The Chambo Restoration Strategic Plan

Proceedings of the national workshop held on 13-16 May 2003 at Boadzulu Lakeshore Resort, Mangochi

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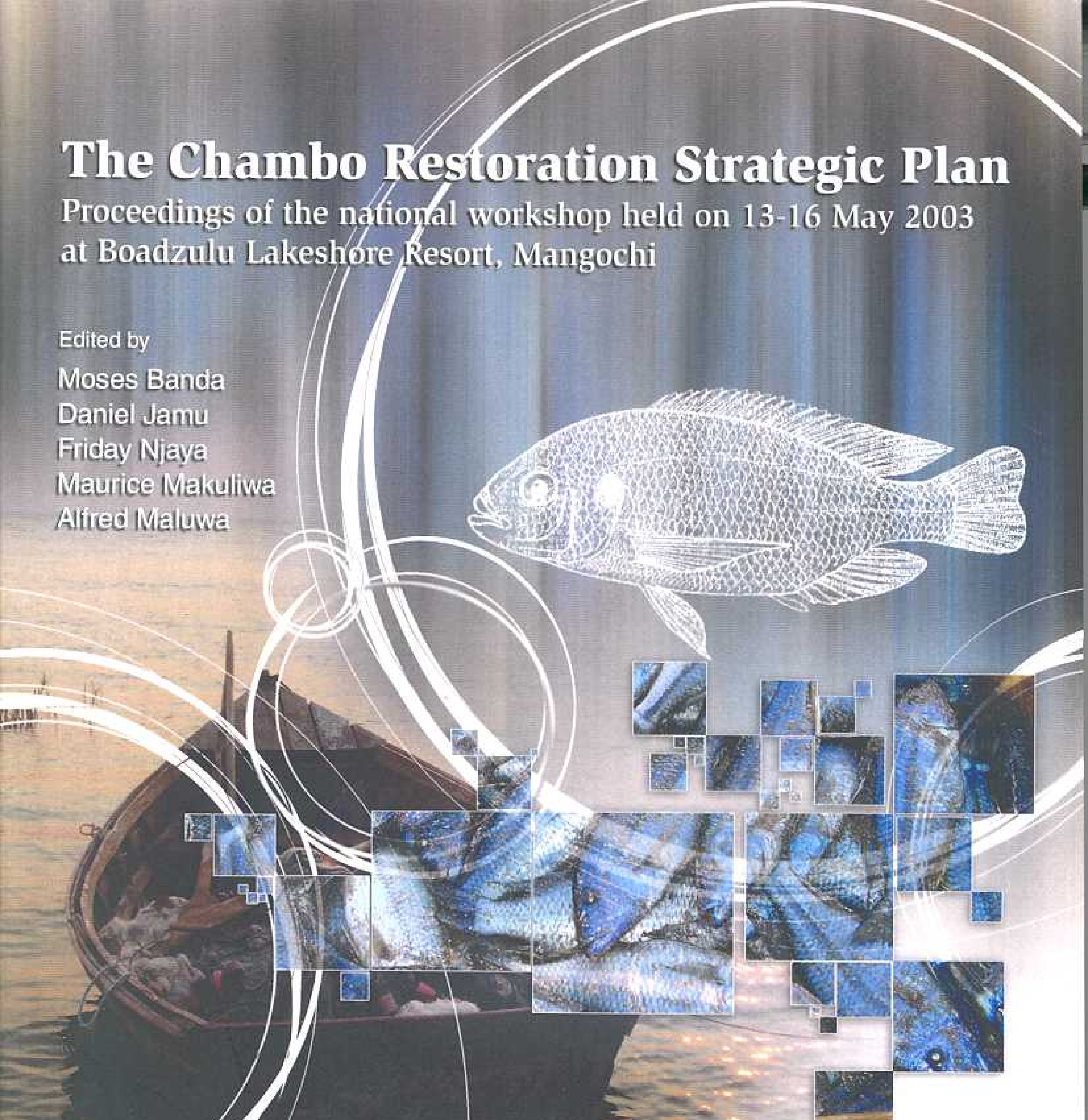

COMPASS

Republic of Malawi

WorldFish CENTER

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The WorldFish Center is one of the 15 international research centers of the Consultative Group on International Agricultural Research (CGIAR) that has initiated the public awareness campaign, Future Harvest.

Contents

Foreword

Fisheries resources contribute substantially to food security and livelihoods of 1.6 million Malawians. Because of increasing population, limited livelihoods opportunities for lake communities, fish habitat degradation, overfishing and the problems of managing a complex multi-species fishery, the annual fish production for the country has declined from over 80 000 tonnes in 1980s to just around 50 000 tonnes since the last decade. Of particular interest is the decline of the Chambo in the southern part of Lake Malawi, Upper Shire River and Lake Malombe from 15 000 tonnes per year to less than 3 000 tonnes per year. This decline of Chambo catches implies a significant loss to the rural and urban economy, reduced food security and adversely affected the livelihoods of a large number of people dependent upon the fishery.

Recognizing the important role that the Chambo plays in the livelihoods and nutritional security of Malawians, the Malawi legislature through the Cabinet Committee on Natural Resources and Environment (CCNRE) demonstrated its commitment to the restoration of the Chambo fishery by endorsing the launch of the "National Save the Chambo Campaign" on 16 January 2003 and the Chambo Restoration Strategic Plan on 24 July 2003. This culminated in a consultative process to consolidate the development of a strategic plan with participation of scientists, academia and policy makers from both within Malawi and abroad. The process materialized in the form of a workshop held on 13-16 May 2003 at the Boadzulu Lakeshore Resort. The workshop, officially opened by the Principal Secretary of Natural Resources and Environmental Affairs, George Mkondiwa and closed by the Director of Fisheries, Sloans K. Chimatiro, resulted in the Chambo Restoration Strategic Plan (CRSP) and the proceedings documented in this book.

The Department of Fisheries considers this commitment and political will an opportunity to exercise its role in developing the Strategic Plan as one way of restoring the Chambo through a combination of strategies that include restocking, artificial reefs, stock enhancement, aquaculture and habitat restoration. At the center of these strategies are the people who exploit the fisheries resources. It is expected that, with participation of all stakeholders including the private sector, advance research institutes, community organizations and donor agencies, this initiative will be successfully implemented and will serve as a model for rehabilitation of collapsed fisheries in other inland fisheries in Africa.

These proceedings should, therefore, inform the reader of the scope of knowledge on the Chambo, the socio-economics and livelihoods context within which the people exploiting the resource operates, and past constraints to the management of the Chambo fishery. The proceedings also provide recommendations on how to overcome these problems and a strategic plan for the restoration of the Chambo fishery. It is hoped that the proceedings will emphasize, to researchers in the natural and social sciences and development practitioners, the fact that a multidisciplinary approach is needed that puts the people utilizing the resource at the center of all planned activities if the Chambo fishery is to be successfully restored.

Finally, I would like to express my thanks to all the participants for their contributions during the workshop and their assistance in developing the CRSP, and to all our partners for their valuable technical and financial support.

Sloans K. Chimatiro
Director of Fisheries

Acknowledgements

We are grateful to our partners for their valuable technical and financial assistance. In particular, we recognize the support from the COMPASS/USAID, the International Food Policy Research Institute (IFPRI) and the WorldFish Center towards meeting the costs of organizing the national workshop, and from MEET and MALDECO for supporting the launching ceremony of the "National Save the Chambo" campaign. Special thanks should go to Mr John Balarin and Dr Johann Bell, who were the workshop moderators. The time consuming work of the team responsible for organizing the national workshop and editing the proceedings are very much appreciated. Contributions from various individuals who are too numerous to mention are also very much acknowledged.

Executive summary

This report provides a background to the issues that have led to the collapse of the Chambo in Lake Malawi and the South East Arm (SEA) of Lake Malawi and to the development of a Chambo Restoration Strategic Plan.

The fisheries sector plays a significant role to Malawi's population as a source of food, income and employment opportunities to nearly 300 000 people involved in the industry either through direct fishing or other associated activities. It is estimated that fish contributes four percent to the country's Gross Domestic Product (GDP). The current beach value of fish is about 15 million USD on an annual basis. Fish once provided 70% of the animal protein supply and 40% of the total protein intake, thereby contributing to food security and livelihood strategies. However, this contribution has drastically declined to less than 30% of the total animal protein supply.

The Chambo (*Oreochromis lidole*, *O. squamipinis* and *O. karongae*) is facing a number of challenges that, if left unchecked, will significantly reduce the potential as well as the actual contribution of the fishery to the national economy. Fish production reached a peak of 70 000 t in early 1990s and has since declined to as low as 50 000 t in the late 1990s. Consequently, per capita fish consumption has dropped from 14 kg in mid 1970s to below 3 kg in 2003. Of particular concern is the Chambo fishery, which has exhibited the most serious decline. From 1980 to 2000, there has been a total production loss of about 8-9 000 t per annum. At current market prices, this is equivalent to an annual loss of USD 15 million in revenue to the industry.

The decline of the fisheries and the Chambo fishery in particular, is attributed to a number of cross cutting and sector specific factors. Notable among them are: the low fecundity, limited migration, slow growth to maturity, over-fishing, illegal fishing mainly due to weak enforcement of regulations, habitat destruction, violation of closed seasons, catchments damage, violation of protected areas, absence of clear property rights, and a poor tax-based economic system that does not reflect the benefits derived from the resource. Several management interventions to restore the Chambo fishery were proposed at the workshop and these included technical restrictions of fishing gears (mesh size, headline length), introduction of cage culture, fish sanctuaries, artificial reefs and community property rights to fishing areas, and restocking of the fishery.

Subsequent discussions on the papers presented were centered on the needs to: (i) set clear fisheries management objectives; (ii) provide a clear and concise analysis of the factors responsible for the Chambo collapse; (iii) involve communities and government in the conservation of the Chambo; (iv) determine the benefits and potential environmental risks of proposed interventions; and (v) develop linkages between research and extension so that research results are translated into development outcomes. Further, it was proposed that research on markets, socio-economics and policy was required to complement biological research.

Finally, an ecosystem approach to the restoration of the Chambo was adopted, focusing on three priority areas of importance to Chambo production, namely the South East Arm (SEA) of Lake Malawi, Lake Malombe and aquaculture. The SEA of Lake Malawi and Lake Malombe were selected because the Chambo stocks there have suffered the greatest decline and yet they have the greatest potential for restoration and enhancement through aquaculture, sanctuaries and restocking.

Introduction

The fisheries sector plays a significant role for Malawi's population as a source of food, income and employment opportunities to nearly 300 000 people involved in the industry either through direct fishing or other associated activities. It is estimated that fish contributes four percent to the country's Gross Domestic Product (GDP). The current beach value of fish is about 15 million USD on an annual basis. Fish once provided 70% of the animal protein supply and 40% of the total protein intake, thereby contributing to food security and livelihood strategies. However, this contribution has drastically declined to less than 30% of the total animal protein supply.

The Chambo (*Oreochromis* spp.) is facing a number of challenges that, if left unchecked, will significantly reduce the potential as well as the actual contribution of the fishery to the national economy. Fish production reached a peak of 70 000 tonnes in early 1990s and has since declined to as low as 50 000 tonnes in the late 1990s. Consequently, per capita fish consumption has dropped from 14 kg in the mid 1970s to below 3 kg in 2003. Of particular concern is the Chambo fishery, which has exhibited the most serious decline. From 1980 to 2000, there has been a total production loss of about 8-9 000 tonnes per annum. At current market prices, this is equivalent to an annual loss of USD 15 million in revenue to the industry.

The decline of the fisheries, and the Chambo fishery in particular, is attributed to a number of cross cutting and sector specific factors. Notable among them are: over-fishing, illegal fishing mainly due to weak enforcement of regulations, habitat destruction, violation of closed seasons, catchments damage, violation of protected areas, absence of clear property rights and a poor tax-based economic system that does not reflect the benefit derived from the resource. It is worth noting that the tax revenue collected allows the government to effectively service the taxpayer and enables it to correct any potential damage that may result from over-exploitation of a resource. Unfortunately, the current tax regime does not favour such a system and the result has been weak enforcement partly due to inadequate financial resources.

Consider as a national issue, this decline has attracted an attention of the wider society including the Cabinet Committee on Natural Resources and Environment (CCNRE) through the Department of Fisheries (DOF) of the Ministry of Natural Resources and Environmental Affairs. The Department of Fisheries was, therefore, requested to come up with a workable strategy in a form of an awareness campaign to protect this most important "living gold from the lake". This initiative called the "National Save the Chambo Campaign" aims at mobilizing all Malawians towards a program of sustainable exploitation of the Chambo and attracting more foreign and domestic funding to revive the Chambo fishery by 2015 by restoring depleted stocks to the pre-1990 level. The launching of the campaign was held in March 2003 and since then a number of consultative meetings have been conducted to seek views of all the key stakeholders to come up with a strategic plan.

A national workshop on the elaboration of the Chambo Restoration Strategic Plan (CRSP) was held at Boadzulu Lakeshore Resort during 13-16 May 2003. This culminated in a consultative process to consolidate the development of the strategic plan with participation of scientists, academia and policy makers from both within Malawi and abroad. The workshop was officially opened by the Principal Secretary of Natural Resources and Environmental Affairs, George Mkondiwa on the first day and closed by the Director of Fisheries, Sloans K. Chimatiro, at its conclusion.

An ecosystem approach was adopted, focusing on three priority areas of importance to Chambo production, namely the South East Arm (SEA) of Lake Malawi, Lake Malombe, and Aquaculture. The SEA and Lake Malombe were selected because these locations are considered as the Chambo hotspots where the stocks have suffered the greatest decline. On the other hand, aquaculture has the greatest potential for restoration and enhancement of the Chambo production through farming, culture-based systems and possibly by supplying juvenile fish for restocking programs.

The workshop adopted an approach that included group work and plenary discussions. After each thematic presentation, work groups deliberated the implications for better management of the Chambo. All paper presentations and general discussions are presented in Section 1. The Chambo Restoration Strategic Plan is in Section 2, which has also been compiled separately. Finally, Section 3 contains annexes that include the official opening speech by the Principal Secretary, a list of all participants and the workshop programme.

Overview of papers

This section provides a broad overview of the papers presented and a contextual framework for the major issues arising from the papers and discussions of the papers by participants.

The papers presented fall into three main broad categories. The first category reviews the Chambo fisheries and the biology of the species and also provides a review of the factors that might have led to the decline and collapse of the Chambo in Lake Malawi and Lake Malombe. The second category reviews the socio-institutional arrangements that have governed the Chambo fisheries and identifies the major socio-institutional factors that might have influenced the decline of the Chambo fishery. The third category reviews options for the restoration of the fishery and provides information on the performance of the Chambo in aquaculture.

The papers by Banda et al. and Bulirani review the current status of the Chambo fisheries and provide information on the critical factors that might have contributed to the decline of the Chambo. The paper by Banda et al. concludes that the Chambo fisheries in Lake Malombe and the South East and South West Arms of lake Malawi are in danger of collapse and require urgent management interventions. Both papers agree that overfishing, use of illegal gears, habitat degradation and non-compliance of fishing regulations have contributed to the collapse of the Chambo fisheries and that technical restrictions such as gear mesh and length sizes and restrictions of fishing areas should be considered in a Chambo restoration plan. During the discussions it was noted that any Chambo management strategies that are put in place should be considered under a wider context in relation to the management of other species in the lake.

The paper by Ambali et al. seeks to answer two major questions on the impact of fishing intensity and genetic diversity of the species and the migration patterns of the Chambo. The authors use molecular genetic techniques to establish the genetic diversity of different populations that have been subjected to different levels of fishing intensity and conclude that despite the decline in number, the Chambo has relatively high levels of genetic diversity and hence restoration of the fishery cannot result in genetic bottlenecks. They further conclude that there are high geographical migration rates among the different populations and they hypothesize that fluctuations in catch levels in different sites may be due to migrations and not fishing intensity.

