boats are dugout canoes and, if one can compare with Tanzania (Ngatunga *et al.*, 1997), these are unlikely to venture farther than 1 km from the shore. In the rainy season 1998-99 in Metangula, Halafo found (by surveying catches) that the use of chilimila nets (targeting the pelagic haplochromines *Copadichromis* spp., "utaka") accounted for more than 50% of the landings, and the percentage might be higher in the dry season. Massinga & Contreras (1988) estimated from interviews that the chilimilas accounted for 75% of the total annual landings.

Table 7: Number of boats in the Mozambican part of Lake Niassa in 1983 and 1995, and number of fishermen and gears per category in the Metangula area in 1983 and 1999. The symbol – means that data were not comparable.

	Whole Sector	Metangula area							
Year	Boats	Gear owners	Assist-ants	Beach Seine	Chili-Mila	Gill Net	Hand line	Long-line	Traps
1983[1]	1228	98	225	8	27	152	102	26	16
1995[2]	1160	-	-	-	-	-	-	-	-
1999[3]	n/a	444	1198	22	78	165	151	64	10

1 Massinga & Contreras (1988)
2 IDPPE (1996)
3 Halafo (2000)

In the 1983 census (carried out in the dry season), it was estimated that 90% of the yield was landed in the rainy season. Assuming a rainy season of five months, chilimila CPUE in those months must have averaged 365 kg. Halafo (2000) estimated chilimila CPUE in the rainy season in the Metangula area by direct observation and estimated it at 36 kg $trip^{-1}$. He suggested that the apparent drop in CPUE might be due to the increasing number of chilimilas, deterioration of the nets and actual over-fishing. Additional explanations could be linked to natural variations in fish abundance and the difference in methods by which the data were obtained.

The fishing methods are described below. Except for the light attraction surface gill netting, not formerly described in the Mozambican sector of the lake, these methods have also been described by Anônimo (1993) and Bukali *et al*. (1995).

4.1.1 Beach seines

Large beach seine nets up to 1,000 metres length, with mesh size of half inch or 1 inch in the central part, increasing gradually to two inches at the ends, target "chambo" (*Oreochromis* spp.), demersal "utaka" (Haplochromines), "sanjika" (*Opsaridium microcephalus*), "n'chila" (*Labeo mesops*), and "m'pasa"/lake salmon (*Opsaridium microlepis*). According to one seine owner, 10 persons operate his 500 metre seine, while another of 700 m requires 16 men.

Small beach seines for the local "sardine", "usipa" (*Engraulicypris sardella*), have mosquito net or half inch meshes in their central part (quarter inch would be ideal, according to one fisherman).

The ones observed during this mission (Meponda, Nonga, Metangula area) were all shorter than 200 metres. In Nonga (north of Meponda), it was explained that, in times when "usipa" are observed near shore, canoes will go out a distance from the shore in the evening and each attract a school of "usipa" using "petromax" paraffin lamps. The canoes will, after a while, be manoeuvred slowly towards the beach where one canoe and school at a time will be encircled by a beach seine team. The small "usipa" seines observed during this mission were operated by eight persons.

4.1.2 Chilimila

Chilimila is a seine in the shape of a trapezium with the upper length being the greatest. Dimensions, as reported in Anônimo (1993), varied between 54 and 80 metres upper length and between 16 and 23 metres depth. Mesh size increases from one inch in the "cod end", to two inches in each end of the net. Pelagic "utaka" (*Copadichomis* spp.) are the target species. Massinga & Contreras (1983) estimated that chilimilas are responsible for at least 75% of the total landings.

4.1.3 Gill nets

In 1995, 53% of the fishing gears in the Mozambican sector were gill nets, and 85% of them were set demersally (IDPPE, 1996). Mesh sizes range from one and a half inches to five inches and principal target species appear to be; demersal "utaka" (demersal haplochromines), "sanjika" (*O. microcephalus*), "n'chisi" (no scientific name given), "chambo" (*Oreochromis* spp.), "n'chila" (*L. mesops*), "n'komo/sapua" (*Bathyclarias nyasensis*), other *Bathyclarias* spp., and "kampango" (*Bagrus meridionalis*) (Bernacsek *et al*., 1983; Anônimo, 1993; IDPPE, 1996). It is likely that the nets exploiting demersal haplochromines are those with mesh sizes between one and a half and two and a half inches.

The present mission found that that, over the last couple of years, a new gill net fishery, with light attraction and supposedly introduced by immigrant Malawian fishermen, has become popular. Surface nets are set 100-300 meters off the shore at night and pelagic "utaka" is attracted by light. After a while of light attraction, the fisherman starts hammering the side of the canoe with a stick, and the frightened fish will get entangled in the net.

4.1.4. Longlines, handlines and traps

Longlines are reportedly used to target bigger fish like "kampango" and "n'komo". Longlines with 300-400 hooks on them are set in the surface, while bottom-set ones tend to have around 100 hooks. Small fish, worms and insect larvae are the main baits. Handlines are employed with natural bait and lures to target n'chila and the predatory cichlids "n'chene" (*Ramphochromis* spp.). Traps are not described in any detail but they are used in rivers to catch potamodromous fish during their spawning runs.

4.1.5 Management systems

No formal management systems are established on the Mozambican part of the lake and it seems as if the fishery is to a large extent an open access one, at least outside the major population centres. Interestingly, there seems to be limited access to the riverine and river mouth fisheries, since such areas are considered to be community property (Thomás & Abdula, 1997). The river mouth fisheries are, at present, the form of harvesting posing the highest danger of overfishing, but the community control over estuarine areas means that there exists a basis for introducing regulations, given that the central authorities discuss and agree upon them with local authorities.

4.1.6 Fishing pressure on Lake Niassa

Kolding *et al.* (1993) estimated the density of fishermen for the Mozambican part of the lake at 1.5 fishermen per km^2 for the zone within 5 km from the coast, and this was evaluated as representing low to intermediate fishing pressure. They implied that the total fishing effort could be translated into 1,900 full-time fishers. In 1983, 3,400 fishermen were classified as 1,100 "proprietors" and 2,300 "assistants" (Massinga & Contreras, 1988) and in 1995, 4,600 fishers were classified as 3,100 "permanent" and 1,500 "temporary" (IDPPE, 1996). If the fishing effort varies between different categories of fishermen and between rainy and dry season, it is difficult to estimate the actual fishing pressure without carrying out much more detailed catch and effort surveys.

Massinga & Contreras (1988) estimated total catches in the Mozambican part of the lake at 9,100 tonnes in 1983. Assuming that only inshore resources, distributed within some 5 km from the coast, are being used, the 9,100 tonnes corresponds to some 73 kg ha^{-1} y^{-1}, less than 40% of the albeit somewhat speculative estimate of 200 kg ha^{-1} y^{-1} presented in 3.3.4, above. Using a very conservative blend of yields reported by fishers in focus group discussions and key informant interviews, and extrapolating up to 2001 using population growth data, we made another independent estimate of aggregate annual artisanal landings for 2001, and this was 10,000 tonnes (see Table 10, chapter 5, below). Because we emphasised the lower yield estimates of fishers, this could well be a conservative estimate, but it is less than half of the estimated potential sustainable yields given in 3.3.4, above. Therefore, overall, fishing pressure appears to be low.

4.2 Current fishing practices and catches in Lake Cahora Bassa

The artisanal fishermen around lake Cahora Bassa use dugout canoes and the only gear of any importance is gill nets. Some Zambian-made "banana boats" operate in the western part of the lake (Zumbo) and a similar type supplied by FAO are found elsewhere on the lake. These boats are considered by the fishermen to be a lot safer than the dugout canoes.

4.2.1 Gill nets

Gill nets are almost exclusively set at the surface. In 1993, 60% had mesh sizes between four and five inches, and 98% had mesh sizes between three and six inches (IDPPE, 1993). In order to cut costs and to obtain the ideal dimensions, the fishers prefer to cut un-rigged nets themselves, both length and cross wise, and to fit ropes, floats, and sinks themselves. Nets observed during this visit were Zambian (in the western part of the lake) and Malawian (in the eastern part). They were very fragile and highly inadequate for fishing in an environment with drowned trees and bushes and crocodiles. Many even appear to be torn by large fish. According to the fishermen, a net normally only lasts around two months. This is extremely short and can be compared with a useful life of one to two years for a gill net in Lake Niassa. Mozambican nets were considered to be a lot stronger but they are considered to be too expensive, possibly in part because they are completely rigged at the factory.

According to one gear owner employing several fishermen, the number of nets that can be handled by one fisherman is limited by the maximum time a fish can be dead without being cleaned and salted. The net capacity per fisherman therefore depends on the expected number of fish caught and was illustrated the following way: 20 nets with big mesh (big but few fish in each net), 10 nets with small mesh, and half of these figures in periods with particularly high catch rates. The average number of nets per fishing unit[5] was recorded as 6.6 during the census in

[5] A fishing unit is defined as one boat, its gear and its crew. In Cahora Bassa the crew will consist of one fisherman or sometimes two.

September-October 1993. Five fishermen at Camahuku at the Mágoè "satellite" basin used on average 7.8 nets each (range: 4-15) when the present mission interviewed them in September 2002.

Fishermen from the villages set up provisional camps some distance from home if better catch rates can be obtained. However, it was reported that the long distances travelled in canoes on the open lake were hazardous and could claim lives when bad weather erupted. The above mentioned gear owner reported that to a certain extent, fishing pressure was too high near the villages, and that more remote areas go unexploited. If larger boats and outboard engines were available in the region then this owner would purchase one to be able to serve remoter fishing camps (to transport fish, salt and other supplies). This particular artisanal enterprise was apparently profitable and expanding, without the need for any credit.

In terms of gill net catch rates, 2002 was said to be an average year, while 2001 (which began with extremely high water levels) was a very good year. The biomass of long-lived species exploited by the artisanal fleet is unlikely to change abruptly in response to environmental changes. The immediate increase in catch rates at very high lake levels are likely to be linked to easier access to the resource through demersal fishing in the drawdown zone (where most of the trees and bushes have been washed away). Under normal circumstances, 99% of nets are set at the surface (IDPPE, 1993). Catches also normally increase with turbidity. In the western part of the lake where the turbidity tends to be highest, we were informed that for a couple of months in the rainy season gill nets may be used both night and day.

4.2.2 Beach seines and other gears

In spite of the submerged vegetation, there is also an embryonic beach seine fishery on the lake. The seines are probably easiest to use at high lake levels when they can sweep the bottom in the drawdown zone but they can also, as observed during this visit, be used from some beaches at low lake levels.

Long lines have been tried with some success (Bernacsek & Lopes, 1984) but are not common, possibly due to high losses of hooks in the submerged vegetation (Marshall, 1995).

4.2.3 "Kapenta" fishing

The semi-industrial "kapenta" fishery is fairly well established in the eastern and central parts of Lake Cahora Bassa. This is analysed briefly in chapter 5 below. There are some 150 "kapenta" rigs operating on the lake, and they catch an estimated 15,000 tonnes, fresh weight annum^{-1} (Table 10, below). The fishery is capital intensive, medium-scale and, as an investment, is out of the reach of artisanal fishers. It does however, provide significant employment and cash, providing some capital for artisanal fishers. There does not seem to be much potential for artisanal use of "kapenta". Artisanal "kapenta" fisheries are established on Lakes Kivu and Tanganyika (but catch rates are rather low; 30-40 kg night^{-1}), while experiments with similar methods on Lake Kariba were unsuccessful (Marshall, 1995). An experiment involving an artisanal fishing method for "kapenta" was apparently initiated on Cahora Bassa but it was not brought to a conclusion. Intuitively, generating the necessary light intensity to attract viable quantities of fish seems even more difficult on Cahora Bassa with its relatively high water turbidity than on the above mentioned lakes.

4.2.4 *Conflicts*

In the eastern part of the lake where the "kapenta" fishing takes place, conflicts have arisen between artisanal fishermen and the "kapenta" operators because "kapenta" vessels destroyed the fishermen's nets, getting their propellers entangled when moving around. Now gill nets are better marked and in periods when there is a risk of geographical overlap between the two fisheries, the gill nets are fished a little under the surface rather than at it. One "kapenta" operator and several artisanal fishermen were interviewed on the topic and both parties seemed to perceive the conflict as solved. It would seem that there is no need to divide the lake in separate zones for artisanal and semi-industrial fishing.

On the other hand, present and potential lodge owners feel that the artisanal fishery practices (especially nets set for tigerfish) will hurt development of tourism based on recreational fishing. Experiences from Lake Kariba as well as the Okavango Delta have indeed revealed that large-mesh gillnetting can reduce the value of an area for sport fishing (J. Kolding, 2002. pers. comm.). These conflicts can be minimised if communities are given custodial rights over resources and are able to benefit themselves from any expansion of tourism activities. It will then be possible for development and resource allocation to be economically and socially beneficial.

4.2.5 *Management*

The mission was not able to identify particular community management measures and the access to the fishery seems to be open. Tchuma-Tchato, a community-based natural resources management programme which focuses on wildlife around the lake shores, has attempted to involve fishing communities (Namanha 1999; Jones, 2002; Cunliffe & Pitman, undated). So far this has only involved taking over the collection of fishing and fish buyer licence fees. The aim is to ensure that a portion of the licence fees is returned to the communities.

An established management measure, organised by Tchuma-Tchato, in the western basins of Zumbo and Messenguezi is a ban on fishing in river mouths. This is a regulation found many places in the world and is based on the fact that fish spawning in rivers congregate in the river mouths prior to the run upstream and that they at this point are particularly vulnerable to fishing. Up in the river, fishing is more difficult and the fish becomes less vulnerable. The river mouth fishing ban appears to be positive. It goes a long way to reduce the risk of recruitment overfishing (fishing that exploit spawners to the extent of reducing recruitment of young fish to the stocks) and it creates refuges where small components of the fish stocks are safe from potential overfishing. Surplus production from refuges can move out of them and benefit nearby fisheries. The negative effects might be that some species, which can only be harvested efficiently in river mouths, go unexploited. This is a relevant issue in Cahora Bassa because bottom-fishing is virtually impossible and some demersal species may be hard to catch unless fished for during their spawning congregations.

4.2.6 *Fishing pressure in Cahora Bassa*

Fishing pressure can be expressed by the density of fishermen (the total amount of surface area used by each fisher). Kolding *et al.* (1993) suggest, based on experience from Lake Kariba, that the artisanal fishermen operate within the 15 m depth contour (Table 8), which in Cahora Bassa corresponds to 38% of the lake surface, while IDPPE (1993) uses the entire lake surface as reference area (Table 8). In Cahora Bassa, the fishermen set their nets in waters deeper than 15 m (Bernacsek & Lopes, 1984) so the truth probably lies somewhere between the two density estimates. One might differentiate fishing pressure according to species. Tigerfish (*Hydrocynus vittatus*) appears to be common even at depths greater than 30 metres and it is possible that the reference area (used to compute fisher density) should encompass the entire lake surface area. Species like the cyprinids *Labeo* spp. are also commercially important but have a strong preference for shallow water (Bernacsek & Lopes, 1984). It would therefore seem as if a given number of fishermen would exercise a higher fishing pressure on *Labeo* spp. than on *H. vittatus* if fishermen have a preference for setting nets near the shore. However, the tendency for nets to be set at the surface to reduce damage means that demersal species can be subject to a moderate (or even low) fishing pressure even in areas with high densities of fishermen.

Table 8: Artisanal fishing pressure in the Cahora Bassa reservoir from 1982 to 1993.

	Bernacsek & Lopes (1984)	Vostradovsky (1984)	IDPPE (1993)
Method	Estimate	Estimate	Census
Year	1982	1984	1993
No. fishermen	1 217	1 500	1362
Fishermen per km^2 [1]	1.2 (0.5)	1.5 (0.6)	1.3 (0.5)

[1] The first figure assumes that the exploited area is the fraction contained within the 15 m depth contour (Kolding *et al*., 1993) holding a surface area of 0.38*2665=1013 km^2. The figure in brackets is based on the entire lake surface area. In the classification by Henderson & Welcomme (1974) for African freshwater environments, resources in lakes with densities above 1.5 are considered to be fully exploited.

Bernacsek & Lopes (1983) estimated the total 1982 artisanal landings in Cahora Bassa at 4,343 tonnes. This corresponds to a mean yearly catch per fisherman of 3.57 tonnes which is higher than the mean of about 3 tonnes for southern African lakes (Jul-Larsen *et al.*, 2002). Current catches can be estimated very roughly. At the landing point[6] of Cadzewe (just west of the Daque River), a five tonne truck carrying fish buyers visits twice a week. Fishers using this particular landing point were from all fishing centres between Giri and Cahie-Daque. The truck carries some 3 tonnes of dried fish per trip. If one assumes 100 trips per year, a fresh to dried fish ratio of 2.8[7], and if one extrapolates from the Giri and Cahie-Daque subset to the total number of boats on the lake, (11:100, IDPPE, 1993), then the annual quantity of table fish marketed by the artisanal fleet can be calculated at around 7,600 tonnes fresh weight (3*100*2.8*(100/11)). If one further assumes 1,362 fishermen lake-wide (as in 1993), and daily domestic consumption of 0.5 kg per fisher, the annual landings estimate for 1993 would amount to 7,900 tonnes. Using a very conservative blend of the yields, reported by fishers in focus group discussions and key informant interviews, and extrapolating to 2001, using population growth data, we made another independent estimate of aggregate annual artisanal landings for 2001, and this was 7,000 tonnes (see Table 10, chapter 5, below). Both of these are very rough estimates and they need to be improved by more sampling in time and space, an updated census of the sector, and better estimates of the dried to fresh fish ratio and of domestic consumption. However the two estimates are not wildly inconsistent.

[6] A landing point is here defined as a meeting place between fishermen from a set of permanent and temporary fishing camps, fish buyers and providers of transport.

[7] This figure originates from Lake Turkana and referres to an overall conversion factor from gutted, salted and sun-dried mixed fish (with head on) to round fresh weight (Bayley, 1982). The conversion factor should apply well to the processed fish observed during the ICLARM/IDPPE mission.

The past estimates of potential sustainable yields for table fish targeted by the artisanal gill net fishery, presented in 3.4.2, above, are all lower than our estimates of actual yield. This would suggest excessive fishing pressure, but all the other evidence obtained by this mission would suggest the contrary. Fishers reported higher yields than even the ones we used to estimate production, which in turn are considerably higher than the average ones for southern African lakes (Jul-Larsen *et al.*, 2002). Fishers also talked of expanding into new unfished areas. Our preliminary financial and economic models (Chapter 5, below) suggest that, if it was not for the problem of net destruction by submerged vegetation and crocodiles, fishing activities on the lake would be profitable. All this points to production being under the potential sustainable yield.

With preliminary empirical data we estimated the current annual yield of "kapenta" on Lake Cahora Bassa to be 15,000 tonnes, which equals the potential yield given, by Kolding et al. (1993). Again, we could find no other evidence that fishing pressure for "kapenta" has been excessive. While one would expect "kapenta" biomass to fluctuate considerably, it is considered that this will happen independent of fishing pressure. We suggest that the estimates of sustainable yield for Cahora Bassa need revisiting, and that research needs to directed toward this.