Official opening address by the Secretary for Natural Resources and Environmental Affairs, Mr. G.C. Mkondiwa

The Chief of Party, COMPASS Project
The Director of the WorldFish Centre in Malawi
The Director of Fisheries and your staff
Distinguished National and International Scientists
Members of the Non-Governmental Organisations
Members of the Donor Community
Representatives of the Fishermen Association of Malawi
Members of the Press
Distinguished ladies and gentlemen

I feel greatly honored to be here today on the official opening of this important event on behalf of the Hon. Minister, who is busy with other equally important official engagements. First and foremost, I wish to welcome you all, ladies and gentlemen, to the National Consultative Workshop on Strategic Plan for the Restoration of the Chambo Fishery.

Ladies and gentlemen, Malawi as a nation cannot run away from discussing her fishery resources. The sector has a great impact on the socio-economic life of the people and 25% of our land is covered by water. One very interesting thing is that Lake Malawi has a large number of endemic fish species that are not found anywhere else in the world and the Chambo is one of such fish species and undoubtedly one of the specialities of the Malawian diet. Indeed, experience has shown that all visitors that come to Malawi have fond memories about Lake Malawi and the Chambo, which has all along been our pride and exported to earn the much needed foreign exchange for the country. However, distinguished ladies and gentlemen, since the 1990s, the Chambo catches have declined quite substantially. For example, before 1970, the Chambo catches were in the ranges of 8 000 to 10 000 t per annum but have since declined to below 500 t per annum as of now.

Ladies and Gentlemen, there are a number of reasons that have brought about this scenario. These include overfishing, use of illegal gears, habitat destruction and violation of the closed fishing season, just to mention a few. It is a reality that our fish stocks have dwindled and that indeed we as a nation have a problem at hand. The problem is a serious one and we cannot just sit back and watch.

During the last sitting of parliament in December 2002, a statement was made on the need to save the Chambo from extinction. A month later, in January 2003, we briefed the Cabinet Committee on Natural Resources and the Environment on the same issue after which the committee was invited to witness the "Save the Chambo Launch Campaign" on the shores of Lake Malawi. Initially the programme was aimed at creating awareness to the public so that the people of Malawi should appreciate the reality about the downward trend in the catches of the Chambo. In the same awareness campaign, appeals were made to individuals, organisations, government and non-governmental organizations, national and international research development agencies to come forward to assist the government in its plan to restore the Chambo.

It is against this background, ladies and gentlemen, that the Department of Fisheries has now put together a draft ten-year National Strategic Plan to restore the Chambo to its pre-1980 levels. The plan needs the input and participation of all stakeholders for it to become a reality and hence this workshop.

The aim of the workshop is to review the causes of the decline, current general trends and various options to restore the Chambo and make recommendations that are socially, economically and politically feasible. It is, therefore, my sincere hope that the output of this workshop will help Malawi to achieve the target set by the World Summit on Sustainable Development (WSSD) in Johannesburg in August 2002, aiming at the restoration of fish stocks to levels that can produce maximum sustainable yields at least by 2015.

In this regard, distinguished ladies and gentlemen, I urge you to ensure fruitful discussions because the recommendations that you will make are certain to have a direct benefit to the nation. Once again, I know that the job you have is quite challenging. Those of us who are listening to you, including the press and the whole nation, are trying to digest the news and are indeed struggling to speculate how the whole Lake Malawi can be managed and its fisheries resources restored to the levels of the 1970s. However one thing makes me confident of this vision. Before me is a group of highly specialized experts who are ready and willing to offer their advice. I urge you to use all the practical means at your disposal: technology, legislation and finances.

The Ministry of Natural Resources and Environmental Affairs is, on its part, committed to the course of restoring not only the Chambo, but also the endangered fish species back to their maximum sustainable levels. Surely, one of the most important factors that will determine the success of our campaign is financing. Permit me, therefore, to convey my sincere gratitude to USAID's COMPASS Project and the WorldFish Center, who have already started assisting by supporting this workshop. The cause we are fighting for today was well spelt out in the recent international agenda developed at the World Summit on Sustainable Development (WSSD). It is, therefore, my sincere hope that donors, individuals, companies, and organizations will give their support and I wish there was a systematic way of inducing pledges and donations. Lastly, I ask all of you to be focused in your deliberations.

SECTION 1: REVIEW OF THE CHAMBO FISHERIES AND BIOLOGY

The status of the Chambo in Malawi: Fisheries and biology

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Abstract

Assessment of the status of the fisheries of the Chambo, an endemic Tilapiine cichlid of the genus *Oreochromis*, in Lakes Malawi and Malombe was undertaken using the 1996 FAO principle of precautionary approach based on catch-per-unit effort (CPUE) as an abundance indicator. The Chambo in Lake Malombe is in imminent danger of collapse and requires urgent management intervention. In Lake Malawi, the Chambo fisheries in Domira Bay, large-scale Chambo commercial fisheries in the South East Arm (SEA) and South West Arms (SWA), and small-scale Chambo commercial fisheries in SEA are also in danger of collapse and require urgent management intervention. The Chambo fisheries in Nkhata Bay, SWA and Likoma are fully exploited and require management intervention. The Chambo fisheries in Karonga and Nkhotakota seem to be relatively healthy but the general declining trend in CPUE suggests that management intervention may also be necessary for these fisheries. The biology of this species complicates the management of its fisheries. *Oreochromis karongae, O. lidole* and *O. squamipinnis*, collectively known as Chambo, are all dimorphic maternal mouthbrooding species depicting low fecundity, slow growth to maturity, as well as limited migration, making them prone to local extinction. Increasing fishing effort coupled with insufficient enforcement of and adherence to fishing regulations further complicates its management.

Introduction

The subgenus of the genus *Oreochromis* (locally known as Chambo) comprises three closely related species of tilapiine cichlid, namely *O. lidole, O. karongae* and *O. squamipinnis*, all of which are endemic to Lake Malawi. The Chambo is found throughout Lake Malawi in shallow waters of less than 50 m deep, with very few fish beyond this depth, as well as in Lake Malombe and the Upper Shire River (Turner 1996 and Palsson et al. 1999). It is mostly present in shallower waters from December to March but is more evenly distributed from June to September (Palsson et al. 1999). Except during the breeding season around October when water temperatures are rising and at the end of the rainy season at the start of the strong southeasterly winds (Lowe 1952; van Zalinge et al. 1991), Chambo populations are generally very localized, exhibiting limited migrations between Lake Malawi and Lake Malombe, and can, therefore, be locally fished out (Palsson et al. 1999).

The Chambo are primarily phytoplanktivores, although zooplankton also feature in their diets (FAO 1993; Konings 1995). Like other cichlids, Chambo species are maternal mouthbrooders, i.e. females carry fertilized eggs and fry in their mouths until the young develop to a stage where exogenous feeding is possible (Lewis 1990). Males construct elaborate conical sand nests that are found at different depths ranging from 0.5 to 48 m with the highest concentration in waters less than 30 m (FAO 1993; Turner 1996). The sizes of the nests range from 150 to 310 cm. The Chambo lays from 100 to 600 eggs although ovaries of adults have been recorded to contain eggs in the region of 1 000 or more (Berns et al. 1978; FAO 1993; Turner 1996).

Chambo nursery grounds are typically inshore and include inlets in the lakeshore, mouths of streams, reedy shores of Shire River as well as rocky and sandy shores (Palsson et al. 1999). Independent fry, beginning from about 15 mm, live in quiet, shallow water at the edges of the lake, especially among reeds and in pools or lagoons partly separated from the main lake while juveniles of 6 to 20 cm live in a zone not far from the shore where they feed as adults (Bertram et al. 1942).

Studies of reproduction indicate that the spawning season of the Chambo species lasts from August to March and peaks between

November and December (Bertram et al. 1942; Turner 1996; Palsson et al. 1999). The size at which 50% of fish reach sexual maturity (Lm_{50}) is approximately 20.3 SL cm (Palsson et al. 1999) and the corresponding age is about 3 years. The Chambo has one clutch per year and each clutch contains 330 eggs on average.

Chambo fisheries in Lakes Malawi and Malombe

The Chambo stocks are exploited by the subsistence, small-scale commercial and large-scale commercial fisheries in Lake Malawi and Malombe (Figure 1). The subsistence and small-scale commercial fisheries are highly complex, scattered in all water bodies and a large variety of fishing gears are employed. These fall into five major categories, namely gill nets, beach seine nets, open water seine nets, hooks and fish traps. In constrast, the large-scale fisheries are mechanized and capital intensive; they use mainly trawling and purse seining ('ring net') and are confined to the southern part of Lake Malawi.

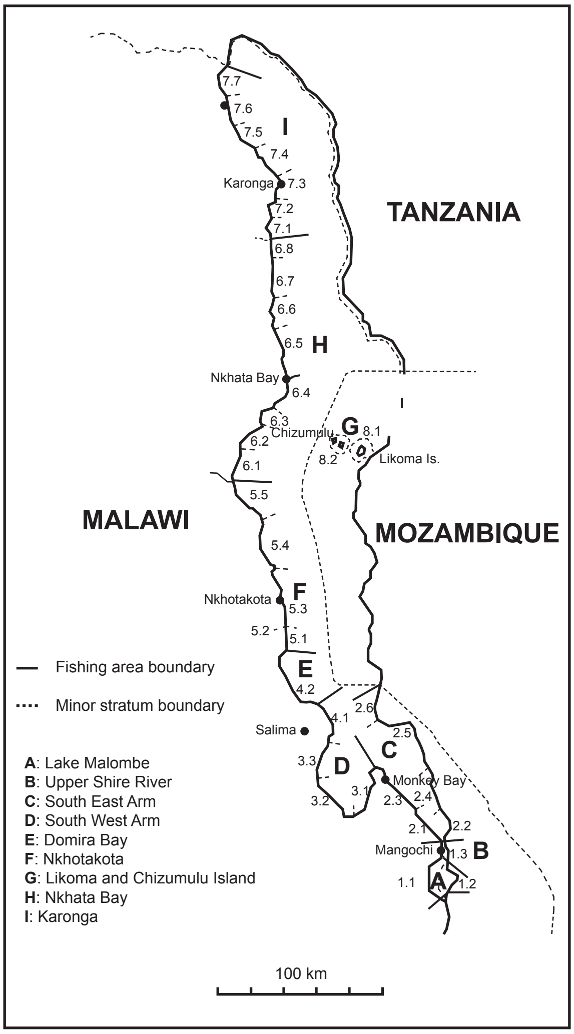

Figure 1. Map of Lake Malawi showing the main Chambo fishing grounds (A to I) and strata (numerical points) for fishery data collection.

The earliest reports (1940s) on the Chambo fisheries of Lake Malawi show that the Chambo stocks supported all different types of fisheries (Lowe 1952). For example, the Chambo accounted for about 75% of the annual native, artisanal catch from Lake Malawi at the time (Palsson et al. 1999) while the commercial exploitation of this fish, which started at about the same time by the Yiannakis operating open water ringnets in the SEA of the lake, was landing in excess of two million (individual pieces) annually by 1946. The Chambo stocks still supports the small-scale fisheries throughout Lake Malawi but their support for the small-scale fisheries in Lake Malombe and commercial fisheries in the southern Lake Malawi faltered in the early 1990s.

The present average total annual Chambo catch in Lake Malawi is 5 500 t, of which 1% is caught in Karonga, 2% in Nkhata Bay, 9% in Nkhotakota, 20% in Salima and 68% in Mangochi. Therefore, the major Chambo fishing area is the southeastern arm of the lake, especially Area A (Figure 2), which contributes 70% of the Chambo in this area. Apart from Area A, the other main fishing grounds for the Chambo in Mangochi are Lake Malombe and the Upper Shire River.

The total annual catch of the Chambo has declined markedly from a record high of over 9 400 metric ton (t) in 1985 to a low level of about 1 400 t by 1999. In early 1982, the Chambo contributed 49% of the total annual fish landings for Lake Malawi, but by 1999 it only contributed 7% to the total catch (Figure 3). In the SEA of the lake, which is one of the main fishing grounds, the Chambo made up to 70% of the total catch in 1982 but by 1999 it only constituted 7% of the catch. The continued decline of the Chambo stocks in the southern part of Lake Malawi has led to the closure of the ring net operation, the main commercial fishing gear targeting the Chambo. In Salima, Chambo catches have declined from a maximum record catch of 23% of total catch in 1982 to less than 1% in 1999. In 1980, the Chambo made up about 19% of the total catch in Karonga, but by 1999 it was down to about 2%. The same scenario is registered in

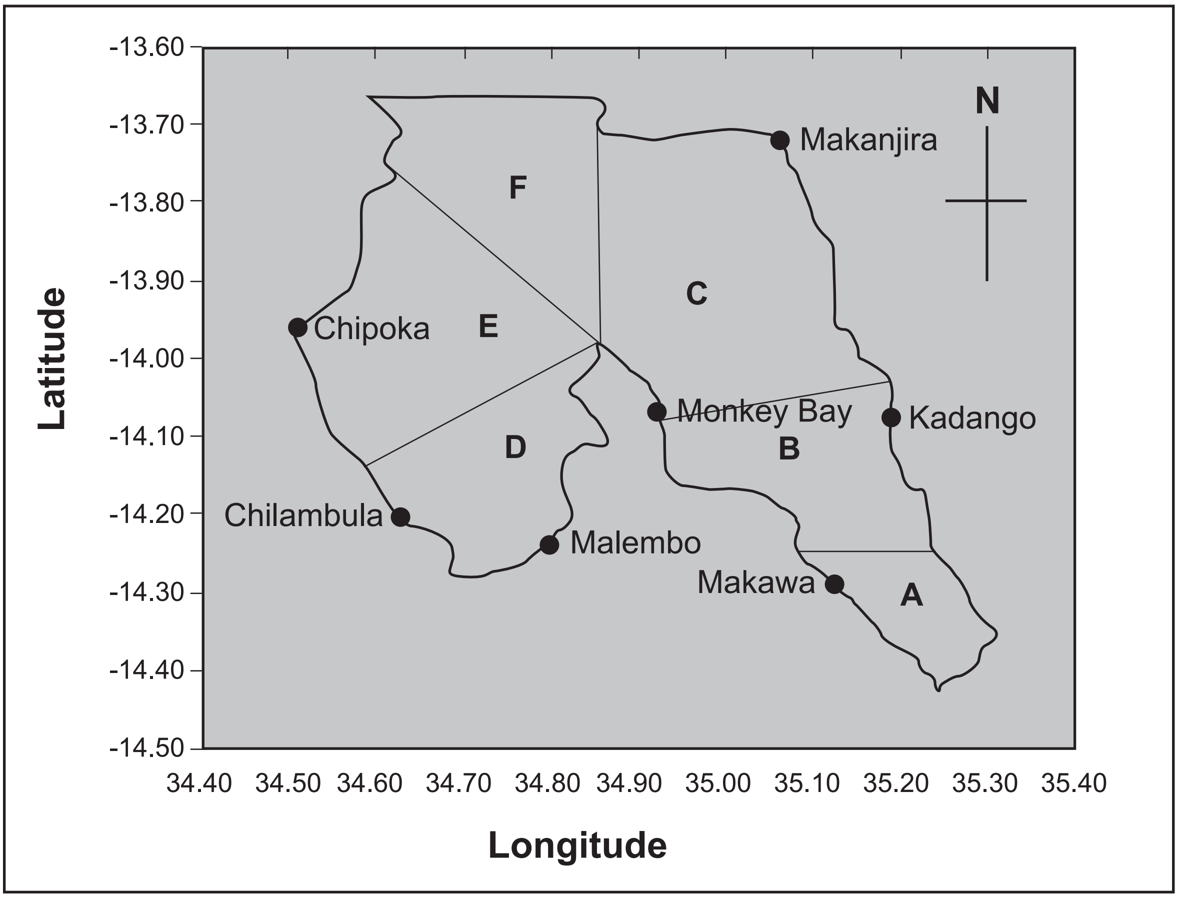

Figure 2. Map of the southern tip of Lake Malawi showing boundaries of management areas (refer to Figure 1).

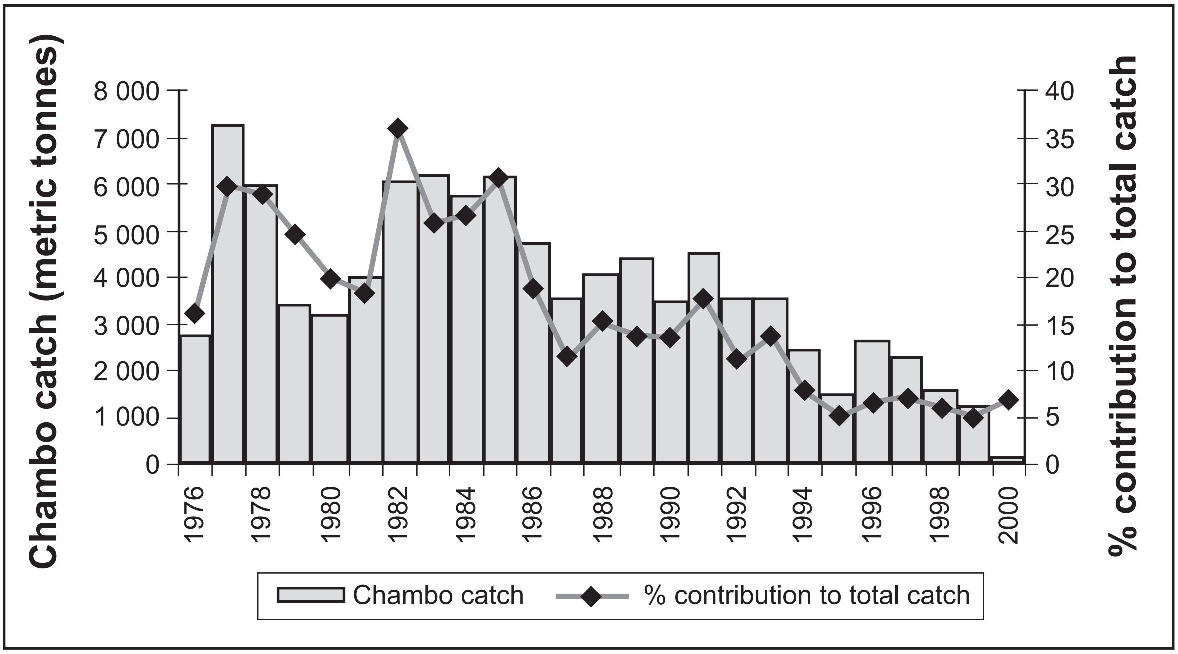

Figure 3. Annual Chambo catches and their percent contribution to total catches of Lake Malawi (Fisheries Research Unit, Monkey Bay, unpublished data).

the SWA, Nkhotakota and Nkhata Bay. In the period 1976-1990, the mean annual percent contribution of the Chambo to the total catch in SEA was 39%, but in the period 1991-1999 it decreased to 14%. A similar reduction in mean annual percent contribution of the Chambo to the whole fisheries landings in these two periods is prevalent in the SWA, Salima, Nkhata Bay, Karonga, Nkhotakota and Likoma (Table 1).

The collapse of the Chambo fishery in Lake Malombe was initially exposed by the FAO Chambo Fisheries Research Project in the early 1990s (van Zalinge et al. 1991). The total Chambo catch in this water body fell from a record high of over 8 400 t in 1982 to a low level of less than 200 t by 1999 (see Figures 3 and 4). In 1980, the Chambo contributed 87% of the total catch for Lake Malombe, but by 1999 it only contributed about 2%. In the period 1976-1990, contribution of the Chambo to the total catch was 49% whereas in the period 1991-1999 it was 4% (Table 1).

An analysis of the current status of the Chambo fisheries in Lakes Malawi and Malombe, using the principle of precautionary approach (FAO 1995) based on catch-per-unit effort (CPUE) as an indicator of abundance, indicates that the Chambo stocks in Lake Malombe and Domira Bay have collapsed (Figure 5). The Chambo large-scale commercial fisheries in the southeast and southwest arms (SEA and SWA) and small-scale fisheries in SEA are in imminent danger of collapse. All these fisheries require urgent management interventions. The Chambo fisheries in Nkhata Bay, SWA and Likoma are fully exploited and require management intervention. The Chambo fisheries in Karonga and Nkhotakota seem to be relatively healthy but the general declining trend in CPUE suggests that management intervention is also necessary for these fisheries.

Table 1. Contribution of the Chambo to total catches in various areas of Malawi (Fisheries Research Unit, Monkey Bay, unpublished data).

Area	Mean Chambo catch (1976 – 90)	Mean Chambo catch (1991 – 99)
Lake Malombe	49.1	4.1
SEA – Lake Malawi	38.5	14
SWA – Lake Malawi	22.1	8.4
Salima	8.8	1.0
Nkhata Bay	4.1	1.0
Nkhotakota	13.5	7.7
Likoma	1.3	1.1
Karonga	8.3	3.3

In socio-economic terms, the decline of the Chambo catches has resulted in economic losses to the fisheries sector and the national economy. Based on current beach price levels, the annual average economic value of the total landings during the periods 1976-90 and 1991-2003, translates to MK 4.8 billion and MK 2.2 billion, respectively (109 Malawi Kwacha[MK]=1USD). This is an economic loss estimated at MK 2.6 billion per annum and is mainly attributed to the decline of the Chambo catches. Species other than the Chambo fetch lower prices at the market and, therefore, even their increased landings could not offset this economic loss attributed to the Chambo decline. The restoration of the Chambo stocks must, therefore, be regarded as a task of major economic importance to the Malawi.

Causes of the Chambo decline

The decline of the Chambo stocks is attributed to several factors mainly overfishing, use of illegal gears, habitat degradation and non-compliance of regulations.

The overfishing of Chambo stocks in Lakes Malawi and Malombe is directly linked to increased fishing effort that has been observed for the last decade. The numbers of fishers, fishing gears and fishing crafts have increased by 27%, 124% and 30%, respectively. The common use of illegal gears with small meshes further increased effort. Small-meshed gears catch juveniles and immature fish. Consequently, increased effort resulted in both growth and recruitment overfishing of the Chambo fishery. This ultimately led to the collapse of the fishery in Lake Malombe because all stages of its life history became vulnerable (Seisay et al. 1992). Increased effort in Lake Malombe also resulted in ecological overfishing where the large Chambo species has been replaced by the small *Lethrinops* species locally known as *kambuzi*. (Figure 6). The kambuzi are small benthic species genera *Lethrinops* and *Otopharynx* found in shallow waters less than 50 m deep.

Removal of the vegetation along the beaches and in shallow areas of the lakes also had some adverse effects on the habitat (Hara and Banda 1994). The devastation of the aquatic vegetation reduced food for the fish and refugee, especially to fry and juveniles. Degradation of the surounding

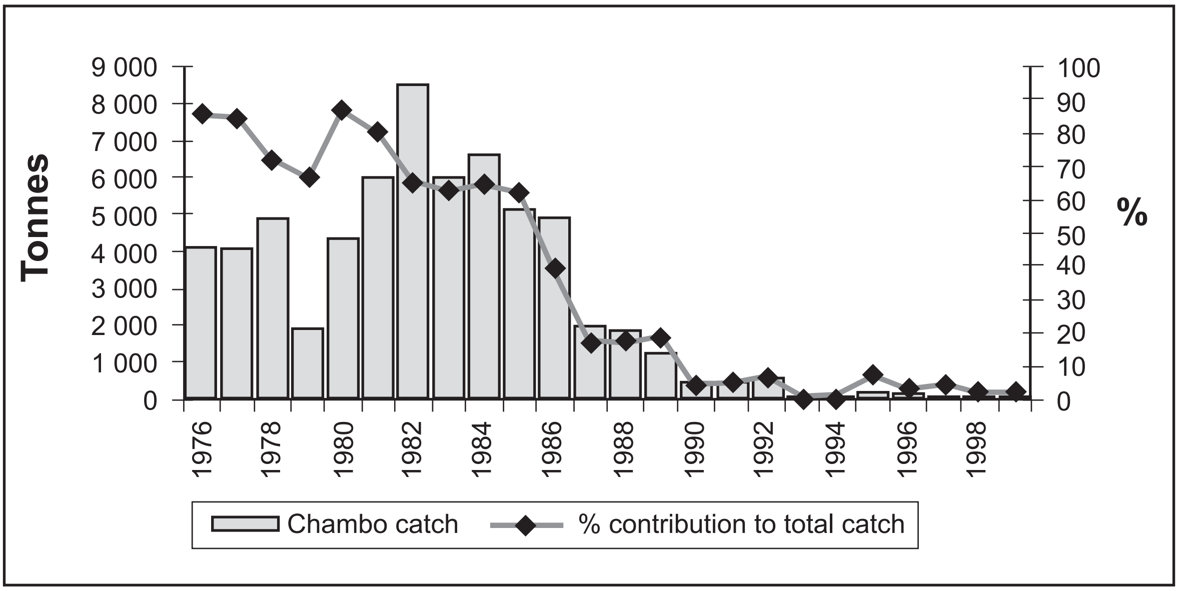

Figure 4. Chambo catches and their percent contribution to total catches of Lake Malombe.

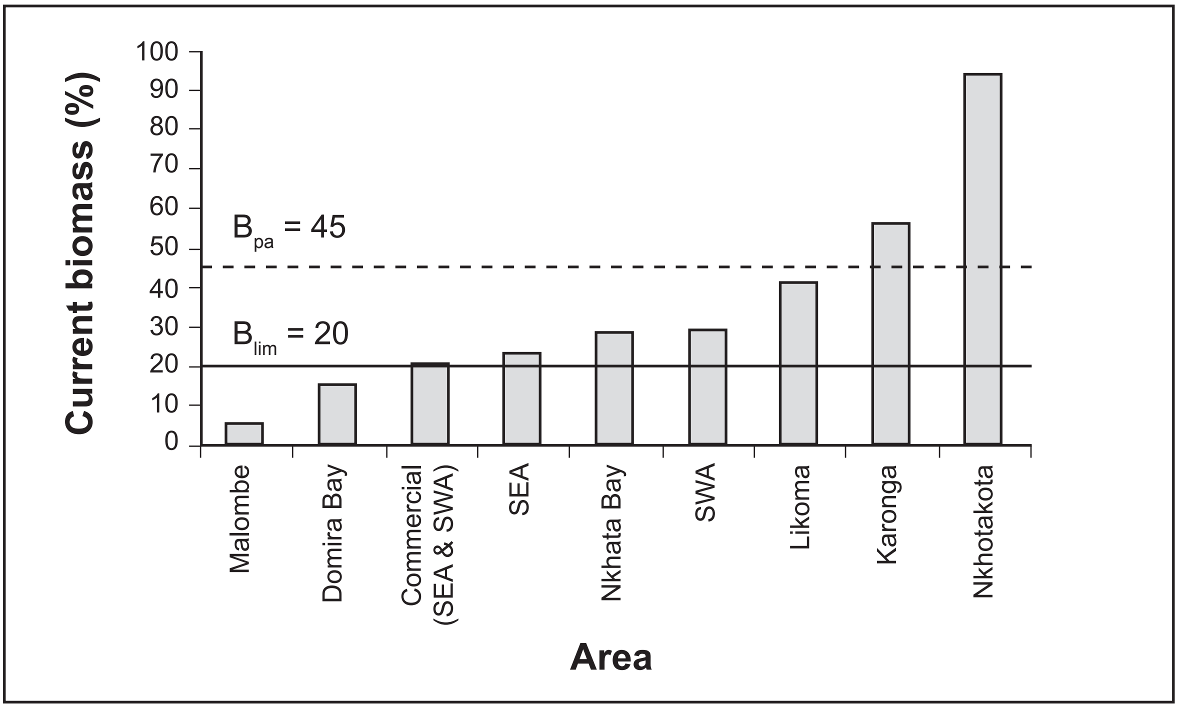

Figure 5. Status of the Chambo in the large and small-scale commercial fisheries of Lakes Malawi and Malombe based on the precautionary approach. B_{pa} is the precautionary point where management intervention is required while B_{lim} corresponds to the point where the stock is in imminent danger of collapse and management must be undertaken.

terrestrial environment has increased soil erosion that has led to siltation affecting the breeding and spawing grounds in the lake.

Non-compliance to regulations has also contributed to the decline of Chambo stocks. For instance, the closed season, which was introduced to protect the spawning of the Chambo, has never been adhered to by fishers. This means that breeding fish are caught, thus reducing the spawner biomass and leading to recruitment overfishing.

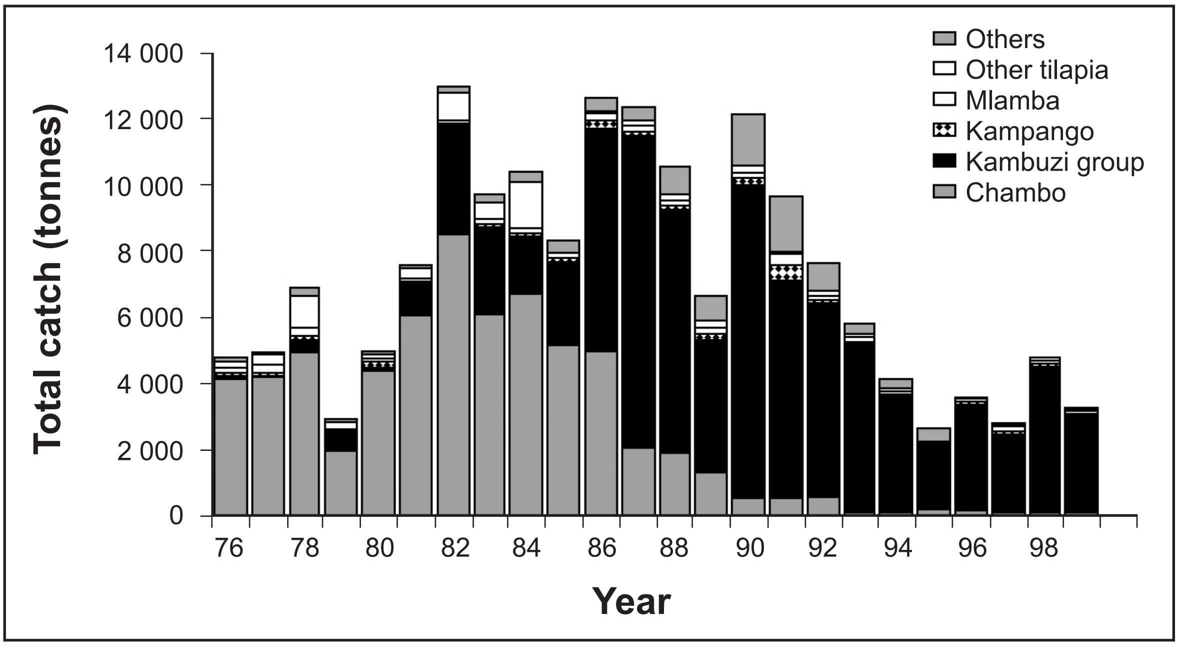

Figure 6. Annual catch by species for all gears combined in Lake Malombe 1976-1999.

Chambo fisheries management interventions

The technical restrictions of the fishing gear, i.e. gear mesh size and head line length, and fishing areas or fishing times, are the regulatory measures applied to the Malawian fisheries. The Chambo fisheries have been subjected to management measures such as closed seasons, minimum size and takeable size. A closed season during November-December in the southern and central areas of Lake Malawi is meant to protect the spawning Chambo and the mesh size regulations protect the juvenile Chambo, locally known as *kasawala*. These management techniques, however, do not address problems of open access and fishers do not follow these management methods. This has resulted in increased fishing effort that has contributed to overfishing.