4.3 Current fishing and catches in other inland waters

Much less is known about the fisheries of inland water bodies away from the two large lakes. This mission has not focussed attention on these and only selected documentation has been secured. As stated, the research of Turpie *et al*. (1999) in the lower Zambeze floodplains is useful to provide an indication of the nature of floodplain fisheries in the country. This study, which involved quantitative survey, showed that artisanal fishers in the lower Shire valley in Tete Province use gill nets, reed wall traps, and to a much lesser extent cast nets, seine nets and spears, to catch species, dominated by *Clarias gariepinus*, *C. ngamensis* and *Oreochromis mossambicus*. A rough estimate of the annual yield in this area is some 1,800 tonnes. Turpie *et al*. (1999) also studied the Zambeze delta area where gill nets and lines are mostly used, along with lesser numbers of circle traps and seine nets to catch species such as "nsomba" *Clarius gariepinus*, "pende" *Oreochromis mossambicus* and *O. placida*, "m'cheni" *Hydrocynus vittatis*, and *Mormyrus longirostris*. They estimated that in 1999, the non-marine artisanal fishery catch of the Zambeze delta was some 15,000 tonnes.

G. Pierconti, (2002, pers. comm.) provided some comparative information on the Limpopo floodplain region. Here, in Gaza Province, centred on the Massingir dam, Mabalane and Bambene, some 760 fishers were reported active, 400 of these in Massingire. Fishing is mostly with gill nets for species such as *Clarias gariepinus* and *Oreochromis mossambicus*. Production in 1999 was around 650 tonnes, but due to flood induced equipment losses, this dropped to some 200 tonnes in 2000.

Artisanal fishery activities in these systems are seen to be similar to those described for the lake fisheries, except that fewer fishing households rely on fishing as a primary source of income. Many practice fishing as one of several similarly important income sources, including crop production, natural plant products harvesting, and livestock keeping. Kolding *et al*. (1993) estimated that the remaining inland water bodies make up some 55% of Mozambique's total surface area of fresh water and are believed to be capable of yielding at least some 45 000 tons per year.

4.4 The legislative and business environments

4.4.1 Legislation

The current fisheries legislation in Mozambique was written to cover the coastal and marine environments. It does not explicitly cover the needs of the inland fisheries sector. Currently, the Ministry of Fisheries applies this legislation directly to inland fisheries, but it is clear that more appropriate laws are required.

4.4.2 Availability of gear and inputs

The census (IDPPE, 1996) reports that in Niassa, fishers get their gear either from Malawi (those on the northern shores of the lake), or from Metangula, Lichinga, and Nampula (those on the central and southern shores). Historically, gear was supplied free, but this ceased with collapse of the socialist economic system. Fishers commonly find the costs of gear supplied in Mozambique prohibitive, and this reflects the extremely remote situation, both in terms of distance and infrastructure.

A similar situation pertains in the case of Cahora Bassa, where the costs of gear supplied in Tete, and nearby, tends to be out of the financial reach of the artisanal fishers. The fishers in the floodplains of the Zambeze delta reported similar problems in the study of Turpie *et al.* (2000). In relation to fisheries rehabilitation in the Massingire dam area after the flooding disaster, G. Pierconti (2002, pers. comm.) reported similar sentiments among fishers.

The issue of whether it is economically efficient for artisanal fishing in remote parts of the country to be stimulated through capital grants or input subsidies needs further investigation. This is discussed below.

4.4.3. Infrastructure

In Mozambique, one of the poorest countries in the world, and until ten years ago, beset by civil war, infrastructure is generally either lacking, or in poor condition. This is the case in most of the main inland fisheries sites. Access to Niassa Province by road is restricted to two extremely poor roads. The nearest marine port is Pemba, 800 km to the east by generally low quality road. Further, the area is three days from Beira, and five days from Maputo. The possibility exists for aerial export of high quality products from Niassa (this may apply to, for example, ornamental fish), but for most artisanal fisheries products this is not an option.

In Niassa, two only seasonally reliable gravel roads lead from the provincial capital Lichinga to the Mozambican part of Lake Niassa, one to Meponda in the south, and one to Metangula in the centre. An extremely poor road links Lichinga with the northern coast. Fish is sent to Lichinga by road from Meponda and Metangula. From the small fishing camps/villages, the fish is transported to Metangula and Meponda by dugout canoes and small sailboats. One small, motorised open boat operates north of Meponda transporting fish buyers to and from the fishing centres. A few similar boats appear to operate from Metangula, and a slightly larger one owned by the Catholic mission, operates along most of the coast. The costs of using this one appear too high for many fishers. With respect to safety and possibility of marketing the product fresh, motorised lake transport has clearly an advantage over other boat types. The Malawian cargo ship, “Ilala”, visits two ports in the northern and central parts of Mozambican Lake Niassa. It appears, from the interviews conducted during this mission, that exports of goods from the harbour in Metangula to Malawi, are currently restricted to agricultural products, and not fish.

On Lake Cahora Bassa, several roads lead to the southern shore and they represent the shortest way to the important fish market in the provincial capital of Tete. On the eastern half of the Lake there are at least five access roads on the southern shore and they go to the Dam wall, Nova Chicoa/Emboque/Chinoco, Chipalapala, Cadzewe (just west of the Daque River) and Cassindire. In the western parts of the lake access is rather better to Zambia, from Zumbo, and to Zimbabwe, from Bawa and Messengeusi, than it is from Tete. However very low quality roads link Tete with these areas on the southern and northern sides of the lake.

Most transport of fish from the western end of Lake Cahora Bassa is exported to Zambia and Zimbabwe. From villages along the northern shore of the lake, which is not served by roads, dried fish has traditionally been transported to the southern shore on large transport dugout canoes. In the last few years the small ferry/cargo vessel, "Gwene" has operated along the northern shore, buying fish, transporting people and goods and selling fishing gear. This boat plies the whole length of the lake stopping in the east at Nova Chicoa and the dam wall, both with access to the paved road to Tete. This mission got some indications that the costs of this lacustrine transport are high, and beyond the reach of many artisanal fishermen.

4.4.4 Markets

Through the inland fisheries visited by the mission, fish not directly consumed by fishing households is sold, either fresh on landing, or after processing, to local households or buyers who then transport the products to markets. Processing is aimed at increasing the life of the product. Generally, small pelagic species are sun dried while larger fish are salted and dried, or very occasionally smoked. Locally, on Lake Niassa around Metangula and Meponda, some, mostly larger, fish are transported fresh, in 30 kg boxes, on ice to Lichinga. Table fish are smoked at the western end of Cahora Bassa, to meet an apparent preference for smoked fish in Zambia.

Fish from the Lake Niassa artisanal fishery are marketed in Lichinga, mainly in the central market. Transport from the lake is done via "chapa-cem" taxi, but also by bicycle and on foot. In addition to local products, there is enough demand in Lichinga to attract fish from outside Niassa Province. This mission recorded product in the Lichinga market from as far as Namibia (frozen horse mackerel), the Mozambique coast (dried prawns), and Lake Cahora Bassa (salt-dried pende, tiger fish, and dried "kapenta").

Salt dried table fish from the artisanal fishery of central and eastern Lake Cahora Bassa is marketed in the main market in Tete. It is transported there by road along the southern shore and by boat along the lake to Nova Chicoa in the east from where it goes by road. The lake transport here is mainly the KU-ZA boat, "Gwene", which calls at points along the northern shore. Road transport is either by "chapa-cem" taxi, including quite large trucks up to 5 tonnes capacity.

Along the western and southwestern shores of Cahora Bassa, marketing by artisanal fishers is mostly to Zimbabwe and Zambia respectively, but also occasionally to high priced markets in the Congo (DRC). Here buyers enter into semi-permanent arrangements with fishers, where they supply gear on credit and accept fish as payment. They commonly take out three-month buyers' permits and engage in processing of the products themselves, before repatriating the products. In Zambia the products are transported to the main urban markets, in Lusaka and beyond. The artisanal fishers in these areas find themselves in a situation of almost permanent bondage to the foreign buyers. Their spatial isolation within Mozambique means that they commonly have no access to alternative sources on gear, have almost no access to cash, and are severely marginalised. Kapenta is transported by operators themselves to be marketed either in Tete, where buyers move the product to Malawi and Zambia or, more commonly in Zimbabwe, from where most operators originate.

In Niassa, women, as is the case in Malawi (Eriksen *et al*., 2002), are prominent in the processing and marketing of fish. Elsewhere, men are still largely dominant. Nearly everywhere marketing is small-scale, involves low technology, and is highly opportunistic. Formal business agreements are rare. Nearly all of the artisanal fishery products are low-priced and aimed at low-income urban or rural segments. Due to economic stagnation in most countries neighbouring of Mozambique, the pattern during the last ten years has been one of increasing volumes of increasingly low value products going to meet the demand of increasingly impoverished populations (Jul-Larsen *et al*., 2002). However, the trade in artisanal fish products is extremely complex, and products are moved over large distances through southern Africa in many directions. This is illustrated by the wide range of sources for products in the market at Lichinga, one of the most remote towns in Mozambique. Reynolds (1993) analysed the markets for fish in Zimbabwe, Zambia, Malawi and Tanzania and also depicted high market complexity.

All artisanal fishers and groups interviewed by this mission were happy with their market environments. Nowhere were markets given as constraints, except perhaps where monopsonistic buyers were seen to constrain access to gears (as in western Cahora Bassa). Market interventions are thus not seen as a priority by this mission. However, it is clear that markets are constrained along with development generally. Poor infrastructure, poor business environments, low consumer buying power, poor processing technologies, all play a part in keeping the incomes of artisanal fishers low. In the longer term, support for inland fisheries needs to address these constraints.

4.5 Current investments in inland fisheries

Inland fisheries in Mozambique have been over-shadowed by the larger and very valuable coastal fisheries sector. Large projects have been initiated by IDPPE, the most notable of which is a very large IFAD-funded project to support the artisanal Sofala Bank fisheries focusing initially in Nampula Province (IFAD, 2001a; 2001b; 2001d). This will be expanded later, further to the south on the Sofala Bank, and may also be expanded to the African Bank, north of Nampula. In this investment and others, IDPPE has gained considerable experience in research, particularly socio-economic research, co-management and community development, extension, support to production and credit provision in coastal artisanal fisheries (IDPPE, 2001a). IDPPE does not currently have the resources and person-power to invest heavily in the inland sector. Despite the shortage of resources some important inland inputs have been made by government in the past, notably in research, conducted through both IDPPE and IIP. Much of this research has been reviewed in chapters 3 and 4 above.