However, when the serious decline of the Chambo in Lake Malombe was exposed in the early 1990s, a management plan was formulated by the FAO-supported Chambo Fisheries Project to help save this collapsing fishery. If the increasing effort in this lake was to be kept in check, free access to the fishery had to be stopped and strictly regulated by an efficient system of licences; besides effort levels were to be expeditiously pegged down to the 1992 levels as the maximum allowable. In addition, minimum mesh sizes for gill nets and Chambo seine nets were to be raised from 70 mm to 95 mm. *Kambuzi/chalira*[1] seines were to be completely banned from Lakes Malombe and Malawi and Upper Shire River. Open water seine nets, called *nkacha*, were to be banned from Lake Malawi. A minimum mesh size of 25 mm and a maximum length of 150 m for *nkacha* nets were to be introduced (FAO 1993).

The management plan was formulated based on conventional technical measures but was to be implemented through a more consultative and participatory approach called Participatory Fisheries Management (PFM). This approach was envisaged to provide an alternative management arrangement as opposed to the top-down approach common with central government agencies. The PFM initiative started on the lake in 1994 but, unfortunately, even with this set up a decade down the line, the status of the Chambo stocks in Lake Malombe is in no better shape. The Chambo stocks of the lake have not recovered despite the significant reduction in effort from gears that target mainly the Chambo (Banda et al. 2002) and the stocks in the southeast arm of the lake are still declining.

Several factors explain the cause of this state. Firstly, although the management plan for

[1] Kambuzi seine is a beach seine used to catch kambuzi while chalira is a small mosquito net that is pulled behind a beach seine to catch small fishes that escape from the beach seine.

Lake Malombe was formulated, it was not fully implemented due to lack of an action plan. This means that the status quo was maintained, i.e. the fishery is still mainly an "open access" one and enforcement of regulations is still ineffective. Secondly, although the PFM concept was adopted as a fisheries management approach, it was not supported by an enabling environment in terms of policy and legislative framework.

Conclusions

Based on the analysis of past failures of Chambo management and the current status of the Chambo stock, there is an urgent need to arrest the declining Chambo fishery in Lake Malawi and restore this fishery in Lake Malombe. In order for this to be achieved there is a need to develop management actions, formulated as a Chambo fisheries management plan or framework to address the problems of declining Chambo catches in Lakes Malawi and Malombe. The plan should be implemented through the adoption of a PFM approach with an action plan. It should also address the problems that were associated with the PFM initiatives and the lack of implementation of the previous management plan.

References

Berns, S., E.H. Chane and and H.M. Peters. 1978. On the biology of *Tilapia squamipinnis* (Gunther) from Lake Malawi (Teleostei, Cichlidae). Arch. Hydrobiol. 84: 218-246.

Bertram, C.K., H.J.H. Borley and E. Trewavas 1942. Report on the fish and fisheries of Lake Nyasa. Published on behalf of the Government of Nyasaland by the Crown Agents for the Colonies, London.

FAO. 1993. Fisheries management in south east Lake Malawi, upper Shire and Lake Malombe. CIFA Technical Report 21, FAO, Rome, 113 p.

FAO. 1996. FAO code of conduct for responsible fisheries. FAO, Rome, 41 p.

Hara, M.M. and M.C. Banda 1994. Seine nets and habitat degradation: how they have caused collapse of the Chambo *(Oreochromis* spp.) fishery of Lake Malombe. Paper presented at the Conference for Inland Fisheries of Africa, Harare.

Konings, A. 1995. Malawi Cichlids in their natural habitat. Cichlid Press, St. Leon-Rot, Germany.

Lewis, D.S.C. 1990. A review of the research conducted on Chambo (*Oreochromis* spp.) and the Chambo fisheries of Lakes Malawi and Malombe, 1859-1985. *In* T.J. Pitcher and C.E. Hollingworth (eds.) Collected reports on fisheries research in Malawi. Occasional papers, Volume 1. Overseas Development Administration, London.

Lowe , R.H. 1952. Report on the tilapia and other fish and fisheries of Lake Nyasa 1945-47, Part 2. Fish. Publ. Colonial Office, London, 1(2).

Palsson, O.K., A. Bulirani and M. Banda. 1999. A review of biology, fisheries and population dynamics of Chambo (*Oreochromis* spp., Cichlidae) in Lakes Malawi and Malombe. Fisheries Bulletin No. 38, Fisheries Department, Lilongwe.

Seisay, M.B.D., N.P. van Zalinge and G.F. Turner. 1992. Population dynamics and stock estimates of Chambo (*Oreochromis* spp.) in the SEA of Lake Malawi and Malombe – length-based approach. GOM/FAO/UNDP Chambo Fisheries Research Project FI: DP/MLW/86/013, Field document 19.

Turner, G.F. 1996. Offshore Cichlids of Lake Malawi. Cichlid Press, Lauenau.

Van Zalinge, N.P., S.B. Alimoso, S.J. Donda, M. Mdaihli, M.B.D. Seisay and G.F. Turner. 1991. Preliminary note on the decline of the Chambo catches in Lake Malombe. GOM/UNDP/FAO Chambo Fisheries Research Project, Malawi, FI:DP/MLW/86/013, Field Document 9.

Observations on the factors behind the decline of the Chambo in Lake Malawi and Lake Malombe

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Abstract

The group of inshore vertically striped large-sized tilapia locally called Chambo falls into one genus, *Oreochromis* and is composed of five distinct species (*O. karongae, O. lidole, O. saka, O. squamipinis* and *O. shiranus*), all of which, except *O. shiranus,* have a lake-wide distribution in Lake Malawi and Lake Malombe. One among the five, *O. lidole* had much of its catch coming from the area next to the outlet of Lake Malawi and the Upper Shire River at the peak of harvesting in the late sixties and early seventies. The *Oreochromis shiranus* is only found in the Shire River and Lake Malombe. The high market value of the fish and the relatively simple methods and gears for harvesting the five species under conditions of open access to the fishery led to over subscription to the fishery. The stocks started to decline gradually in Lake Malawi and Lake Malombe by the late eighties but the rate of harvesting kept increasing. In the mid eighties, the Chambo catch in Lake Malombe stood at 6 000 metric ton (t). By 2001, however, the reported catch had come down to a mere 200 t representing a decline of about 97% over the catch of the mid eighties. In Lake Malawi, the reported catch in 1985 was 9 400 t. This declined to 1 400 t by 1999, again a loss of about 85% in 14 years. The reason for the decline in these five species has been mainly speculation. This paper attempts to bring into focus some of the major factors that are believed to have played an important part in the decline of the Chambo stocks and thus contribute to the debate on what measures need to be taken now to restore the stocks or slow down the rate of further decline.

Introduction

Between the early to the mid seventies, the main species making the bulk of the landings in both Lake Malawi and Lake Malombe was the Chambo (*Oreochromis* spp.). This high value and mainly inshore group of fishes was being harvested using very simple techniques and gears ranging from gillnets, fish traps and beach seines. Because of the simplicity of harvesting, many fishers were engaged in the fishing. Knowledge on the existence of abundant deep-water fish stocks was available as evidenced by the introduction of pair trawling in the late sixties and early seventies. The simplicity of harvest method and equipment coupled with uncontrolled entry into the fishery led to over subscription of the fisheries. The Fisheries Department Research Unit at Monkey Bay was collecting data that could have been used to forecast the status of the stocks but the data collected was not processed immediately to provide the decision-making inputs about the stocks. The situation, therefore, remained unclear even though it was obvious that the stocks were not healthy. The status of the Chambo stocks came into perspective during and after the FAO Chambo Project, which made an assessment for the South East Arm of Lake Malawi and Lake Malombe.

The status of the stocks

The Chambo stocks remained stable in the initial phase of serious harvesting in the mid to late sixties. Then, much of the land/water interface was intact in the Chambo producing parts of Lake Malawi and Lake Malombe. The lakeshore infrastructure development in the late seventies and early eighties saw a further decline and it is difficult to determine which factor played a bigger role, the excessive fishing effort or the lakeshore infrastructure development. For Lake Malawi, the catch of the Chambo, which was reported at 9 400 t in 1985, had gone down to 1 400 t by 1999, a decline of about 85% in 14 years. The situation was more desperate for Lake Malombe and the Upper Shire, where catches for the Chambo had plummeted by 97% over a period of 11 years, having dropped from 6 000 t in 1980 to 200 t in 2001.

Why the decline?

As already mentioned in the introduction, no special studies have been undertaken to seriously look into the biophysical factors that are responsible for the decline in the catch and stock of the Chambo. The FAO/Chambo Project collected statistics on Chambo catches for Lake Malombe and the South East Arm of Lake Malawi pointing to the number of fishers as being the largest component that contributed to the decline of the stocks and catch. Casual observations on the present status of the water/land interface for the two lakes reveal that the life cycle of the species would have difficulties to be completed even if the case for overfishing was not considered. Therefore, most of the speculations on why the Chambo stocks have declined rapidly come under four categories.

Increasing fishing effort unmatched by available fish biomass

The Fisheries Department Annual Frame Survey (AFS) of fishing gears and fishers indicates that the highest entry into Chambo fishing happened in the late seventies. The time lag between the over harvesting of the stocks and the actual effect which started to be felt in the early eighties could be explained by the resiliency of the stocks.

Over the last 10 years the number of gears in Mangochi District, which is the largest Chambo producing district, has been increasing (Figure 1). Starting from 1993 when there were about 750 units, the number swelled to about 1 500 in 1995. There was a slight drop in 1996 that cannot be explained but for the remaining years from 1997 to 2002 the number of gears has shown an increase, particularly in 2002.

As regards the number of gears that actually catch the Chambo, the situation has not been better (Figure 2). The number increased from about 600 in 1993 to about 1 200 in 1997, an increase of 100% in a space of four years and levelled off at about 1 100 from 1997 to 2001.

As already mentioned elsewhere in this paper, the situation of the Chambo poses the most difficult problem. The fish is the most highly priced fishery product in the entire country; yet the means used to harvest it are among the most rudimentary of fishing methods in both lakes. The high price of the fish and the relative ease with which it is harvested require that some measures be put in place to discourage people from investing further in the catching of the Chambo in the two lakes.

Illegal fishing

A situation that exists for both Lake Malawi and Lake Malombe whereby small-meshed gears normally meant to harvest small-sized cichlids

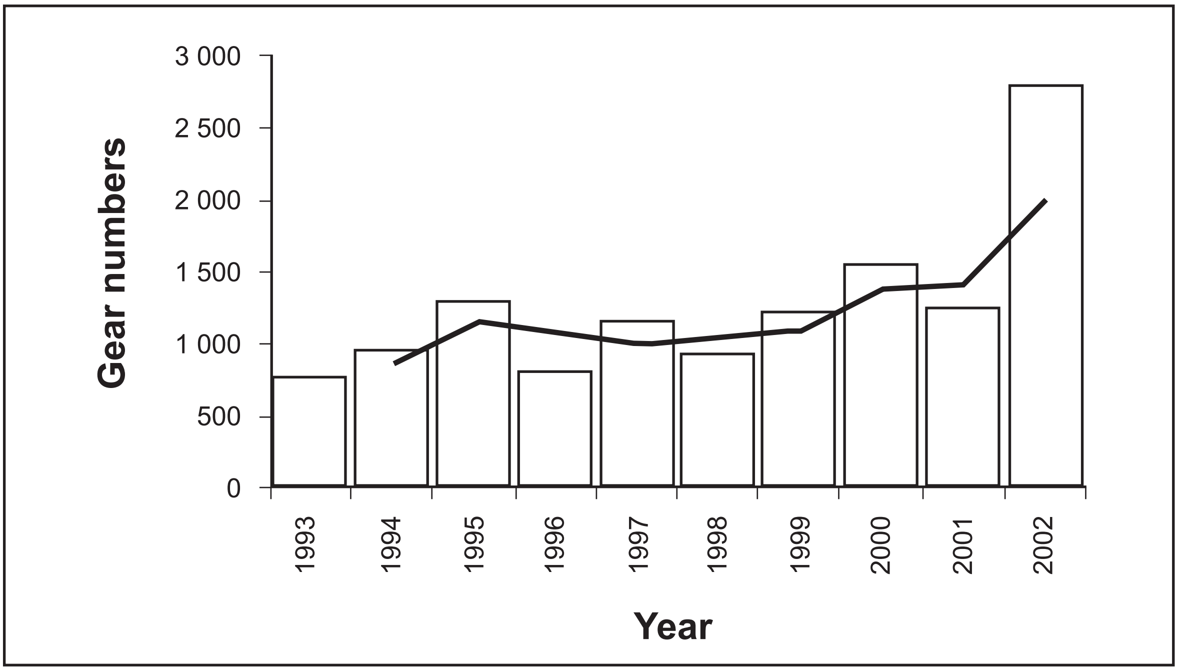

Figure 1. Total number of gears in Mangochi District (Fisheries Department 2002).

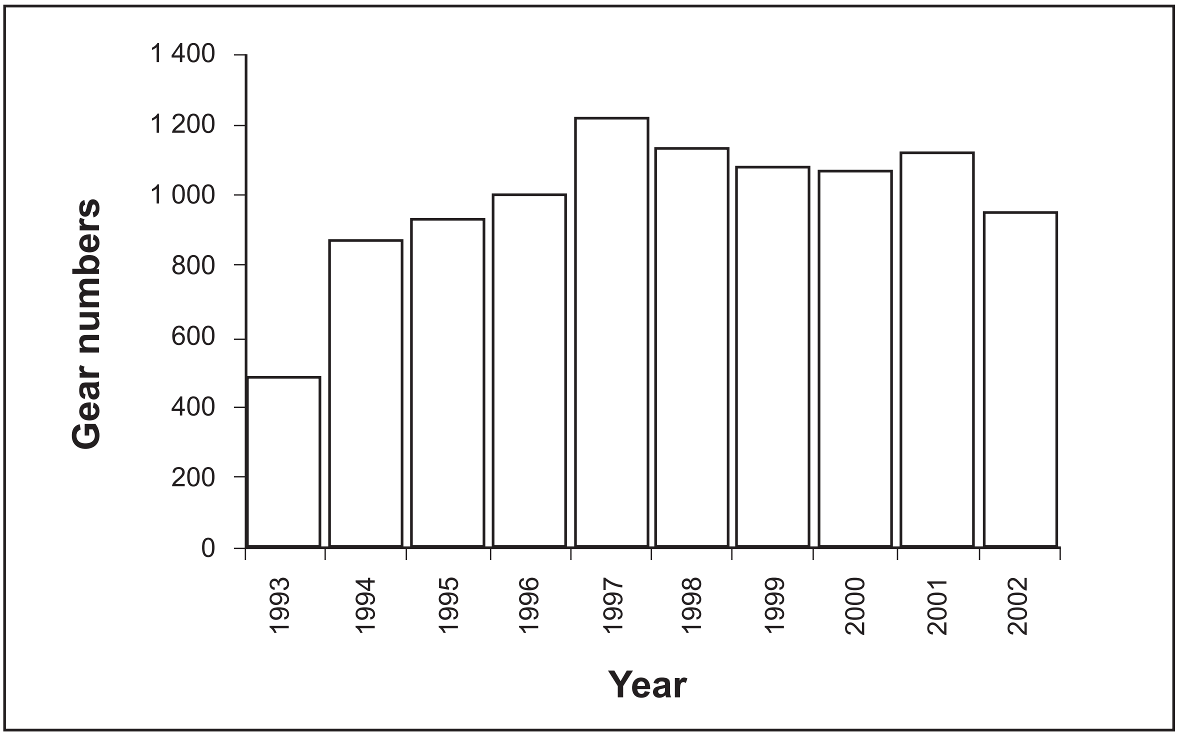

Figure 2. Number of Chambo catching gears in Mangochi District (Fisheries Department 2002).

such as *utaka* (*Copadichromis* spp.) causes havoc as these gears also catch Chambo juveniles. Gillnets of mesh sizes ranging from 38 mm to 68 mm are the most common type of gears in the whole of the South East Arm of Lake Malawi and Lake Malombe. While it is possible to ban the use of small-meshed Chambo seines and other ground-raking gears, the use of the small-meshed gillnets cannot be legally stopped as they represent the only way of harvesting these small-sized cichlids in the lakes.

Non-compliance to the closed season

The Fisheries Conservation and Management Act makes provision for a closed season of 31 days for Lake Malawi, and 61 days in the case of Lake Malombe, when all bottom-raking active gears such as Chambo seines and *nkacha* seines are not allowed to operate. The period in question is the time when the Chambo make huge mating aggregations. During this time, the fish becomes more vulnerable to encircling gears and a large part of the lake bottom where they are usually found would be full of nests with eggs. Operation of bottom-raking gears during this time poses two problems. The nests get destroyed and the eggs buried by sand and other substrate. The fishing operation also scatter the mating aggregations before effective mating takes place; and, worse, most of the catch is composed of fish in running condition. Another issue that needs some consideration is the effect of trawlers who continue to operate even during the close season. Small-scale fishers have raised this issue in many fora but the Department of Fisheries has shunned discussing this point purely on the ground of economic consideration for the trawl operators. A justification that used to be made in the past, when there was a large number of beach seines operating in many parts of Lake Malawi, was that the area being swept by the trawl operators was relatively small compared to that which was being swept by the traditional beach seines. Now, with the decrease in the number of beach seines and some containment of the *nkacha* gears on Lake Malawi, this argument does not seem to hold.

An exploding lakeshore human population, with limited alternative livelihood options

The human population of lakeshore districts of Nkhata Bay, Nkhotakota, Salima and Mangochi has increased due to migrations of upland people to the lakeshore in search of economic opportunities (Todd et al. 2000; Mvula et al. this volume). In addition to physical migration, the increasing number of fishers is also due to the change in livelihood strategies of farmers to fishing (Mvula et al. this volume).

Fishing as opposed to farming as an economic activity is particularly favoured by desperate groups as it offers quick relief due to the fact that each harvesting starts immediately after the investment is made and each fish caught almost represent instant cash. Fishing assistants who sometimes come from the upland are engaged in an activity for which payment is made on a daily basis and no matter how little the catch is for the day, it is possible to sustain their livelihoods. The cheap labour also ensures that inefficient operations of fishing depleted fish stocks are sustained.

The districts of Mangochi and Salima, where most of the Chambo are caught, boast of tourism infrastructure which could be considered to be offering alternative employment to the population and so reduce their dependence on the harvesting of natural resources for their survival. While it is true that some of the family members are employed at a tourism venture, the impact has been very small and insignificant. Instead of acting as a catalyst in the creation of numerous support businesses to the tourism industry, the central buying systems by the hotels of even the most basic commodities has not allowed the communities to benefit more than direct employment, and money made in the lakeshore is used to support far off economies where the hotels purchase in bulk.

Habitat destruction

The successful life cycle and recruitment of the Chambo normally require undisturbed lake bottom for nesting and some refugee against predators in very shallow waters for the small fry. The clearing of reeds and other macrophytes of the water/land interface, therefore, has a definite impact on successful reproduction. A casual look at the coastline of Lake Malawi, from the outlet of the Shire River to Cape Maclear in Mangochi and from the estuary of the Linthipe River to Lifuwu in Salima, shows that most of the areas that were famous for producing the Chambo used to have vegetated water/land interface. However, today most of these areas have been cleared for tourism infrastructure and private cottages. Thus the disturbance of the Chambo mating by fishers not observing the closed seasons and the lack of effective nursery areas for the fry have played continuously against the Chambo. Most of the fry that are produced in any year are believed to be eaten by other predator fishes of the shallow waters. A vegetated shoreline would offer effective protection to the fry against predation as carnivorous fishes are obstructed by the vegetation in their hunting activities. It is, therefore, believed that one of the measures that need to be taken in any effort to restore the stocks of the Chambo to anything close to that of the pre 1980 levels must address this problem by creating quiet areas as sanctuary for small fry.

Conclusion

Most of the major factors believed to have caused the decline of Chambo stocks treated in this paper do not come from special studies undertaken to try and resolve the issue of the decline. Rather, they derive from the connectivity of these factors to the biological requirement of the Chambo, the size of the fishers population and the environmental status of the areas that used to produce huge amounts of the Chambo. This makes a very strong case that the starting point to restore the stocks to significant levels must involve reduction of the fishing effort and rehabilitation of the water/land interface to provide for nursery areas.

References

Fisheries Department. 2002. A frame survey of the traditional fisheries of Lake Malawi and Malombe.

Mvula, P., F. Njaya and B. Mkoko. 2005. Socio-economic factors influencing the decline of the Chambo, p. x-xx. *In:* M. Banda, D. Jamu, M. Makuwila, F. Njaya and A. Maluwa. Proceedings of a national consultative workshop on the development of the Chambo Restoration Strategic Plan. WorldFish Center, Penang. XX p. (In press)

Todd, B., J. Kaphuka, S. Kanyanda and R. Chinula. 2002. Malawi: an atlas of social statistics. National Statistical Office, Zomba and International Food Policy Research Institute, Washington D.C.

Genetic diversity of the *Oreochromis* (*Nyasalapia*) species in Lake Malawi

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Abstract

The Chambo fishery supports artisanal fisheries throughout Lakes Malawi and Malombe and commercial fisheries in the south of Lake Malawi. A study was carried out to determine the level of genetic diversity distribution of tasseled tilapias, *Oreochromis (Nyasalapia),* species using microsatellite DNA markers. *O. squamipinnis* showed the highest variability and *O. lidole* the least. Mean observed number of alleles (na) was higher than mean effective number of alleles (ne). Estimates of migration rates per generation (Nm) using Slatkin's Private Allele Method suggest that there is considerable migration of the *Oreochromis* (*Nyasalapia*) group that takes place within the confines of Lake Malawi. The extent of genetic similarity observed among fishes collected from various sites of the lake may suggest that the unpredictable seasonal catches of the Chambo may result from coincidental hits of migrating populations other than sedentary stocks. There is, therefore, a need for further studies to monitor the geographical range of these migrations. The overall results suggest that the Chambo has still maintained a reasonable level of genetic variation in the face of intense fishing pressures. This may mean that the observed decline in the Chambo is substantially numerical in nature and that the species possess adequate potential for recovery.

Introduction

The Chambo fishery supports artisanal fisheries throughout Lakes Malawi and Malombe and commercial fisheries in the south of Lake Malawi (Lewis 1990; Turner et al. 1989; Palsson et al. 1999). The two sectors of the fishery take out on average, 54% and 46%, respectively, of the Chambo in Lake Malawi (van Zalinge 1992). Before 1993, the Chambo contributed about 30-50% of artisanal and commercial fisheries. The total Chambo catch peaked to around 17 000 t in the early 1980s then declined substantially in the mid 1980s and has stagnated around 3 000 t in recent years (Banda, this volume). In Lake Malombe alone, for instance, Chambo annual catches collapsed from a peak of 8 000 t in 1982 to less than 500 t in 1996.

The decline in Chambo catches in recent years, especially in southern Lake Malawi, has been attributed to severe overfishing (Seisay et al. 1992a). Considering the localized nature of Chambo populations (Banda, this volume), overfishing and the consequent reduction of populations could be a cause for concern about the future sustainability and diversity of the populations. This paper discusses the relation between fishing intensity and genetic diversity of the Chambo.

The objective of this study was to determine the level of genetic diversity distribution of tasselled tilapias, *Oreochromis* (*Nyasalapia*) species, in Malawi.

Biology of the *Oreochromis* (*Nyasalapia*) species

Morphological variation

Studies by Lowe (1952) and Konings (1990) indicate that morphological variation is evident amongst the *Oreochromis* (*Nyasalapia*) species. One of these species, the *O. squamipinnis,* displays a deep body and sharp bend on the forehead. Its ripe male has a pale blue background with a characteristic vertical band on a white forehead. The *O. karongae* has a deep body but with a depression on the forehead and its breeding males are black. The *O. lidole* has a big head and a generally slender body. Breeding *O. lidole* males are also black. However, the *O. lidole* actually seems to have a proportionally lower mean head length than that of the *O. saka* or *O. squamipinnis*

(Trewavas 1983). *O. saka* breeding males are also black but are different from the *O. karongae* in that the *O. saka* has 'heavily toothed' pharyngeal dentition and a more slender body. The *O. karongae* and *O. saka* show considerable overlap of morphometric and meristic characters. Turner and Robinson (1991), therefore, propose that the *O. saka* is a junior synonym of the *O. karongae*. They suggest that the *O. saka* is a southern variation of the *O. karongae,* which shows a morphological cline from the north to the south of Lake Malawi; hence they believe that there are three species of the Chambo and not four as otherwise believed. McKaye and Stauffe (1988) claim that nuptial colors of the *Oreochromis* (*Nyasalapia*) species do switch between blue and black, implying that identification of these species by breeding dress is not reliable.

Geographical variation

Turner and Robinson (1991) further demonstrated geographic variation among the *Oreochromis* (*Nyasalapia*) species in pharyngeal dentition and external morphology. This variation is gradual and clinal and appears to be linked to the substrate type (Pàlsson et al. 1999). *Oreochromis (Nyasalapia)* populations from soft-bottomed areas have slender pharyngeals while those from coarse sandy or rocky areas have relatively broad pharyngeals. Populations collected from the northern parts of Lake Malawi have expanded pharyngeals (Turner and Robinson 1991). Turner and Mwanyama (1992) echoed the same results from a repeated survey of a larger sample population in which the species were reproductively isolated by female choices for male breeding dress (Turner 1994). It is, however, claimed that genetic differences are minor among the Chambo species although behavioral separation was achieved in earlier studies (Sodsuk at al. 1995). These observations have, however, not been strongly supported by genetics data.

Restrictions to reciprocal genetic exchange between migrants and residents are apt to have important effects on the apportionment of genetic diversity because the extent of gene flow among local populations determines their potential for genetic differentiation (Lessios 1981). Population pairs that are separated geographically would show greater genetic differences than those that are closer to each other. Genetic similarity among members of a population depends largely on the extent to which they interbreed. Populations that mate frequently would share a higher proportion of common genes than those that have some restriction to breeding and, therefore, would have a correspondingly lower level of genetic divergence. The rate of gene flow between populations depends on the dispersal ability of an organism relative to habitat discontinuities and on successful mating between migrant and resident populations (Meffe 1986). Further to this, the visible external phenotypes of organisms are not a reliable guide on how their genetic diversity is partitioned. External appearances are affected by genetic, environmental and physiological factors and, therefore, are not unaltered throughout the lifetime of an organism (O'Connell and Wright 1997). It can thus be inferred from estimates of genetic differences whether populations are sufficiently variable or not, geographically or otherwise. So a genetic study of the Chambo would provide answers to the question of the genetic basis behind the clinal morphological and geographic differences among the three Chambo species of Lake Malawi.

Distribution and migration

The *Oreochromis* (*Nyasalapia*) species are found in the Lake Malawi drainage system alone and nowhere else in the world. Populations of *Oreochromis* (*Nyasalapia*) adults tend to migrate into Lake Malombe during their breeding season and when temperature begins to rise in the summer. They return at the onset of the windy '*mwera*' season when temperature begins to fall (Lowe 1952; Seisay et al. 1992a). However, the rates of migration have been decreasing steadily since the early 1990s (Seisay et al. 1992b). Pàlsson et al. (1999) speculate that the decline of *Oreochromis* (*Nyasalapia*) species stocks in Lake Malawi, especially in the southeastern arm, has obscured former migration patterns leading to the reduced migration and that this has contributed to the collapse of Lake Malombe Chambo stocks.

If indeed migrations do occur, does transfer of genetic material occur between populations so that there is mixing of gene pools? What is the extent of gene pool exchange? If there is no migration, is there distinct population structuring? Do the Chambo stocks consist of single random mating populations, a series of small isolated sub-populations or continuous populations with individuals sharing genes with geographically proximate individuals only? Given the suggestion that there is localized depletion of stocks in some of the microhabitats in the lake, are gene pools in the heavily fished areas replenished by the populations from the areas where the Chambo stocks still exist in considerably large numbers? Or have such sporadic disturbances helped to maintain considerable genetic diversity? Are the fluctuations in the Chambo due to strong seasonal influences or coincidental hits of migrating populations? These questions underline the need to describe the population genetic architectures within the Chambo species and suggest the forces that dictate genetic partitioning. Knowledge of the genetic diversity of the Chambo would not only allow monitoring of the species but also provide insight into management implications that are beyond the purview of non-molecular approaches. Studies in molecular genetics of the *Oreochromis* (*Nyasalapia*) species might contribute to assessment of their natural diversity.

Genetic diversity

Genetic diversity refers to the amount of genetic variability, the variety of genes or hereditary units among individuals of a species or population. Populations or species with high genetic diversity are believed to be less susceptible to internal and external hazards and stress than those with low genetic diversity (Brown 1983). Genetic diversity ensures the future survival of a population or species against the vagaries of the environment. Both natural processes of evolution and anthropogenic processes determine patterns of genetic diversity in a population or species (Avise 1994; Kamonrat 1996). Sources of genetic diversity occur at two fundamental levels: differences among individuals within a population (within population variation) and differences among (geographic) populations (among population variation). Loss of within-population genetic diversity erodes a population's adaptive flexibility to selective pressures while loss of among-populations variation leads to replacement of many populations by one (Meffe 1986). Three main processes reduce within-population variation: random genetic drift, genetic bottlenecks and inbreeding through their effect on effective population size. Between-population variation is reduced by either outright extinction of populations or replacement of some populations by others (Ambali 1996).

Materials and methods

Sample collection

Strategic sampling was conducted from the major fishing grounds throughout the Malawian shores of the lake from Mangochi to Karonga. Sampling areas were clustered into four main groups according to the lake districts, namely Karonga in the northern part of Lake Malawi, Salima and Nkhotakota in the central parts, and Mangochi in the southern extreme of the lake. Fishing grounds were identified within each main sampling site with respect to geographic distances in order to come up with fairly representative samples of the total Chambo populations at a particular site. Table 1 presents the sample sizes per site per Chambo species.

DNA extraction

Tissue of about 5-10 mm^3 was extracted from each fish and preserved in 95% ethanol. Genomic DNA was extracted using the extraction protocol outlined in Kafumbata (2001).

Microsatellite and Polymerase Chain Reaction (PCR)

Microsatellite markers

Microsatellites or simple sequence repeats (SSR) are regions of DNA that consist of identical, short repeated di-, tri- or tetra nucleotide motifs spaced at 7-10 kilobase pairs in eukaryotic genome. They are highly abundant, widely dispersed and highly polymorphic throughout the nuclear genome of most eukaryotes (Tautz 1989). Microsatellites are known to have relatively very high mutation rates of the order of 10^{-3}-10^{-4} and this causes microsatellites to exhibit extensive allelic variation and high levels of heterozygosity (Wright and Bentzen 1994). These markers are co-dominant such that data generated can be assayed by

Table 1. Sample sizes per site per Chambo species collected from various districts along Lake Malawi.

District	Species	*Population ID Number	Sample size
Karonga	*O. karongae*	1	34
	O. lidole	2	18
	O. squamipinnis	3	54
Salima	*O. karongae*	4	40
	O. lidole	5	40
	O. squamipinnis	6	40
Nkhotakota	*O. karongae*	7	40
	O. lidole	8	40
	O. squamipinnis	9	40
Mangochi	*O. karongae*	10	29
	O. lidole	11	34
	O. squamipinnis	12	28

*ID-Identification
All samples were collected in the year 2000.

polymerase chain reaction (PCR) and size fractionated to easily distinguish heterozygotes from homozygotes (Wright 1993). Variation among individuals occurs in the number of the nucleotide motif repeats and, therefore, the size of these regions (Wright 1993; O'Connell and Wright 1997).