Government has invested in the fishery over the years through the “combinados pesqueiros” of which there was one at Metangula on Lake Niassa, and one at Nova Chicoa on Lake Cahora Bassa. These served as central units, supplying gear through credit, purchasing produce, and accepting produce as repayments. They also developed ice-making facilities and other services. These units were privatised in the 1990s, their services have been discontinued, and considerable infrastructure lies idle, or has been sold. Lack of appropriate skills among buyers and lack of sufficient profit incentives, are possible causes for the collapse of these units.

FAO has invested in the artisanal fisheries sector through emergency relief, following the floods of 1999/2000. This has involved provision of start-up gear to replace materials lost in the floods. This has been focused mainly in the provinces of Gaza and Inhambane, but also in Tete, Zambézia and Sofala. Inland fisheries at Massingire Dam, the lower Limpopo floodplains, the Zambeze valley and Cahora Bassa benefited (G. Pierconti, 2002, pers. comm.; Ssentongo, 2002a). FAO is considering further investments in the inland fisheries for example in Niassa, but the exact nature of these is not finalised. They will likely involve research to gather planning information on the fishery resource base, promotion of fishing gear supply, assistance in reducing post harvest losses, and enhanced provision of basic management inputs by the Ministry of Fisheries, including control and surveillance and control of use of illegal gears (Ssentongo, 2002b).

An important intervention in the inland artisanal fishery has been the "Projecto de reabilitação da capacidade da pesca e da comercialização de pescado no Lago Niassa" (project for rehabilitation of fishing capacity and commercialisation of fisheries on Lake Niassa), which was funded by Cooperação Irlandesa, described by IDPPE (1997; 2001a). This project has involved the supply of grant-funded gear, through a private company in Lichinga, as well as the supply of credit for gear purchase though an NGO, Accord, also with a base in Lichinga. The provision of gear has been with price conditions attached, and the credit supplied through Accord was done through a scheme, where fishers have been encouraged to form groups, which collectively pay for gear purchased by individuals on a rotational basis ("fundos rotatórios"). Unfortunately, as stated in section 2.1, the key players in Lichinga could not be contacted during this study, so the progress of this project could not be clearly ascertained. Community groups and key informants indicated that the gear available with the private dealer in Lichinga was too expensive, and lacking in suitable variety. Further the rotational credit system was reportedly hampered by difficulties with group formation and default. The true status of this project is not clear.

In Tete, an important intervention in the artisanal fishery has been the "Projecto integrado para o desenvolvimento da pesca e comercialização de pescado no Lago Cahora Bassa" (integrated project for the development of fisheries and commercialisation of fish products on Cahora Bassa Lake). This project was initiated in 1998, funded through the European Union (EU), and implemented by the Italian NGO, ISCOS, with the Mozambican NGO, KU-ZA. It is described by Falcão (2000) and Falcão & Gervásio (2001). This involves the provision of passenger and cargo transport services on the lake (through the boat, "Gwene", mentioned above), as well as assistance with commercialisation of fish products and some provision of small-scale credit.

The Tchuma Tchato programme on Lake Cahora Bassa is funded by the Ford Foundation, and aimed at development of community-based natural resource management in the area. It has partly involved the artisanal fishing communities (Namanha, 1999; Jones, 2002).

5. Potential for development

5.1 Potential for sustainable development

5.1.1 Household income and livelihoods

Qualitative focus group data collected during the field visits, data from the censuses (IDPPE, 1993; 1996; 2001b) and data from various reports consulted, suggest that for most fishers living in lakeshore fishing villages and camps, fishing is their household's primary income earning activity. Very few households however, were found to be totally dependent on fishing and nearly all also practice traditional small-scale agriculture, producing crops, and in the case of Tete, keeping livestock. A small proportion of the households was found to also derive income from commerce. Wherever possible households also derive wage income, but lack of employment opportunities makes this uncommon. Evidence from Turpie *et al* (1999) indicates that fishing households in floodplain environments such as in the Shire and Zambeze delta, derive income more or less equally from fishing, crop production, and use of wetland plant resources.

Based on the empirical data collected during the field visits, and corroborative data from the literature, preliminary financial and economic models were developed for typical examples of four fishing enterprises in Niassa and Tete. These included a non-motorised artisanal enterprise for Lake Niassa, a motorised artisanal enterprise for Lake Niassa, a non-motorised artisanal enterprise for Lake Cahora Bassa, and a semi-industrial "kapenta" enterprise for Lake Cahora Bassa. The models are preliminary, based on rudimentary data, but they are able to provide a wealth of indicative information relative to the development of the inland fisheries sector. Of interest here, is the degree to which fishing contributes to household income and to livelihoods.

Annex C contains detailed summaries of the main assumptions and results in the four models. Table 9 shows some financial characteristics extracted from these. It must be noted that "financial values" are defined to embrace both home consumption and market transactions, as these affect fishing households. The preliminary data suggest that, generally, inland artisanal fishery activities generate poor returns on investment for owners. This clearly needs further, more detailed study, firstly to confirm or refute the preliminary findings, and secondly to identify any policy interventions which might make investment in fishing more attractive. The preliminary indications are that artisanal fishing in Cahora Bassa is even less attractive financially than that in Niassa. This is expected, as gill net activities generally tend to be less profitable than others (IFAD, 2001d), but also because cost of net damage from submerged trees and crocodiles appears to be important in Cahora Bassa.

Table 9: Indicative financial characteristics[1] for typical inland fishing enterprises on Lakes Niassa and Cahora Bassa, Mozambique, 2002.

	Province and fishing enterprise			
	Niassa 1. Artisanal Non-motorised	Niassa 2. Artisanal Motorised	Tete 3. Artisanal Non-motorised	Tete 4. Semi-industrial
Boats/rigs (Number)	6	6	6	6
Employment (Jobs)	11	9	9	51
Catch (Tonnes fresh year $^{-1}$)	37	93	41	617
Initial capital (Cts)	86,000	247,000	33,000	6,177,000
Turnover (Cts year $^{-1}$)	111,000	279,000	75,000	4,073,000
Operating costs (Cts year $^{-1}$)	88,000	256,000	66,000	4,960,000
Net profit (Cts year $^{-1}$)	23,000	23,000	9,000	-887,000
FRR[2] (%, 10 years)	12%	4.3%	4.0%	Negative
FNPV[2] (Cts, 10 years, @ 8%)	30,000	-61,000	-17,000	-9,316,000
Community income[3] (Cts yr $^{-1}$)	72,000	71,000	50,000	677,000

1 Derived from preliminary financial enterprise models, and embracing consumption, exchange and market transactions.
2 Financial rate of return (FRR) and financial net present value (FNPV) over 10 years at 8% discount rate.
3 Fishing remuneration and fishing net profit, after capital servicing.

It would appear that semi-industrial "kapenta" fishing enterprises in Cahora Bassa are not financially viable, at present product prices, which have declined markedly due to economic contraction in Zimbabwe. The fishery appears to be currently over-capitalised, but this could well be temporary. The fishery continues to provide significant income for community households in the form of wages.

Table 10 shows preliminary aggregate estimates of household income derived from our data and models, and projections of the artisanal fishery census results. We estimate that in Niassa some 5,100 artisanal fishers catch some 10,000 tonnes of fish annum^{-1}, and derive some Mts 20,000 million (Cts 20 million) annum^{-1} from this activity. This estimate includes the fisheries of lakes Niassa and Amaramba but excludes those of lakes Chiúte, and Chilwe in that province. Some 20,000 people (household members) are likely to benefit from this income. We estimate that in Tete, on Lake Cahora Bassa, some 1,600 artisanal fishers catch some 7,500 tonnes of fish annum^{-1}, and derive Mts 9,000 million (Cts 9 million) annum^{-1} from the activity. Some 6,000 people are likely to benefit. We also estimate that the "kapenta" fishery provides some Mts 21,000 million (Cts 21 million) to some 1,500 households in the form of wages, and that this benefits some 6,000 people.

Table 10: Indicative aggregate estimates[1] of community household income[2] derived from fishing activities on Lakes Niassa and Cahora Bassa, Mozambique, 2002.

	Province and fishery		
	Niassa Artisanal	Tete Artisanal	Tete Semi-industrial
Total catch (Tonnes fresh weight year $^{-1}$)	10,000	7,5000	15,000
Community profits (Cts year $^{-1}$)	10,000,000	3,000,000	-
Community remuneration (Cts year $^{-1}$)	10,000,000	6,000,000	21,000,000
Total community income[2] (Cts year $^{-1}$)	20,000,000	9,000,000	21,000,000
Fisher households (Number)	5,100	1,600	1,500
Family members affected (Number)	20,000	6,000	6,000
Income/household (Cts year $^{-1}$)	3,922	5,625	14,000
Income/family member (Cts year $^{-1}$)	1,000	1,500	3,500

1 Derived from preliminary financial enterprise models.
2 Remuneration and net fishing profits which accrue to community members, and embracing consumption, exchange and market transactions.

Artisanal fisheries on the major river floodplain systems, for example the lower Zambeze, Limpopo and Pungwe/Busi basins are also likely to be important. Turpie *et al*. (1999) using data from a detailed quantitative survey, and the same methods of valuation as ours, estimated that in 1999, the non-marine artisanal fishery catch of the Zambeze delta was some 15,000 tonnes, and that this provided household income worth some Cts 30 million per annum

Clearly inland fisheries in Mozambique are significant in terms of household income generation, and this alone justifies investment in their development. They provide livelihood maintenance for many thousands of families. They contribute very importantly to household food security but also to household cash income.

5.1.2 Contribution to national income

Associated with the preliminary financial enterprise models described in 5.1.1 above, are preliminary *economic* models. These, also shown in Annex C and described in Table 11 below, provide measures of the contribution of the fishing activities to the economy as a whole, from the perspective of Mozambican national society. This illustrates the degree to which fishing activities affect national income, and thus contribute to development.