Polymerase Chain Reaction

Following extraction, the DNA was subjected to PCR for amplification of microsatellite loci using the cocktail provided in Kafumbata (2001).

The cocktail was thoroughly mixed in the appropriate volumes and then 10.5µL of the mixture was aliquoted to the reaction tube containing 2.0 µL sample DNA. This was gently mixed and DNA amplification proceeded. Six microsatellite primers, UNH 103, UNH 154, UNH 160, OS 008, OS 064 and OS 075 were used to analyze 12 populations of the *Oreochromis* (*Nyasalapia*) species (Kafumbata 2001).

DNA amplification and microsatellite detection

DNA amplification was performed in Perkin-Elmer GeneAmp PCR System 9600 thermocycler. Samples were subjected to the temperature of 95°C for 12 minutes to activate Amplitaq Gold thermostable enzyme. Then 10 cycles of amplification were performed. For each cycle, DNA was denatured at 94°C for 30 seconds, annealed at primer specific temperature for 15 seconds, and then extended at 72°C for 30 seconds. Another 25 amplification cycles followed, each consisting of a 30 second denaturing step at 89°C, a 15 second annealing step at primer specific temperature and a 30 seconds extension step at 72°C. A further extension period was allowed at 65°C for 20 minutes. The products were analyzed by electrophoresis through 6% denaturing polyacrylamide gel fixed and sized relative to pGEM DNA and ϕX174DNA/*Hin*f 1 Markers (Promega 2000).

Data analysis

Genetic variation

POPGENE version 1.31 (Yeh et al. 1999) was used to compute various measures of genetic variation within and among sample populations. The following variables were computed to determine the allelic diversity: number of alleles per locus, total number of alleles in each population, mean number of alleles per population and effective number of alleles per population (Crow and Kimura 1970), observed (direct count) heterozygosity, expected heterozygosity (Nei 1973) and Shannon's Information Index (Lewontin 1974). The direct count heterozygosity, which is an indicator of potential response to selection, was compared among various populations in order to determine the amount of genetic variation in populations.

Genetic distance

Nei's (1978) unbiased genetic distance was determined using the POPGENE program. Multidimensional scaling of Nei's (1978) unbiased genetic distance and F_{ST} values between population pairs was carried out using the MDSCALE program of NTSYS-pc (Rohlf 1992) to examine the relationship among populations. The goodness of fit of the distances in the configuration space to the monotone function of the original was measured using a statistic stress (Rohlf 1992).

Population structure and gene flow

The DIPLOIDL program in GENEPOP version 3.2a (Raymond and Rousset 2001) was utilized to compute the various F-Statistics of Sewall Wright (Wright 1978) according to Weir and Cockerham (1984). The among-population component of genetic variance (F_{ST}) was calculated to measure the proportion of total variation that could be ascribed to differences between population allele frequencies. F_{ST} was computed for all populations and between pairs of populations. F_{IS} values were also calculated to determine heterozygote deficiency and excess within populations.

Using Slatkin's (1985) private allele method, a multilocus estimate of the effective number of migrants (Nm) was computed. This provides an estimate of the rate of migration of individuals between populations.

Results and discussion

Allelic diversity in the *Oreochromis* (*Nyasalapia*) species

The total number of alleles and a summary of heterozygosity statistics for six loci in the *O. karongae*, *O. lidole* and *O. squamipinnis* are presented in Table 2.

Table 2. Total number of alleles (A) and Size Range (SR) in bp at six loci in the *Oreochromis* (*Nyasalapia*) species.

Species	UNH 103		UNH 154		UNH 160		OS 008		OS 064		OS 075	
	A	SR	A	SR	A	SR	A	SR	A	SR	A	SR
OK	32	172-268	37	98-118	34	22-218	25	102-160	20	130-170	22	76-126
OL	26	180-268	38	94-222	30	140-214	21	96-152	19	130-170	25	76-140
OSQ	29	176-258	41	96-188	35	124-226	23	102-160	21	130-170	24	76-128

(OK=*O. karongae*; OL=*O. lidole*; OSQ=*O. squamipinnis*)

The mean (±se) observed and the mean effective numbers of alleles are plotted in Figure 1. Across all four localities of Karonga, Nkhotakota, Salima and Mangochi, the mean observed number of alleles ranged from 13.17±0.43 to 18.00±0.48 while the mean effective number of alleles ranged between 8.45±0.48 to 11.69±0.57 in the *O. squamipinnis*, 7.86±0.42 to 10.80±0.44 in the *O. karongae* and from 9.12±0.25 to 10.00±0.42 in the *O. lidole*. There was no significant difference (p>0.05) among the species and populations from different localities. The *O. squamipinnis* showed the highest variability and the *O. lidole* the least. The mean observed number of alleles (na) was higher than the mean effective number of alleles (ne). The effective number of alleles takes into account the relative frequencies of alleles which rare alleles contribute negligibly to the estimates (Kamonrat 1996). A large difference margin between the two estimates in most populations may be indicative of the presence of low frequency alleles at the six loci. This typifies microsatellites in which each locus displays a large number of alleles of which many are individually rare (Kamonrat 1996). The effective number of alleles is a measure of the stability of a population. Such a relatively high mean effective number of alleles seems to suggest that the *O. Nyasalapia* species flock is in a relatively stable state. Shannon's Information Index also suggests a relatively high degree of diversity within the species group.

Observed heterozygosities and expected heterozygosities have been summarized in (Table 3). Observed heterozygosities were lower than expected heterozygosities in all populations for all species. Mean heterozygosity value of 0.88±0.03 was observed amongst the three species with mean direct count heterozygosity ranges of 0.50±0.19 to 0.67±0.22 in *O. squamippinis*, 0.52±0.30 to 0.64±0.18 in *O. lidole* and 0.49±0.17 to 0.67±0.15 in *O. karongae*. These are higher than mean heterozygosity values of 0.208±0.053, 0.188±0.500 and 0.125±0.043, respectively reported in earlier allozymes studies in the *O. Nyasalapia* species group (Sodsuk et al. 1992). The allozyme data suggest that a decrease in genetic diversity might have occurred especially in the *O. karongae*.

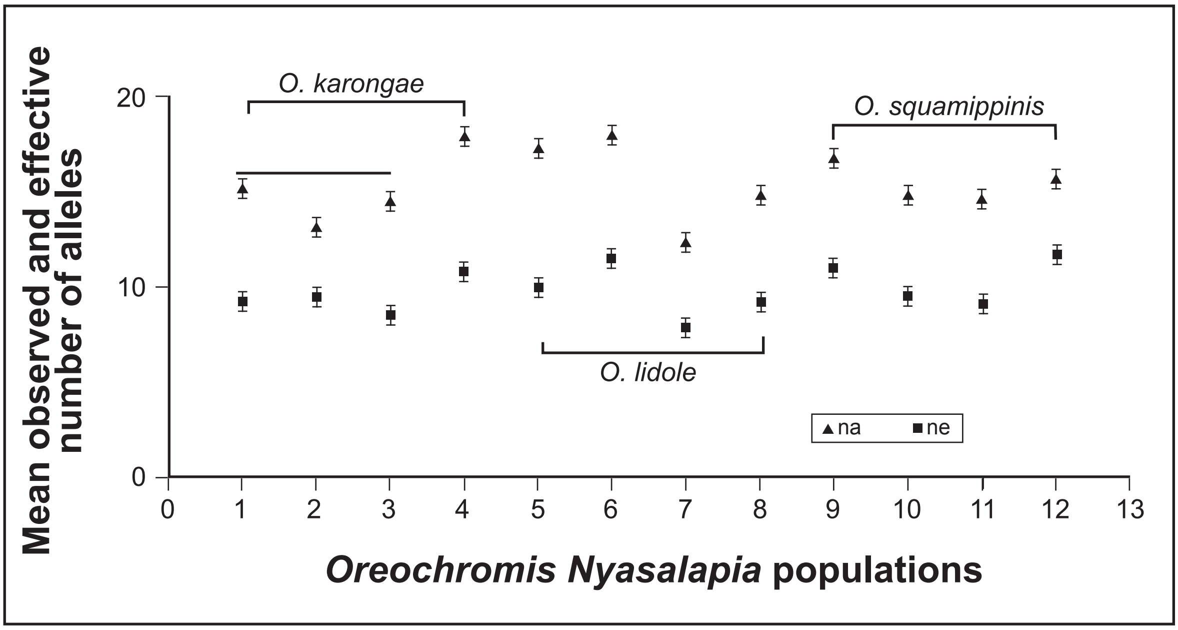

Figure 1. Plot of measures of population variation; mean±se observed (na) and effective (ne) number of alleles for individual Chambo populations.

Table 3. Summary heterozygosity statistics for all loci and populations.

Population	Observed Heterozygosity	Expected Heterozygosity
1	0.49±0.17	0.90±0.03
2	0.68±0.25	0.91±0.04
3	0.50±0.19	0.87±0.06
4	0.58±0.18	0.90±0.05
5	0.59±0.25	0.90±0.03
6	0.63±0.22	0.91±0.44
7	0.61±0.13	0.85±0.09
8	0.52±0.30	0.89±0.04
9	0.66±0.12	0.91±0.03
10	0.67±0.15	0.91±0.03
11	0.64±0.18	0.90±0.03
12	0.67±0.22	0.91±0.05

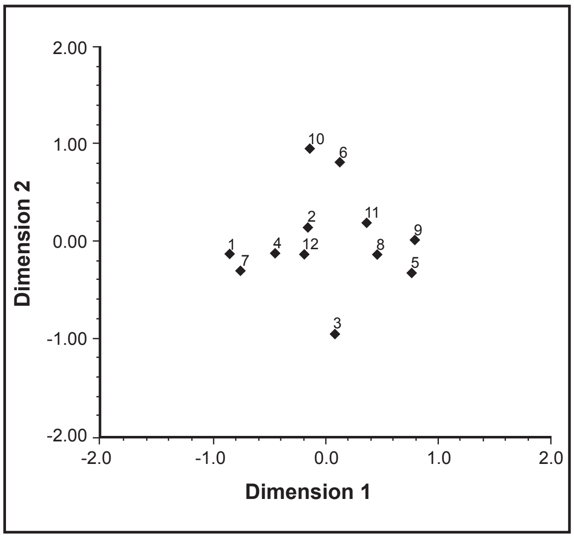

Figure 2. Multidimensional scaling plot of genetic distance data showing observed pattern of relationship among the three Chambo species. Refer to Table 1 for details of populations corresponding to the number labels.

Genetic distance between populations

A plot of the first two dimensions of multidimensional scaling based on F_{ST} is presented in Figure 2. The pattern of relationship among the three species observed shows a high degree of consensus with overlaps among three species whereby the *O. squamippinis* strongly overlaps with the *O. lidole*. Stress was less than 0.20 and, therefore, considered a reasonable fit (Rohlf 1992). This suggests genetic closeness of the species, with the *O. squamippinis* showing the greatest genetic distance across the four localities with population three having probably the least component of the gene pool.

Gene flow

Estimates of migration rates per generation (Nm) using Slatkin's Private Allele Method are provided in Table 4. These results suggest that there is considerable migration of the *Oreochromis* (*Nyasalapia*) group that takes place within the confines of Lake Malawi. Therefore, it is plausible to deduce that the unpredictable seasonal fluctuations of Chambo catches may result from coincidental hits of migrating populations other than sedentary stocks. This is supported by the remarkable genetic similarity observed among the fishes collected from various sites of the lake. Incidentally, according to fishermen at Makanjira and Fort Maguire (Chipole), the Chambo had not appeared in catches for at least two years. Then it suddenly appeared for only three days before disappearing again. This observation also supports the migratory behavior of the Chambo. This considerable gene flow also manifests itself in the minimal genetic differentiation amongst the species, F_{ST} of 0.058.

Table 4. Estimates of number of migrants per generation (Nm).

Populations	Nm
O. squamippinis	2.62
O. lidole	1.95
O. karongae	1.83

Conclusion

For a long time, there have been questions about the genetic basis behind the clinal morphological and geographical differences among the three Chambo species of *O. karongae*, *O. lidole* and *O. squamippinis*. Questions have also been asked as to whether the Chambo does indeed migrate or not. The findings of this study suggest that the clinal geographical variations are not significantly supported by genetic variation. The three species show a high degree of within-species uniformity. The study finds that there are low levels of microsatellite differentiation among the species flock. It seems plausible to suggest that the populations are likely to be reproductively isolated by female preferences for male breeding dress as proposed earlier by Turner (1994). With the perceived localized depletion of the stocks, largely depleted areas are probably being replenished from areas where the Chambo exist in large numbers in a charging effect. Although earlier studies reported a decrease in genetic richness in the *O. karongae* species, this study reveals otherwise, with the decline being highest in the *O. lidole* throughout the lake. The extent of genetic similarity observed among fishes collected from various sites of the lake may suggest that the unpredictable seasonal catches of the Chambo may result from coincidental hits of migrating populations other than sedentary stocks. Therefore, there is a need for further studies to monitor the geographical range of these migrations.

The overall results suggest that the Chambo still maintains a reasonable level of genetic variation in the face of intense fishing pressures. This may mean that the observed decline in the Chambo is substantially numerical in nature and that the species possess adequate potential for recovery.

References

Ambali, A.J.D. 1996. The relationship between domestication and genetic diversity of *Oreochromis* species in Malawi: *Oreochromis shiranus* (Boulenger) and *Oreochromis chilwae* (Trewavas). Dalhousie University, Halifax, Nova Scotia, Canada. Ph.D. Thesis.

Avise, J.C. 1994. Molecular Markers: natural history and evolution. Chapman and Hall, Inc. New York, London, 511 p.

Crow, J.F. and Kimura. 1970. An introduction to population genetics theory. Harper and Row, New York, 591 p.

Kafumbata, D.R. 2001. Genetic diversity distribution of tasselled tilapias (*Nyasalapia*: Cichlidae) in Lakes Malawi and Malombe. University of Malawi, Chancellor College, Zomba. M.Sc. Thesis.

Kamonrat, W. 1996. The spatial structure of Thai Silver Barb *Puntius gonionotus* (Bleeker) populations in Thailand. Dalhousie University, Halifax, Nova Scotia, Canada. Ph.D. Thesis.

Koning, A.D. 1990. Koning's book of cichlids and all the other fishes of Lake Malawi. T.F.H. Publications. Neptune City. New Jersey.

Lessios, H.A. 1981. Divergence in allopatry: molecular and morphological differentiation between sea urchins separated by the Isthmus of Panama. Evol. 35:618-634.

Lewis, D.S.C. 1990. A review of the research conducted on Chambo (*Oreochromis* spp.) and the Chambo fisheries of the Lakes Malawi and Malombe, 1859-1985. Collected Reports on Fisheries Research in Malawi. Occasional Papers 1:5-22.

Lewontin, R.C. 1974. The genetic basis of evolutionary change. Columbia Univ. Press, New York.

Lowe, R.H. 1952. Report on the Tilapias and other fish and Fisheries of Lake Nyasa 1945-47. Col. Off. Fish. Publs. 1(2):1-126.

McKaye, K.R. and J.R. Stauffer Jr. 1988. Seasonality, depth and habitat distribution of breeding males of *Oreochromis* spp., "Chambo" in Lake Malawi National Park. J. Fish Biol. 33:825-834.

Meffe, G.K. 1986. Conservation genetics and the management of endangered fishes. Fisheries 11(1): 14-23.

Nei, M. 1973. Analysis of gene diversity in subdivided populations. Proceedings of the National Academy of Sciences. USA 70:3321-3323.

Nei, M. 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics 89:583-590.