The preliminary economic values in Table 11 are all positive, indicating that all the fishing activities are economically efficient, that they contribute positively to the national economy, and that their expansion will contribute positively to national development. If internal rates of return for the financial models (FRR) in Table 9 are compared with those from the economic models (ERR) in Table 11, it is seen that the economic rates are much higher. Further, the annual economic net values are all strongly positive and much higher than the financial net incomes for the same enterprises. These differences suggest that due to policy effects and/or market imperfections fishing activities are being taxed more than they are being subsidised. They also suggest that the inland fishery sector could withstand some subsidy if needed, for example, to make fishing more attractive for investors.

Table 11: Indicative economic characteristics[1] for typical inland fishing enterprises on Lakes Niassa and Cahora Bassa, Mozambique, 2002.

	Province and fishing enterprise			
	Niassa 1. Artisanal Non-motorised	Niassa 2. Artisanal Motorised	Tete 3. Artisanal Non-motorised	Tete 4. Semi- industrial
Boats/rigs (Number)	6	6	6	6
Employment (Jobs)	11	9	9	51
Catch (Tonnes fresh year $^{-1}$)	37	93	41	617
Initial capital investment (Cts)	88,000	247,000	35,000	5,984,000
Gross output (Cts year $^{-1}$)	120,000	301,000	78,000	4,481,000
Intermediate costs (Cts year $^{-1}$)	33,000	139,000	30,000	3,492,000
Gross value added[2] Cts year $^{-1}$)	87,000	162,000	48,000	989,000
Net value added[2] (Cts year $^{-1}$)	69,000	112,000	43,900	446,000
ERR[3] (%, 10 years)	61%	40%	73%	11%
ENPV[3] (Cts, 10 years, @ 8%)	414,000	631,000	250,000	2,026,000

[1] Derived from preliminary economic models of enterprises, embracing direct economic use values.
[2] Net value added (net national income or "*rendimento nacional líquido*") is gross value added (gross national income or "*rendimento nacional bruto*") less depreciation of fixed capital.
[3] Economic rate of return (ERR) and economic net present value (ENPV) over 10 years at 6% discount rate.

Table 12 shows the aggregate economic measures, based on the preliminary models, and projected fishery census figures. The economic contribution of artisanal fishing for Niassa (Cts 24 million) must be considered partial for the province, as Lakes Chiúte and Chilwe are not included in the estimate, and neither are any rivers, such as the Lugenda or Messalo. Similarly, the economic contribution of artisanal fishing measured for Tete Province (Cts 9 million) is missing estimates for the Zambeze and Shire river systems below Lake Cahora Bassa. Extraction of data from Turpie *et al*. (1999), who used similar valuation methods to ourselves, suggests that artisanal fishers in the lower Shire valley in Tete Province produce some 1,800 tonnes of fish annually, contributing some Cts 5 million to gross national income. Further extraction of results of Turpie *et al*. (1999) would suggest that, in the Zambeze delta (Zambézia and Sofala Provinces), the freshwater artisanal fishing catch is around 15,000 tonnes, and this contributes some Cts 21 million to gross national income.

Table 12: Indicative aggregate estimates[1] of economic value contributed by fishing activities on Lakes Niassa and Amaramba in Niassa Province, and Lake Cahora Bassa in Tete Province, Mozambique, 2002.

	Province and fishery		
	Niassa Artisanal	Tete Artisanal	Tete Semi-industrial
Total catch (Tonnes fresh weight year $^{-1}$)	10,000	7,500	15,000
Gross national income[2] (Cts year $^{-1}$)	24,000,000	9,000,000	31,000,000
Net national income[2] (Cts year $^{-1}$)	19,000,000	8,000,000	14,000,000
Occupied persons (Number)	5,100	1,600	1,500
Capital cost per fishing job (Cts)	8.0	3.9	117.3

1 Derived from preliminary economic models of enterprises, embracing direct economic use values.
2 Net national income (*rendimento nacional líquido* or net value added) is gross national income (*rendimento nacional bruto* or gross value added) less consumption of fixed capital.

The estimates of gross value added contributions to national income for lakes Niassa, Amaramba, Cahora Bassa, the Shire wetlands and the Zambeze delta, if taken together (some Cts 90 million), amount to some 5% of the total gross value added for the total fisheries and related services sector in Mozambique (INE, 2000a). This is a significant contribution to the economy, making inland fisheries a worthy target for development efforts. The findings in Tables 9, 11 and 12 indicate that the artisanal fisheries are more efficient than the semi-industrial fishery in terms of financial profitability (net profits), economic returns (ERR), and use of capital (capital cost per job). This conforms to general wisdom (Weber & Fontana, 1984), and is expected. But on Lake Cahora Bassa, the artisanal and semi-industrial fisheries tend not to compete for resources, and they are in fact complementary.

5.1.3 Sustainability and potential for growth

Sensitivity analysis on the preliminary enterprise models described above shows that the profitability of fishing is sharply affected by relatively small changes to catch rates, product prices and fisher wage rates. Changes in these parameters will affect the viability and sustainability of the fisheries. If catch rates declined due to excessive fishing effort, the already very poor private incentives for investment in fishing would be eliminated. The positive economic contribution of the fishery would also be threatened. Product price decline due to excess supply in markets would have similar effects. Conversely, increases in catch rates or product prices, could sharply improve financial attractiveness and economic contributions.

Current fishing effort levels appear not to threaten the resources. During our field visits, we did not get any impression that catch rates were threatening sustainability. Catch rates, as elicited through our field investigations with focus groups and key informants appear to be high, compared with those found to prevail, for example, in the coastal artisanal fisheries, in Nampula

(Muchave, 2001; IFAD, 2001e). While the pelagic resources are relatively resilient, the demersal fisheries for larger species appear more vulnerable. It would seem that care is needed to avoid the depletion problems, described in Sections 3 and 4 above, that have emerged in southern Lake Malawi (Kasulo, 2000). The population of Mozambique is increasing at a rate of some 2.4 % and it can be expected that growth in fisher numbers will follow a similar pattern. Our investigations suggested that access to the fisheries tends to be open. Given these circumstances, one would expect economic rents to be driven down in the future. Some form of common property management would seem to be desirable in order to restrict access to levels which optimise rents, and ensure the sustainable productivity of the fisheries.

Jul-Larsen *et al*. (2002) in a detailed four-year research study, analysed the issues surrounding community management in southern African freshwater lake fisheries. They found that central management by the state had been ineffectual in reducing effort. Namanha (1999) also found the same on Cahora Bassa. In their study, Jul-Larsen *et al*. (2002) found few common property mechanisms for management among fishing communities. They also found that there has been a tendency, in southern Africa, for communities to simply leave artisanal fisheries when growth in fishing effort started to reduce catches (and thus rents). The fact that nearly all fishers interviewed in our field visits have other sources of income in agriculture would suggest that this might also be the case in Mozambique. The results of social and economic research on artisanal fishing groups on lake Kariba (Bourdillon, 1985; Bourdillon *et al*., 1985) would tend to support this. Thus, while a few vulnerable species may be depleted or eliminated, one might expect fisheries in Niassa and Cahora Bassa to be, at least to some extent, sustainable in the medium term as fishing communities leave and rejoin the fishery. We would suggest that although fisheries are partly cushioned from excessive use in this way, they will nevertheless have to withstand excessive pressure due to human population growth in the long term.

Measures which make it possible for artisanal fishing communities to form local fisher committees ("*conselhos de gestão*") would seem to be essential to allow regulation of fishing access and effort, if and when this becomes necessary to safeguard private profits and economic rents. The experience of the IFAD Sofala Bank project in developing such committees (IFAD, 2001c) will prove invaluable here. But the committees will have important roles beyond fisheries management, providing the vehicle through which communities can capture rents from local tourism, larger scale commercial fisheries, etc. and through which communities can negotiate with others to resolve conflicts, etc.

In line with the findings in section 3 above, there seems to be potential to increase catch-rates, biological production, and profits for artisanal fishers in Lake Niassa if there is a shift from the traditional demersal fisheries toward the pelagic resources "utaka" (gill net and seines), "usipa" (seines) and the table fish "n'chene" (mid-water longlines; Ngatunga *et al*., 1997). These pelagic species are expected to be more resilient to exploitation and the rich ichthyological diversity of the lake fauna will be better preserved. In Cahora Bassa, there may be a biological basis for some increase in production of demersal species, yet the drowned vegetation makes it difficult to exploit this potential. Also within the remainder of the inland artisanal fisheries there appears to be only marginal potential for growth in production. It should be kept in mind that attaining MSY (maximum sustainable yield) should not automatically be an aim of interventions. As total yield raises with increasing effort, there is a steady decline in the standing biomass of the target resource and (especially in artisanal fisheries) a corresponding decline in catch rates. Thus, it is quite possible for fishing activities to cease to be profitable before MSY is attained. When this is true, fishing effort must be restricted to a level below the one that would produce MSY (or be subsidised).

The fishery resource in Lake Niassa has potential for development of ornamental fish capture and export enterprise (see chapter 4, above and Eichler, 1981). Capture of ornamental cichlids (mbuna) for export is currently being undertaken in Malawi by two companies, but in Mozambique such activities are restricted to the coast (Whittington *et al*., 2000; Motta, 2000). They are likely to require specific expertise, skills, and captured markets, and are best suited to the development of joint ventures between fisher communities and private investors. Similarly, there is potential in Lake Niassa for tourism, particularly that involving ornamental fish watching and angling. Again, activity along these lines is embryonic. Specific skills and high capital investments are required to successfully develop and run these enterprises.

Artisanal fishing communities would do well to position themselves institutionally so that they can enter into joint ventures with private investors in tourism and live fish export. This way they could capture significant parts of the income, through rents and wages. In Cahora Bassa the potential for angling tourism is considerable, and developments so far are restricted to one or two lodges. Here again, through joint venture arrangements, communities could derive considerable benefits from any expansion (Jones, 2002). Experience elsewhere in southern Africa has shown that communities can derive considerable income from tourism in their areas through formation of groups to appropriate rents from these activities (Barnes *et al*., 2002).

5.2 Strategy for development

5.2.1 Selection of priorities for development

Based on the findings above, certain priorities have emerged for the development of inland fisheries. First, the whole sector is important and should be targeted, but the lakes in Niassa and Tete Provinces, should get priority. Scarce resources should be focused on those interventions, which have maximal chance of enhancing sustainable improvements in incomes and livelihoods among inland artisanal fisher communities.

On the basis of the data currently available we do not believe that there are any large untapped fish resources in the artisanal fisheries of Niassa and Cahora Bassa. Thus, while more specific research is needed on potential yields and current fishing effort we recommend that development priority should be given to sustaining and where possible enhancing the benefits of the existing fisheries through a number of carefully targeted interventions accompanied by continuing investment in improving the information base for management.

In all the artisanal fisheries it appears that fisher populations are expanding, as is the general population of Mozambique, and since there are few income alternatives, this is likely to continue. Currently, community-based management of fish resources is weak, and access tends to be open. Community-based management initiatives are limited to a few protected zones established in Cahora Bassa within the Tchuma Tchato programme. As fisher populations expand, and pressures on the recourses increase, catch rates must inevitably decline, increasing the incentives for introduction of community-based management measures and creation of management committees.

Our preliminary financial and economic analyses of fishing activities indicate low financial profitability, but high economic benefit. These were based on conservative yield estimates and may underestimate profitability, which is highly sensitive to catch rates. However, almost all fishers and fisher groups interviewed cited lack of suitable, or suitably cheap, gear as their main constraint. There would appear to be a financial constraint here, particularly given the indications that credit schemes are affected by repayment problems. Interventions, which can enhance artisanal fisher catch rates, will greatly improve net incomes for fishers. Projects where access to suitable gear is enhanced will likely achieve these benefits.

The preliminary economic analyses (which incorporate the benefits of job creation, and generally provide a more accurate measure of the worth of the fishing activity for Mozambican society) indicate that all the inland fishing activities are economically efficient. They all contribute positively to the economy. The findings here are strongly positive, and indicate that all the fishing activities analysed are desirable and worthy of promotion. This provides sound motivation for interventions, which might enhance the financial attractiveness of fishing for investors. It points to the likely economic soundness of support to the artisanal fishery enterprises.

The preliminary models also indicate that financial profitability is highly sensitive to changes in product prices. Thus interventions that can improve product prices have a good chance of dramatically enhancing fisher incomes. We consistently found fishers satisfied with their markets, which would suggest that interventions to improve markets would not pay. However, at broader level, constraints in the market environment have been identified, above, including poor infrastructure, poor product quality, poor business development, etc. Interventions directed at these would likely have the effect of enhancing product value, and thus fishing incomes. The crosscutting development problems referred to here are complex and intractable, and should be tackled with care and planning. A first step to this would be more research into the fisheries market systems.

More research is needed on the potential, as well as the current yields. Research on potential yields in Niassa could benefit from comparisons with current yields in selected, similar areas in Malawi, where fishing effort on inshore pelagic resources is in general a lot higher than in Niassa. Offshore fish species occur at low volume densities and may not be adequate to sustain commercial fishery.

Given the higher population numbers in pelagic than in demersal haplochromines and the potentially higher sustainable yields by pelagic than demersal resources, the current thinking is that demersal haplochromines are best left lightly exploited, for example, as high value aquarium fish. A shift of traditional demersal fisheries towards the pelagic resources seems likely to improve catch rates, profits and bio-production, and also contribute to conserve the unique biodiversity of the lake.

The development of tourism related use of inland fish resources is embryonic in Mozambique. Considerable expansion of these, and some development of ornamental fish export activities is possible. Artisanal fishing communities lack the skills and capital to use these resources. However, with their *de facto* territorial right to the resources in question, and with appropriate institutional development, communities can appropriate significant amounts of the economic rents from these developments. Interventions aimed at ensuring this are bound to significantly enhance artisanal fisher incomes.

The legislative environment does not adequately cover the needs of inland fisheries. Laws are designed for the coastal setting and require review, based on sound research, to make them useful for the inland setting. One area where such review might be useful for fishing communities would be in establishing their ability to form groups with rights to lease out tourism and other use rights in their areas.

6. Proposals

A number of of proposals are provided below. These specify the actions that we believe provide the best opportunities for enhancing the debelopment contribution of inland fisheries in Mozambique.

6.1 Development initiatives

6.1.1 Credit/finance/gear provision

A project to relieve the widespread shortage of capital and gear, especially nets and boats, perceived by artisanal fishers, would seem highly appropriate. This may or may not need to involve an element of subsidy, and small-scale credit supply, depending on the findings of ongoing economic research (6.2.2, below), which will be needed to guide the design of the project. Pilot activities would begin on the two large inland lakes, Niassa and Cahora Bassa, but the project would be expected to later embrace all inland fisheries.

6.1.2 Development of "concelhos de gestão" among fishing communities

A project to facilitate the development of management bodies among artisanal fishing communities. This would be focussed as a pilot in Lakes Niassa and Cahora Bassa, with the long-term aim of expanding elsewhere. The management bodies would have two primary functions. The first function would be to enable common property management of the fishing resources. This could help preclude likely future problems associated with open access, and ensure sustainability. The second function would be to enable comminutes to develop joint ventures between themselves and other users of local natural resources, for example, operations for sport fishing tourism, hunting tourism, ornamental fish viewing and/or export, etc. Communities would in this way be able to appropriate rents from these activities as they develop. They would also be able to access international donor funds (non-use values), aimed at ensuring conservation of fish resources. Management bodies could perform further functions in conflict resolution and, for example, management of rotational credit schemes.

The existing programme of Tchuma Tchato on Cahora Bassa has to some extent begun this process, in assisting fishing communities to set aside protected zones. However, it is possible that the community structures being developed within the IFAD coastal fisheries initiative (IFAD, 2001c) are more appropriate. Systems need to be adapted specifically for the needs of artisanal fishers in the pilot areas, but without wasteful duplication.

6.1.3 Legislative review

As stated above, the existing fisheries legislation is written for the marine sector, and is largely inappropriate for the inland sector. There is thus a need for the law to be reviewed, and a set of regulations, at least, to be drafted and promulgated for inland fisheries. These regulations need to be carefully designed. As an example, in Lake Niassa, inappropriate imposition of mesh size regulation for demersal gill netting involves a real risk of favouring the smallest species of demersal haplochromines which, in turn, could provoke local irreversible changes to fish communities. Appropriately designed regulation would assist in protecting the apparently vulnerable potamodromous species, and localised demersal endemics. In addition, attention needs to be paid to the design of licensing and fees and the general taxation environment, particularly ensuring that the profitability of artisanal fishing enterprises is not jeopardised through excessive taxation. Further, legislation should also address and enable the formation of group (common property) custodial rights over fishing waters, resources and assets. This is needed to entrench the rights discussed in 6.1.2, above. The initiative could be carried out centrally in Maputo.

6.2 Research

Design of these development initiatives will need to be based on an improved understanding of inland fisheries. A series of research initiatives that will help provide this understanding are proposed.

6.2.1 Census 2003/4

It is recommended that the artisanal fisheries census, already planned for 2003/4 by IDPPE, be carried out. This will provided vital information for the planning and guiding of the development initiatives set out above, and will especially provide data to measure change since the previous survey, carried out 10 years ago. While being structured to provide data directly comparable with that of previous surveys, the survey could also incorporate additional questions relating to ownership of gear. For example it will be important to know the degree to which fishers or creditors own the gear in use. If resources permit it would be very useful to expand the scope of the survey to embrace Lakes Chiúte, and Chilwe in Niassa, and floodplain wetlands in the lower Zambeze valley. However, this should not jeopardise the surveys on Lakes, Niassa, Amaramba and Cahora Bassa.

6.2.2 Social and Economic Research

The socio-economic research, which has already been undertaken among artisanal fishing communities in Niassa and Tete, and described above, needs to be built on and developed into an ongoing programme. This research can also build on the existing IDPPE programme for monitoring fish product prices in markets through the country, expanding this function to the Niassa and Tete Provinces. Similarly, the research into the economics of fishing and markets already done and being done in the coastal fisheries sector can be built on. The research programme could be started in two study areas, one in the central part of Lake Niassa (for example, around Metangula) and on the southern shores of Lake Cahora Bassa (for example around Daque).

This mission has developed preliminary financial and economic models, which form a useful basis for policy development, planning and project design. An important aim for the proposed social and economics research programme needs to be to secure reliable empirical data for these or similar models. An important aim of the financial and economic analyses would be to determine the financial attractiveness, economic viability, resilience, need for subsidies, etc. among the various types of artisanal fishing enterprises. Another would be to determine constraints to, and potential for, growth in enterprise efficiency, changes to the scale of activities, and capital formation.

The issues surrounding the degree to which artisanal fishing ensures family livelihoods, and the place of fishing among other household coping strategies need research. Similarly, the degree to which fishing can contribute to capital formation in rural communities and the patterns of benefits distribution among communities need attention. The research and analysis activities will need to embrace the other non-fishing, income-earning activities of fishing households, and the determinants of their income-earning decisions. Lastly, the social and economic research programme needs to investigate constraints to, and potential for, development of common property management bodies in fishing communities.

6.2.3 Biological Research

Although a fair amount of research has been undertaken on the biology of fish in Lake Cahora Bassa, and, particularly, Lake Niassa, we consider that more long term research, and more targeted research, is appropriate in these two lakes. In line with the research being planned by IIP, and as with the proposed social and economic programme above, the biological research programme could be started in two study areas, one at Lake Niassa and the other in Cahora Bassa. The Niassa work would be based at the existing laboratory at Metangula in the central part of Lake Niassa, and the Cahora Bassa work based on the southern shores, from where access to the full lake length is facilitated.