O'Connell, M. and J.M. Wright. 1997. Microsatellite DNA in fishes. Reviews in Fish Biology and Fisheries 7:331-363.

Pàlsson, O.K., A. Bulirani and M. Banda. 1999. A review of biology, fisheries and population dynamics of *Oreochromis* spp., (CICHLIDAE) in Lakes Malawi and Malombe. FRU.

Promega. 2000. Life science catalog: DNA molecular weight markers.

Raymond, M. and F. Rousset. 2001. GENEPOP (v 3.3) A population genetics software for exact tests and ecumenism. J. Hered. 89: 248-249.

Raymond, M. and F. Rousset. 1995. GENEPOP (v.1.2). A population genetics software for exact test and ecumenicism. Journal of Hered. 89:248-249.

Rohlf, F.J. 1992. NTSYS-pc. Numerical taxonomy and multivariate analysis system. Exeter Software, Setauket, NY.

Seisay, M.B.D., G.F. Turner and N.P. van Zalinge. 1992a. The relationship between the Chambo stocks of Lakes Malombe and Malawi and the Upper Shire River. FI: DP/MLW/86/013, Field Document 18.

Seisay, M.B.D., N.P. van Zalinge and G.F. Turner. 1992b. Population dynamics and stock estimates of Chambo (*Oreochromis* spp.) in the south-eastern arm of Lake Malawi and Lake Malombe- a length-based approach. GOM/FAO/UNDP/Chambo Fisheries Research Project, FI: DP/MLW/86/013. Field Document 19.

Slatkin, M. 1985. Rare alleles as indicators of gene flow. Evol. 39:53-65.

Sodsuk, P.K., B.J. McAndrew and G.F. Turner. 1995. Evolutionary relationships of Lake Malawi *Oreochromis* species: evidence from allozymes. J. Fish. Biol. 47:301-308.

Tautz, D. 1989. Hypervariability of simple sequences as a general source for polymorphic DNA markers. Nucl. Acids Res. 17(16):6463-6471.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon, Oreochromis* and *Danakilia*. British Museum of Natural History, London. UK, 583 p.

Turner, G.F., T.J. Pitcher and A.S. Grimm. 1989. Identification of the Lake Malawi *O.* (*Nyasalapia*) spp. using multivariate morphometric techniques. J. Fish Biol. 35: 799-812.

Turner, G.F. and R.L. Robinson. 1991. Ecology, morphology and taxonomy of the Lake Malawi *O.* (*Nyasalapia*) spp. flock. Ann. Mus. Roy. Afr. Centr., Sc. Zool. 267:23-28.

Turner, G.F. and N.C. Mwanyama. 1992. Distribution and biology of Chambo *(Oreochromis* spp.*)* in Lakes Malawi and Malombe. FI: DP/MLW/86/013 Field Document 21.

Turner, G.F. 1994. Speciation mechanisms in Malawi cichlids: A critical review. Advances in Limnology (Arch. Hydrobiol. Beih. Ergen. Limnol.) 44:139-160.

Van Zalinge, N.P. 1992. South-east arm of Lake Malawi: Chambo stock assessment and implications for the management of the fishery. Chambo Fisheries Research Project. Workshop. Nkopola Conference Centre, Malawi. GOM/FAO/UNDP Project NLW/86/013 Technical Summary Paper 15.

Weir, B.S. and C.C. Cockerham. 1984. Estimating F-statistics for the analysis of population structure. Evol. 38:1358-1370.

Wright, J.M. 1993. DNA fingerprinting of fishes, p. 57-91. *In* P.W. Hochachka and T.P. Mommsen (eds.) Biochemistry and molecular biology of fishes. Volume 2. Elsevier, Amsterdam.

Wright, B. S. and P. Bentzen. 1994. Microsatellites: genetic markers for the future. Rev. Fish Biol. 4:384-388.

Wright, S. 1978. Evolution and genetics of populations, Volume 2. Theory of gene frequencies. Chicago. University of Chicago Press.

Yeh, F.C., R.C. Yang and T. Boyle. 1999. POPGENE (v1.31). Microsoft Window-based Freeware for Population Genetic Analysis. University of Alberta.

SECTION 2: SOCIO-INSTITUTIONAL FACTORS AFFECTING THE CHAMBO FISHERIES COLLAPSE

A review of Chambo fisheries management strategies

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Abstract

This paper reviews the different fisheries management typologies worldwide and their influence on the development of participatory fisheries management in Malawi. Participatory fisheries management in Malawi developed out of crises caused by stock depletion or political pressure resulting from allegations about the government's inability to manage the resource. These crises resulted in the evolution of government-centralized management and community-based management into co-management and eventually participatory fisheries management whereby the communities are allowed to manage the resource jointly with the Fisheries Department. The paper concludes that for participatory fisheries management to be used successfully in the restoration of the Chambo fishery, the Department of Fisheries should: (i) have thorough understanding of the socio-economic and cultural factors of the fishing communities; (ii) institutionalize the appropriate rights over fish and lake resources; (iii) build the capacity of communities and the Department of Fisheries; and (iv) define the roles of different stakeholders.

Fishery resource management has been a theme of debate among the resource managers for a very long time. The debate has mainly focused on how appropriate fishery management policies and strategies can be developed and implemented to protect the stocks from over-exploitation without adversely affecting the welfare of the resource users (Donda 2000). Fisheries management can, therefore, be defined as the regulated and controlled use of fishery resources and can range from total protection of individual species for aesthetic and preservationist reasons to free resource utilization (International Institute for Economic Development (IIED) 1994). In view of the complexities of this subject, this paper will briefly review the concepts of fisheries management as applied in the management of fisheries in Malawi, the role of fishing communities and beach village communities (BVCs) in participatory fisheries management (PFM), fisheries legislation and enforcement, and methods to control habitat degradation, and will then conclude by suggesting how the Chambo fisheries can be managed in the South East Arm of Lake Malawi and Lake Malombe.

Fisheries management, whose responsibility?

Initially, it is important to put into context the need for fisheries management and whose responsibility it is to manage fishery resources. While the potential importance of aquatic resources in meeting food security, nutritional needs and contribution towards poverty alleviation goals in Malawi is apparent, so are the inevitable pressures that will be exerted on these resources as Malawi's human population increases annually by about 1.9% (Todd et al. 2002). Fisheries have long been viewed as a vehicle to promote economic growth through their contributions to the Gross Domestic Product and foreign exchange earnings, to provide employment for rural people and to provide valuable nutrition to the population (Copes 1979; Lawson 1984; Bland 1991). However, without effective management of the sector, such aims are unlikely to be achieved.

Capture fisheries have a number of characteristics that suggest that effective management is needed in order to prevent biological and economic inefficiencies. Fish are a renewable natural resource, varying in size according to growth, recruitment and mortality. The resource is reduced in size by either natural factors or human factors such as degradation of both terrestrial and aquatic environment and fishing. However, Smith (1995) asserted that significant reduction in fish resources is attributed to the fishing activities carried out by man.

One school of thought asserts that fisheries management, just like any natural resource management, has its roots in the common property resource management regimes theory, which states that what is everybody's property is no one's responsibility to manage and preserve (Gordon 1954; Scott 1955). This type of attitude among the resource users may, under certain circumstances like population pressure, lead to over-exploitation or extinction of the resources, as each resource user tries to maximize the personal benefits from resource exploitation. Based on this attitude among the resource users, other scholars (Hardin 1968; Scott 1955) have suggested two options to the management of the resources. The government either controls the commons under the state property regime, or privatizes them. It is because of the individualistic irrational behavior of the resource users and the difficulty of privatizing the resources that most state governments have taken full responsibilities in the management of fishery resources.

Another school of thought disagrees with this (Feeny et al. 1990) and argues that not all natural resources have been under the control of the government; some have remained under the management of the resource users themselves and still have not been depleted. This view is supported by the argument put forward by Feeny et al. (1990), who points out that Hardin's argument does overlook the important role of institutional arrangements that provide for exclusion and regulation of resource use. Along the same lines, Feeny et al. (1996) asserts that people often forget that human beings do not exercise their rationality in a vacuum, but rather they do so within the context of institutions.

From the preceding paragraphs, it can be seen that fisheries resources management is neither the full responsibility of government nor that of the communities. It is because of this difficulty in deciding who should manage the fishery that a number of fishery management typologies have evolved over time.

Fishery management typologies

Based on the preceding argument, two types of management approaches (government- and resource user-controlled) have, therefore, been in practice for a long time. The first, fisheries management controlled by the government, has often been referred to as the top-down or government-centred management system because the government formulates management and institutional strategies and passes them on to the user communities without their involvement. The second, management controlled by the user communities, is commonly known as the community-based management system, whereby all management objectives, strategies and institutions are developed and implemented by the resource users themselves.

Due to the complexities of fisheries resource management and the costs involved, some fisheries resource management analysts (Rettig et al. 1989; Hanna 1995) have advocated shared responsibilities between the government and the user communities in managing the fisheries. This move shifts the emphasis of fisheries management from being either government-based or community-based to collaborative management or co-management. As a result, a third management typology has emerged, which aims at bringing together the government and the user communities to manage the same resources. This is the co-management approach. Co-management strongly advocates a more bottom-up approach, that is, most of the management ideas should originate from the communities themselves, and that there should be a continued dialogue between the two co-managing partners.

State-based fishery management

As indicated earlier, government intervention in natural resource management is carried out in order to control the individualistic behaviour of resource users due to the open-access nature of the resources. This intervention is justified by the fact that fishery resources are classified as social resources that should benefit the whole of society.

It is worth pointing out at this stage that in most fisheries, the management strategies often adopted by government fisheries managers have been heavily influenced by their national policy objectives. These fisheries-related national policy objectives can broadly be categorized into three: (i) conservation/maintaining the resources; (ii) economic performance/productivity; and (iii) income distribution/equity/social needs (Charles 1992). These categories of policy objectives resulted in the development of three management paradigms presented in Table 1.

Table 1. Policy objectives and fishery paradigms (Charles 1992).

Management Policy Objective	Paradigm
Conservation / Resource maintenance	Conservation
Economic performance / Productivity	Rationalization
Community welfare Equity	Social/community

The conservation paradigm, which has a biologically based management philosophy, focuses on the protection of fish stocks and has its roots in the concepts of Maximum Sustainable Yield (MSY). Other scholars have argued that resource management can be for the purpose of conserving or preserving the resources (Passmore 1974; Bonner 1993). Passmore (1974) describes management for conservation as the saving of natural resources for later consumption and management for preservation as the saving of natural resources from use. From these definitions, it can be deduced that fisheries conservation does not mean fossilizing or preventing other forms of resource use, but the wise and planned use of resources. Bonner (1993) interprets this as a utilitarian approach to conservation that embraces preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment.

Within the philosophy of this paradigm, it is assumed that fishers and consumers of fish will take care of their own interests, and the primary duty of fishery management is to take care of the fish. Apart from the concern for fish stocks, the paradigm also recognizes the fact that future fishers and consumers will benefit from fish stock protection now. From this point of view, substantial amounts of biological studies have been carried out with the aim to ensure that harvest levels do not exceed the sustainable capacity of the fish stocks. Within this paradigm, fishers are viewed as a threat to the fish stocks (Pinkerton 1989) and must be controlled in order to protect the fish.

The rationalization paradigm focuses on economic efficiency and wealth creation in the fishery. The rationalization literature typically assumes that society should seek to maximize fishery rents, considering economic benefits over and above payments to fishers. It has been argued that fisheries that fail to seek out economic efficiency and maximize rents must be rationalized (Charles 1992; The Ecologist 1995). This typically involves: (i) reducing to an optimal level the number of fishers who are viewed as profit-maximizing firms (Pinkerton 1989); and (ii) instituting private property rights to the fishery. Within this line of thought, a key philosophical conflict in fisheries management is created in balancing the two objectives of wealth generation (efficiency) and distribution (equity). Society often expresses dual desires to maximize the size of the wealth created in the fishery and at the same time to achieve a reasonable distribution of the wealth, both now and in the future. The latter desire often comes from the politicians.

The social paradigm focuses on community welfare, distributional equity, and other social and cultural fishery benefits. There is a strong advocacy element in this paradigm seeking to protect the small fishers who are seen as being buffeted by economic forces beyond their control. Emphasis is placed on fishers as members of the coastal communities rather than as a threat to the fish stocks, as is the case in the conservation paradigm, or as individualistic fishing firms as viewed by the rationalization paradigm. This paradigm is increasingly gaining support from social scientists and politicians because small scale fisheries offer employment to many people among the fishing communities, both directly and indirectly.

These three paradigms are often a source of management dilemma and conflict in fisheries. Based on these three policy objectives, a paradigm triangle which forms a framework within which the various fishery players are situated can be envisaged (Figure 1).

Community-based fisheries management

This kind of management falls to the far right almost outside of the co-management arrangement spectrum, and it is the opposite of the government-based management system. Here the user communities develop their own management objectives and strategies and implement them without the intervention of the government. As argued by Feeny et al. (1990), this approach, too, has its roots in the common property resource management regimes theory. However, while Feeny et al. (1990) did agree with Hardin (1968) that the "tragedy" may start, they

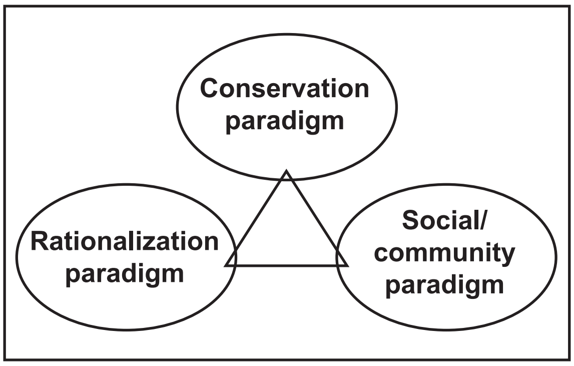

Figure 1. The fishery management paradigm triangle.

did not agree with him that the outcomes would always be the same. They further criticized Hardin by saying that his theory overlooked cultural factors that would influence these resource users to come together, after several years of declining resources, to seek ways to control the decline and agree upon a set of rules of conduct that would effectively limit exploitation.

This type of management is characterized by well-defined boundaries of the resource being managed and in most cases has been under the control of clan or tribe leaders. An exception to this has been the Japanese system (Lim et al. 1995) and the Maine Lobster Fisheries in the United States of America, where Fisheries Co-operative Associations and harbour gangs have controlled the fisheries, respectively. With the exceptions of these two, the management systems have been based on the spiritual affinity with the natural environment and traditional customs. Certain taboos have helped to protect fishery resources in some parts of the world (Ruddle 1995).

The management system is heavily dependent on tenurial rights and the main regulatory measures are the control of fishing effort by limiting access to resource areas, by restricting the use of various fishing technologies and by regulating the capture of certain species (Hviding and Jul-Larsen 1995).

The main advantage with these systems is that the local fishers broadly accept the local notions of social justice and legitimacy of the management system is ensured in the eyes of the local residents (Bailey and Zerner 1992). However, the major weakness of this system is that the management institutions are, from the government point of view, informal and thereby operate on *de facto* rules that quite often lead to conflicts between the various resource users, especially those from outside the managed territory. This makes the system less immune to outside pressures.

Co-management (Participatory fisheries management – PFM)

There is no universally agreed definition of co-management. Several people have described co-management according to the situations they have experienced (Jentoft 1989; Berkes et al. 1991; Raakjaer Nielsen et al. 1996). In broad terms, co-management is a partnership and the sharing of power and responsibility between the government and the resource users. This system takes the bottom-up approach and has two core elements: *authority to execute* and *participatory decision making*. Authority to execute is the granting of authority by the government to the user community organizations to implement management functions alongside the government. This encompasses the sharing of responsibilities and legally empowering the community organizations. Participatory decision making is the enabling of the resource users to participate in the resource management decision making process with the government. This involves power sharing between the government and the communities. Thus formal organization, democracy, decentralization and devolution of power and responsibility are crucial requirements to co-management regimes (Pomeroy and Williams 1994; Murphree 1996; Sen and Raakjaer Nielsen 1996).