In Lake *Niassa*, allied with the social and economic research programme proposed above, there is a need for ongoing monitoring of fishing effort and catches for the different gear types over time. Also in Niassa, an important priority should be on the specific determination of potential and actual yields of inshore pelagic fish. Reliable catch estimates are also needed to determine how much of this potential is actually being used. Sampling of the traffic of fish from the lake would, when corrected for local consumption, yield useful estimates of total catch. The growth of, and the characteristics of, the new light attraction based surface gill net fishery could be studied. Research is needed to assess the needs, if any, for protection of the potamodromous species, and the biologically and commercially valuable locally endemic species in the lake. The appropriateness and feasibilities of sanctuary establishment for river mouths and inshore demeral sites should also be a focus. The management needs associated with allocation of fish resources between artisanal fisheries and expanding tourism and ornamental export activities need attention. The research programme would best endeavour to ensure harmonisation with research in Malawi and Tanzania, to allow direct comparison of data.

In *Cahora Bassa*, the priority should be more accurate determination of the potential sustainable yields, and the accurate measurement over time of actual effort and catches of the lake-wide demersal table fish resources. Suggestions for a routine sampling programme have been presented elsewhere (Kolding *et al.*, 1993; Marshall, 1995) and IIP has already a good system for routine collection of catch, effort and biological data from artisanal fisheries. Research needs to cover the differences between the northern shores, southern shores, and the west of the lake. The great distances to markets, relatively few access roads and the regularity of transport, present good opportunities for estimating total yields through sampling of the traffic of fish from the lake. Research should also be directed to the management needs associated with allocation of fish resources between artisanal fisheries and likely future expansion of recreational angling tourism. Linked to this is the need or research on the effectiveness of sanctuary creation in river mouths and elsewhere.

6.2.4 Market Research

A research project is proposed to examine the broader constraints to development of more durable producer-market relationships in artisanal inland fisheries. This project would specifically examine the complexities of fish marketing in Mozambique and in the southern African region. The project would also examine the markets for inputs to artisanal fisheries. It would be a quantitative study, unlike the more qualitative studies of the past, and it would aim at getting quantitative survey data for estimating measuring price and other elasticities of demand for various artisanal fish products in the markets. Mozambique, Malawi, Zambia, and Zimbabwe would be the core area for study.

A priority for the project would be to identify opportunities for strengthening market and business institutions involved in the marketing of output, and the supply of inputs, to inland artisanal fisheries. The development of financial and economic models, like those presented above, for these services could also form part of the project. A component of the project would also be to determine any needs for infrastructural development (roads, water and land transport).

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Annexes

Annex A: Terms of reference for the ICLARM mission

Evaluating the Importance and Potential of Inland Fisheries in Mozambique

Background/Justification

The National Institute for Small Scale Fisheries Development (IDPPE) has the mandate to study and develop artisanal fisheries along the coast as well as inland fisheries for the whole of the country's territory.

At present, the IDPPE has mainly concentrated on the promotion and sustainable development of coastal artisanal fisheries. Currently a number of on-going projects and studies are working to improve the knowledge and understanding of the status of these resources and the design of systems for their sustainable management.

In relation to inland fisheries, the information available and the potential for investment and development are much more poorly understood and appropriate strategies are lacking. Therefore, the IDPPE, with the support of ICLARM would like to conduct a study identifying the importance and potential of these inland water resources upon which future strategies of intervention could be based.

The importance of such a study is to allow for a better understanding of the contribution of these resources for the socio-economic well-being of the communities living in the interior and the importance of inland fisheries for food security.

Objectives

The general objective of the study is to produce a comprehensive description of the current status of inland fisheries and make recommendations for the potential improvement of the use of these resources, as well as to identify areas of particular importance or concern.

Specific Objectives

The Mission will pursue this study through a series of meetings and discussions in Maputo, through review of available literature and other information, and through field visits to priority areas. This process will be designed to provide and analyse currently available information on inland fisheries which will be used to address specific objectives in three inter-related areas: (i) the status of the fishery resource and its use; (ii) fishing practices and investments; and (iii) potential for development.

(i) Status of the Fishery resource
- Identify priority inland fishery resources and fishing areas;
- Collect basic socio-economic data on these priority areas, including;
    - current resource management systems;
    - existing or potential sources of conflict;
- Assess current catch rates;
- Where possible estimate MSY (Maximum Sustainable Yield);

(ii) Fishing practices and investments
- Assess fishing gear and fishing methods used;
- Evaluate the availability of fishing gears;

- Assess fish processing methods used;
- Evaluate available infrastructure;
- Assess market access;
- Identify existing areas of private investment in artisanal fisheries;

(iii) Potential for Development

- Assess the potential of inland fisheries in relation to food security and sustainable livelihoods;
- Identify actions which could be taken to develop this potential;
- Identify other issues which need to be addressed in order to support the future development of inland fisheries resources;
- Identify potential constraints which could affect future investment and development of these resources.

Expected Results

The expected result of the study is a report describing in general terms the current status of artisanal inland fisheries which provides the bases for the elaboration of a development intervention strategy for the sustainable use and management of these resources.

Actvities/Methodology

In carrying out the study and collecting the necessary background information, the Mission would need to:

- Conduct a bibliographical and document review;
- Investigate into data available through other institutions involved in the research, use and management of inland fisheries (IIP, Office for the Promotion of the Zambeze Vale (GPZ); Provincial Authorities etc);
- Interview key officials and community representatives;
- Visit the field and conduct technical observations related to fishing technology;
- Discuss the outcomes of the study with the appropriate central institutions in Maputo.

Work team

The core of the work team will be composed of the members of the ICLARM Mission, as identified by ICLARM. However, IDPPE staff in Maputo and the field will collaborate and facilitate the Mission's work activities.

Duration

The total duration of the work, including report writing would be approximately 6 weeks. The different stages of the study could be structured as follows:

1 week - to identify and consult all available information sources in Maputo and identify priority areas;
3 weeks - field work;
2 weeks – report writing.

Annex B: Persons interviewed

Instituto de Desenvolvimento da Pesca de Pequena Escala (IDPPE)

Simeão Lopes (Director, IDPPE)
Maria Ascensão Ribeiro Pinto (Diretor Adjunta, IDPPE)
Maria Eulália Vales (Bióloga e Chefe, Departamento de Cooperação)
Rui M.M. Falcão (Economista, Departamento de Desenvolvimento Social)
João Gomes (Funcionário, Departamento de Tecnólogia Pesqueira)
Jorge Fife (Funcionário, Departamento de Tecnólogia Pesqueira)

Insitituto Nacional de Investigação Pesqueira (IIP)

Fernando Loforte Ribeiro (Head, Aquacultura)
José Halefo (Biólogo de Pescas, Avaliação de Recursos de Pesca de Pequena Escala)
Jorge M. Mafuca (Biólogo de Pescas, Avaliação de Recursos de Pesca de Pequena Escala)

Directorate of Economics, Ministério de Pesqueira (DE)

Laurentina Cossa (Economista de Pescas)

Ministério de Turismo

Simon M. Munthali (Chief Technical Advisor, GOM/GEF/World Bank – TFCA Project, Maputo)

FAO – Mozambique

Gianni Pierconti (Fisheries Specialist, FAO Project OSRO/MOZ/004/ITA)

Província de Niassa

Fernando Aualo (Chefe da Estação, IDPPE, Metangula, Província de Niassa)
Paula Ruth Atanásio (Méd. Veterinária, Servico Provincial de Administração Pesqueira)
Arzídio Vida Matshine (Administrador, Distrito de Lago)
Paulo, Saide (Diretor, Direcção de Agricultura e Desenvolvimento Rural, Distrito de Lago)
Jaime Catungue (Chefe Secretaria, Administração Maritima, Distrito de Lago)
Gabriel Katawala (Presidente da Concelho Municipal de Metangula, Distrito de Lago)
Tove Andersen (Diretor, Projecto de Pesca, Micala, Distrito de Lago)
Manuel Samuel Sane (Pescador, Metangulo, Lago Niassa)
Gabriel Katawala (Pescador/Armador de Chiwanga, Lago Niassa)

Província de Tete

Maria Cunhete Chingoma (Chefe dos Serviços, Ministério de Pesca, Província de Tete)
Argentina Trausene (Extensionista, Direcçao dos Serviços, Ministério de Pesca, Província de Tete
Luis Dos Santos Namanha (Diretor de Turismo, Província de Tete)
Matias Mkunga Sandramo (Chefe, Unidade de Tchuma Tchato, Bawa, Distrito de Mágoè)
Daniel Joal Lusaka Zumbe (Pescador, Zumbo)
Herculano Conde (Administrador, Distrito de Zumbo)
Pedro Fazenda Sarange (Diretor, Direcção de Educação, Distrito de Zumbo)
Maria Albertina Mangove (Administrador, Distrito de Cahora Bassa)
Gianni Belotti (Coordinador, ISCOS, Songo)

Annex B: (Continued)

Pedro Joalinho (Gerente, Associação KU-SA, Songo)
Januário Zunga (Administrador, Distrito de Mágoè)
Feriado Damião Alferes (Chefe, Unidade de Tchuma Tchato, Daque, Distrito de Mágoè)
Richard Yiend (Gerente, Kapenta de Cabora Bassa, Mágoè District)
Jan Lombard (Gerente, Kapenta de Moçambique, Mágoè District)

Annex C: Preliminary financial and economic enterprise models for inland fisheries

C1 Artisanal fishing enterprise, Lake Niassa

C2 Motorised artisanal fishing enterprise, Lake Niassa

C3 Artisanal fishing enterprise, Lake Cahora Bassa

C4 Semi-industrial "kapenta" fishing, Lake Cahora Bassa

ANNEX C1: FINANCIAL/ECONOMIC MODEL - ARTISANAL FISHING - NIASSA 2002 – BASE CASE

SUMMARY OF MODEL

ASSUMPTION		UNITS	TOTAL
Production System:	Six boat artisanal fishery enterprise, based 20kms from Metangula in Lake Niassa, to produce salt/dried Utaka, Usipa, Chambo and Clariidae for sale on beach, using gill, seine and chilimisa nets as well as long lines.		
Site:	Eastern shore, lakeside fishing camp with grass huts, drying racks, access by water from Metangula, and footpaths.		
Scale of Operation:		Number of Boats:	6
Use of Water		Hectares	400
Capital Item Prices:		Variation from Normal for Sensitivity Analysis	100%
Employment:		Number of Fishers	11
Fishing Effort:		Fishing Trips (Days) per Annum:	493
Catch Rate:		Tonnes Fresh Weight per Fishing Day	0.075
Total Catch		Tonnes Fresh Weight per Annum	37
Product Price:		Contos per Kg Product Weight (Average)	7.00
Fuel Price:		Contos per Litre	17.50
Resource Royalty:		Percentage of Turnover	0%

RESULTS	Cts/TCI	Cts/Ha.	CONTOS
Total Financial Capital (TCI)	-	216.08	86434
Financial Gross Income	1.28	277.17	110869
Variable Financial Costs	0.11	23.89	9557
Fixed Financial Costs	0.91	195.84	78337
Net Cash Income	0.27	57.44	22975
Local Community Cash Income	0.84	181.19	72475
Land Rental	0.00	0.00	0
Resource Royalty	0.00	0.00	0
FRR (@ 10 Years)	-	-	11.74%
FNPV (@ 8%, @ 10 Years)	-	75.27	30108
Total Economic Capital	1.02	220.11	88043
Economic Gross Output	1.38	299.11	119646
Economic Intermediate Costs	0.37	81.02	32407
Economic Gross Value Added	1.01	218.10	87239
Economic Net Value Added	0.80	173.15	69262
Economic Rate of Return (IRR, @ 10 Years)	-	-	60.69%
Economic Net Present Value (ENPV, @ 6%, @ 10 Yrs)	-	1034.20	413678
Economic Capital Cost/Job	-	-	8004
Domestic Resource Cost Ratio	-	-	0.31

Policy Analysis Matrix:	Effects of Policy / Market Imperfections :	on Output	-8777
		on Tradable Inputs	849
		on Domestic Factors	-38359
	Net Effects of Policy / Market Imperfections:	on Annual Net Income	-46287
		on Net Present Value (10 Years)	-383570

ANNEX C2: FINANCIAL/ECONOMIC MODEL - MOTORISED ARTISANAL FISHING - NIASSA 2002 - BASE CASE

SUMMARY OF MODEL

ASSUMPTION		UNITS	TOTAL
Production System:	Six boat motorised artisanal fishery enterprise, based 20kms from Metangula in Lake Niassa, to produce dried Utaka, Usipa, Chambo and Clariidae for sale on beach, using gill, seine and chilimisa nets and long lines.		
Site:	Eastern shore lakeside fishing camp with grass huts, drying racks, access by water from Metangula, and footpaths.		
Scale of Operation:		Number of Boats:	6
Use of Water		Hectares	400
Capital Item Prices:		Variation from Normal for Sensitivity Analysis	100%
Employment:		Number of Fishers	9
Fishing Effort:		Fishing Trips (Days) per Annum:	591
Catch Rate:		Tonnes Fresh Weight per Fishing Day	0.158
Total Catch		Tonnes Fresh Weight per Annum	93
Product Price:		Contos per Kg Product Weight (Average)	7.00
Fuel Price:		Contos per Litre	17.50
Resource Royalty:		Percentage of Turnover	0%

RESULTS	Cts/TCI	Cts/HA.	CONTOS
Total Financial Capital (TCI)	-	617.93	247174
Financial Gross Income	1.13	698.47	279389
Variable Financial Costs	0.53	326.48	130591
Fixed Financial Costs	0.51	315.72	126289
Net Cash Income	0.09	56.27	22509
Local Community Cash Income	0.29	177.77	71109
Land Rental	0.00	0.00	0
Resource Royalty	0.00	0.00	0
FRR (@ 10 Years)	-	-	4.34%
FNPV (@ 8%, @ 10 Years)	-	-153.38	-61350
Total Economic Capital	1.00	616.73	246693
Economic Gross Output	1.22	753.77	301508
Economic Intermediate Costs	0.56	347.90	139160
Economic Gross Value Added	0.66	405.87	162348
Economic Net Value Added	0.45	279.29	111715
Economic Rate of Return (IRR, @ 10 Years)	-	-	39.61%
Economic Net Present Value (ENPV, @ 6%, @ 10 Yrs)	-	1578.74	631496
Economic Capital Cost/Job	-	-	27410
Domestic Resource Cost Ratio	-	-	0.31

Policy Analysis Matrix:	Effects of Policy / Market Imperfections:	on Output	-22118
		on Tradable Inputs	-134
		on Domestic Factors	-66954
	Net Effects of Policy / Market Imperfections:	on Annual Net Income	-89206
		on Net Present Value (10 Years)	-692846

ANNEX C3: FINANCIAL/ECONOMIC MODEL - ARTISANAL FISHING - TETE 2002 - BASE CASE

SUMMARY OF MODEL

ASSUMPTION	UNITS	TOTAL
Production System:	Six boat artisanal fishery enterprise, based near Magoe on Lake Cahora Bassa, to produce dried Tembe/Tiger and Clariidae for sale at Cadzewe buying point, using gill nets as well as hooks and lines.	
Site:	Southern shore, lakeside fishing camp, close to village, with grass huts, drying racks, access by road from Tete	
Scale of Operation:	Number of Boats:	6
Use of Water	Hectares	400
Capital Item Prices:	Variation from Normal for Sensitivity Analysis	100%
Employment:	Number of Fishers	9
Fishing Effort:	Fishing Trips (Days) per Annum:	493
Catch Rate:	Tonnes Fresh Weight per Fishing Day	0.083
Total Catch	Tonnes Fresh Weight per Annum	41
Product Price:	Contos per Kg Product Weight (Average)	5.55
Fuel Price:	Contos per Litre	17.50
Resource Royalty:	Percentage of Turnover	0%

RESULTS	Cts/TCI	Cts/HA.	CONTOS
Total Financial Capital (TCI)	-	81.72	32686
Financial Gross Income	2.30	188.01	75206
Variable Financial Costs	0.45	36.75	14701
Fixed Financial Costs	1.57	128.69	51477
Net Cash Income	0.28	22.57	9029
Local Community Cash Income	1.52	123.82	49529
Land Rental	0.00	0.00	0
Resource Royalty	0.00	0.00	0
FRR (@ 10 Years)	-	-	3.96%
FNPV (@ 8%, @ 10 Years)	-	-43.35	-17339
Total Economic Capital	1.06	86.31	34526
Economic Gross Output	2.38	194.60	77838
Economic Intermediate Costs	0.92	74.83	29932
Economic Gross Value Added	1.47	119.77	47906
Economic Net Value Added	1.31	107.19	42877
Economic Rate of Return (IRR, @ 10 Years)	-	-	72.86%
Economic Net Present Value (ENPV, @ 6%, @ 10 Yrs)	-	623.75	249500
Economic Capital Cost/Job	-	-	3836
Domestic Resource Cost Ratio	-	-	0.31

Policy Analysis Matrix:	Effects of Policy / Market Imperfections:	on Output	-2632
		on Tradable Inputs	577
		on Domestic Factors	-31794
	Net Effects of Policy / Market Imperfections:	on Annual Net Income	-33849
		on Net Present Value (10 Years)	-266839

ANNEX C4: FINANCIAL/ECONOMIC MODEL - SEMI-INDUSTRIAL KAPENTA FISHING - TETE 2002 - BASE CASE

SUMMARY OF MODEL

ASSUMPTION		UNITS	TOTAL
Production System:	Kapenta semi-industrial fishery, based in the Chicoa basin in Lake Cahora Bassa, to produce salt/dried kapenta		
Site:	Southern shore, lakeside fishing camp with sheds, workshops, drying racks, and housing, access by track from Moderate gravel road to Estima and Songo and tar road to Tete. Two splinter camps with drying racks and shed.		
Scale of Operation:		Number of Boats (Rigs):	6
Concession Extent:		Hectares	4000
Capital Item Prices:		Variation from Normal for Sensitivity Analysis	100%
Employment:		Number of Staff	51
Fishing Effort:		Fishing Trips (Days) per Annum:	1686
Catch Rate:		Tonnes Fresh Weight per Fishing Day	0.366
Total Catch		Tonnes Fresh Weight per Annum	617
Product Price:		Contos per Kg Product Weight (Average)	19.80
Fuel Price:		Contos per Litre	17.50
Resource Royalty:		Percentage of Turnover	0%

RESULTS	Cts/TCI	Cts/HA.	CONTOS
Total Financial Capital (TCI)	-	1544.18	6176730
Financial Gross Income	0.66	1018.36	4073426
Variable Financial Costs	0.39	607.24	2428951
Fixed Financial Costs	0.41	632.87	2531477
Net Cash Income	-0.14	-221.75	-887001
Local Community Cash Income	0.11	169.20	676800
Land Rental	0.00	0.00	0
Resource Royalty	0.00	0.00	0
FRR (@ 10 Years)	-	-	(Negative)
FNPV (@ 8%, @ 10 Years)	-	-2328.96	-9315843
Total Economic Capital	0.97	1495.94	5983746
Economic Gross Output	0.73	1120.19	4480769
Economic Intermediate Costs	0.57	872.98	3491918
Economic Gross Value Added	0.16	247.21	988851
Economic Net Value Added	0.07	111.51	446033
Economic Rate of Return (IRR, @ 10 Years)	-	-	11.13%
Economic Net Present Value (ENPV, @ 6%, @ 10 Yrs)	-	506.61	2026459
Economic Capital Cost/Job	-	-	117328
Domestic Resource Cost Ratio	-	-	0.80

Policy Analysis Matrix:	Effects of Policy / Market Imperfections:	on Output	-407343
		on Tradable Inputs	100421
		on Domestic Factors	-1026113
	Net Effects of Policy / Market Imperfections	on Annual Net Income	-1333035
		on Net Present Value (10 Years)	-11342302