Fisheries management approaches in Malawi

Prior to the early 1990s, the management policies of the Department of Fisheries (DOF) were influenced by the principles of the conservation paradigm, and, as such, belonged to the conservation camp. They were characterized by the formulation and enforcement of legislation based on biological research findings and to some extent an application of economics. The philosophy behind this approach was that of protection or preservation. The role of the government in this case was to guard the fisheries against inappropriate uses and to shield the resources from over-exploitation. The objectives and modes of implementation of this approach are determined by groups of outsiders, without consulting the local communities.

However, with the dawn of the 1990s, there was a shift in the sectoral environmental management policies and strategies in Malawi, towards the involvement of resource users in management. The Department of Fisheries was one of the first departments that opted for a change in the management of the fishery resources by going for participatory fisheries management (PFM).

Move towards PFM in Malawi

In 1993, the Malawi Department of Fisheries (DOF) commissioned a study to assess the potential of introducing PFM in Lake Malombe and the study resulted in three recommendations (Bell and Donda 1993). The first scenario was for the DOF to continue managing the fishery alone, with an intensified enforcement approach to law breakers. The second scenario was to adopt a community-based resource management strategy whereby the communities could take full control of the management responsibilities, with none or very little assistance from the DOF. The third scenario was for the DOF to share *equally* the management responsibilities with the fishing communities.

After a thorough analysis of the three options, the DOF decided to adopt the third scenario. The first recommendation required the DOF to strengthen its enforcement section by providing the necessary resources in terms of materials, finances and personnel, which it could not fulfil. As for the second, the problem was that the communities did not have the capacity to carry out the management tasks. The only other feasible alternative was the one that allowed the participation of the user communities in managing the resources in a kind of a joint effort between the DOF and the communities. This approach is commonly termed "co-management".

In a related case, the Lake Chiuta fishery moved from the community-based management approach to the co-management one in the early 1990s. Dissi and Njaya (1995) documented that the management approach of the Lake Chiuta fishery had initially been under customary tenure whereby the regulations and the management of the fishery were controlled by chiefs and fisher committees. There was, to some degree, limited entry since new fishers had to consult with local leaders for permission to join the fishery. The Department of Fisheries had not been directly involved in the management of the fishery due to lack of fisheries regulations governing the fishery.

In the mid 1980s, Lake Chiuta was invaded by seine netters who came to fish for *matemba* (*Burbus paludinosus*). These seine nets were open water seines locally called *nkacha* if they came in from Lake Malombe, and *matemba* seine nets if they came in from Lake Chilwa. These nets have bunt meshes of about 0.25 inches and smaller. These fishing gears were non-selective and were known to catch all sizes of different fish species. Initially, these fishers came in from Lake Malombe, but due to the good catches realized from the seines, more and more fishers joined the fishery from the neighbouring Lake Chilwa. The situation got out of control and the seine netters had no respect for the other lake users. There were constant conflicts between these fishers and other fishers because the seine nets constantly damaged the latter's gears and the water was repeatedly being disturbed. The other villagers who had nothing to do with fishing also felt the impact because the quality of water for domestic use was greatly affected. There were also problems of drinking water as during the operations of the seine nets, the bottom soil was disturbed, making the water turbid, dirty and thus unfit for domestic use. As a result, most people did not like the seine netters.

The absence of formal fisheries regulations in Lake Chiuta made it impossible for the local fishers deal with the seine net fishers. The local fishers then requested the DOF to assist them in chasing away the seine net fishers and to manage the fishery jointly with them. This marked the birth of co-management in the lake.

Synthesis of the two co-management development processes

Pinkerton (1989) observed that most co-management agreements between governments and fishing interests have arisen out of crises caused by rumoured or real stock depletion or from political pressure resulting from claims that the government's ability to manage is insufficient to handle specific problems. This observation rightly describes the beginning of co-management in Lake Malombe and in general terms, Lake Chiuta, as the co-management in that lake was initiated by the failure to control entry into the fishery of the seine netters. Table 2 summarizes the main factors that led to the movement towards co-management in the two lakes.

The picture emerging here (Figure 2) is that of the government-centralized management

Table 2. Summary of main factors that led to the movement towards co-management in Lake Malombe and Chiuta.

Malombe	Chiuta
System failure – poor implementation strategies.	System failure – outsiders could not be excluded from joining the fishery.
Management objectives not achieved – catches continues to decline.	Invasion of the lake by foreign seine net fishers who used unaccepted fishing methods.
Lack of legitimacy on the *de jure* fishing regulations by the fishers.	Lack of legitimacy on the *de facto* regulations by the seine net fishers and the government.
High transaction costs – the DOF was poorly funded.	

system moving towards co-management in Lake Malombe and that of community-based management system moving towards co-management in Lake Chiuta. It is interesting to note that each case developed independently of each other and both have gone through a moving process towards co-management. It should be emphasized that the moving process in an organizational structure requires changes and adaptation to the new format. This may involve changes in the structures, functions, institutions and orientation of the individuals concerned.

The preceding discussions raise two major questions about fisheries management: who should manage the fishery and for whom should the fishery be managed? The two lake cases mentioned above have demonstrated that fisheries management can be carried out by either the state (centralized fisheries management), the user community (community-based), or a combination of the two (co-management). In the following sections of the paper the basis for these three management approaches and their theoretical concepts will be explored. Particular emphasis will be placed on co-management as this is the main theme of this study. An assessment of whether the state or the user communities can accommodate the essential requirements for co-management implementation will also be carried out.

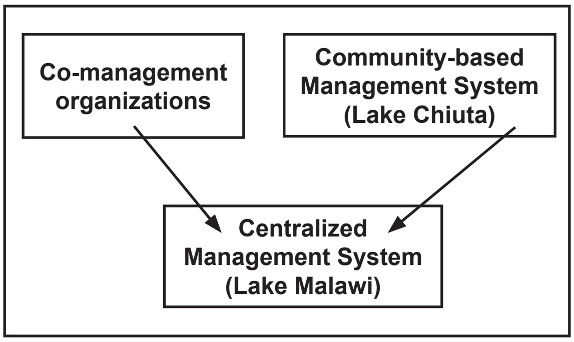

Figure 2. Shift towards co-management in Lake Malawi and Chiuta.

Development of fisheries legislation in Malawi

The first fishing regulations in Malawi, then Nyasaland, were introduced in 1930 by adding a section (Section 3: Fishing Rules MP.437 of 1930) to the Game Ordinance (Chirwa 1996). The ordinance statutorily enabled the Ministry of Natural Resources to implement, through the Department of Fisheries,[1] regulations with regard to the sector. In 1949, the objectives of these regulations were mainly aimed at controlling fisheries, regulating commercial fishing, assuring its taxation and providing, as far as it was possible, an equitable return to the largest possible number of fishers and all those engaged in the fishing industry.

By 1973, the Malawian political institutions noted the need to formulate a new Fisheries Act. It became necessary to take into account the needs to conserve fishing stocks to assure a long-term optimum catch, to adapt fishing methods and regulations, to improve gears, and to prevent the dangers of pollution.

Consequently, a completely new statute, namely the Fisheries Act 1973, replaced the Fisheries Ordinance 1949. By the mid 1990s, there was a gradual shift in the fisheries management philosophy from the conservation paradigm to the social/community paradigm, i.e. focusing on fisher community involvement in fisheries management. As such, the Fisheries Act 1973 was reviewed with the intention of including community participation in fisheries management. A new act known as the Fisheries Conservation and Management Act 1997 was then passed by the parliament in October 1997 to replace the 1973 Fisheries Act.

Current fisheries regulations

The following are some of the practical regulations that were in the 1973 Act and still appear in the 1997 Act, which are targeted at the small-scale fishers.

a. Closed Fishing Season and Area: This regulation was designed to protect certain species during their spawning period. It is prohibited to use selected fishing gears (various beach seines) in the closed areas and during the closed season. The closed season runs from 1st November to 31st December each year in Lake Malawi for all beach seines and from 1st January to 31st March each year in Lake Malombe for all seine nets. In the upper Shire, the closed season runs from 1st November to 31st March.

[1] The Department of Fisheries in Malawi was established in 1946 (Chirwa 1996).

b. Mesh size restrictions: This regulation was formulated to protect the fishing of immature fish and to supplement the closed season and areas regulations. Minimum mesh sizes for various types of fishing gears are set based on information on the size at maturity of the target species.

c. Minimum takable size of fish: Based on species and information on the size at maturity, this regulation was designed to supplement the mesh size restriction regulation by protecting young fish.

d. Maximum headline length of fishing nets: This regulation was designed to control fishing effort by limiting the size of the fishing nets. Each type of net has its own maximum permissible length depending on the water body in which it is to be used. For example, the same gear, such as the Chambo seine net, would be longer in Lake Malawi than in Lake Malombe.

e. Licensing of fishing gears: This regulation was intended to control the amount of fishing effort by limiting the number of gears licensed to fish. In so doing, it regulates access to the fishery. However, this regulation has not been used correctly since it is only strictly applied to the medium- and large-scale fishers whose numbers have been controlled by the use of this regulation. On the other hand, the licensing of artisanal (small-scale) fishers has not regulated their number as licensing does not control their access to the fishery.

The role of Beach Village Committees (BVCs) in Chambo restoration and control of habitat destruction

There is a long debate on the difference between CBNRM and co-management or, in this case, Participatory Fisheries Management (PFM). This paper does not intend to open up this debate here. The rest of this paper will refer to the community participation in fisheries management as PFM. It is now a known fact, as is the case of Lake Malombe, that fisheries management is more about people than it is about fish and that one cannot have management strategies that focus on the fish resources more than on the people who exploit the fishery (Donda 2000). Co-management requires the establishment of user groups and recognize those that already exist so that they can participate in the co-management with the management authority. In the case of both Lake Malombe and the South East Arm of Lake Malawi, such local-level user representative organizations have been established and most are functional.

The on-going PFM programs have already created among the village committees and the rest of the communities awareness of the change in the management systems, declining fish catches, and aquatic habitat destruction. In addition to this, the PFM program has established BVCs at the grass roots level, Area Fisheries Management Units (AFMUs) at the intermediate level, and Lake-wide Fisheries Management Associations (such as Lake Malombe Fishermen Association) at the top. This local management structure has high potential of contributing to the success of the Chambo restoration program as long as they are taken on board.

The general assessment of the potential of PFM in the restoration of the Chambo in Malawi does indicate that there is potential for successful involvement of fishing communities in fisheries management in most water bodies in Malawi (Donda 2000). This assessment is based on the fact that the groundwork for the establishment of local resource user representative organizations has been completed with some considerable success, except for a few problems that are highlighted below for consideration.

Organizational capacity building

Most of the problems faced by both BVCs and the field-based DOF staff in the implementation of PFM were due to lack of capacity in various aspects of fisheries co-management. To improve the situation, therefore, there is a strong need for the DOF to develop a mechanism for building such needed capacity within and among the people that are directly involved in planning and implementing co-management activities.

Power conflicts

A potential problem exists that may affect the sustainability of BVCs. Evidence indicates that these BVCs have come in as parallel organizations in some village communities where organizations with similar functions already existed, especially in Lake Malombe and the SEA of Lake Malawi. The old organizations may be called "shadow organizations" of the current functional ones.

These shadow organizations are the ones that have managed the beaches and the fisher activities before the advent of co-management. In some villages, they were not organizations as such, but rather individuals vested with authority as beach chairmen. Research findings have also indicated that there is some dialogue between the two management systems (i.e., the shadow and current systems) and that memberships to these two systems are either the same, mixed or completely different (Donda 2000). The potential conflict exists where the two organizations (current versus the shadow) have different members and there is no dialogue between the two as the shadow organizations feel they are made redundant.

BVC embeddedness

In some communities, the BVCs as community organizations are not yet embedded within the village social and cultural systems. The importance of having the BVCs embedded within the village systems cannot be over-emphasized as this has an advantage of drawing in social capital from the communities towards the achievement of co-management goals.

Sustainability of the Chambo restoration program with the participation of communities

The sustainability of the Chambo restoration program with the participation of communities is hinged on four major factors, namely the DOF's understanding of the socio-economic and cultural factors of fishing communities, the institutionalization by the DOF of appropriate rights over the lake and fish resources, capacity building of the DOF and communities, and the definition of roles among different stakeholders.

The DOF's understanding of the socio-economic and cultural factors of fishing communities is important because it will make the DOF able to assess the potentials and constraints of fishing communities that will enable them actively participate in the restoration program. In addition, the knowledge of local institutions and how they affect the peoples' behavior will greatly help the DOF to plan effectively how to approach and involve the fishing communities in the program. Finally, it will enable the DOF to assess whether or not there is tendency within the communities towards collective action because collective action among the resource users is an important aspect that provides social capital in community development activities.

The institutionalization by the DOF of appropriate property rights over the lake and the fish resources will provide the rights of exclusion, which in the long run will help reduce fishing effort and will at the same time instill the sense of ownership over the resources.

Capacity building among the fishing communities is divided into three aspects, i.e. legal empowerment, financial empowerment and training of people to understand and have knowledge of the Chambo restoration strategy and concept. The addressing of these three will help build confidence and, to some extent, act as incentives for them to actively participate in the Chambo restoration program. On the DOF side, capacity building should be viewed in terms of training the staff involved in the restoration program and its concept, as well as the DOF's ability to change its attitude and adapt to the requirement of PFM.

Defined roles among the participating stakeholders in the Chambo restoration program will empower participating stakeholders as well as mandate them for what they need to do. It is envisaged that if this is not done, then it can end in total chaos as there will be a lot of grey areas regarding who is expected to do what and when. Eventually, the whole restoration program may not run as planned.

References

Bailey, C. and C. Zerner. 1992. Community-based fisheries management institutions in Indonesia. Paper presented at the 1992 meeting of the Society for Applied Anthropology, 25-29 March 1992, Memphis, Tennessee.

Bell, R.H.V. and S.J. Donda. 1993. Community fisheries management program: Lake Malombe and Upper Shire River, Volumes 1 and 2. Mangochi. Consultancy Report, Government of Malawi, Department of Fisheries and the Malawi – Germany Fisheries and Aquaculture Development Project (MAGFAD).

Berkes, F., P. George and R.J. Preston. 1991. Co-management: the evolution in theory and practice of the joint administration of living resources. Alternatives 18(2).

Bland, S.J.R. 1991. Managing artisanal fisheries and their development. Centre for the Economics and

Management of Aquatic Resources (CEMARE), University of Portsmouth, UK. M.Sc. Thesis.

Bonner, R. 1993. At the hand of man: peril and hope for Africa's wildlife. Simon and Schuster, London.

Charles, A.T. 1992. Fishery conflicts: a unified framework. Marine Policy 16(5):379-393.

Chirwa, W.C. 1996. Fishing rights, ecology and conservation along Southern Lake Malawi, 1920-1964. African Affairs 95:351–377.

Copes, P. 1979. Fish and the national interest. Discussion paper 79-12-3, Simon Fraser Universtity, Canada, 25 p.

Dissi, C.S. and F.J. Njaya. 1995. The development of a community-based fish stock management approach: a case study from Lake Chiuta, Malawi. A paper presented at the Regional Workshop on Fisheries Co-management, 20-22 November 1995, Kariba, Zimbabwe.

Donda, S.J. 2000. Theoretical advancement and institutional analysis of fisheries co-management in Malawi; Experiences from Lakes Malombe and Chiuta. Aalborg University and Institute for Fisheries Management and Coastal Community Development (IFM), Denmark. Ph.D. thesis (unpublished).

Feeny, D., F. Berkes, B.J. McCay and J.M. Acheson. 1990. The tragedy of the commons: twenty-two years later. Human Ecology 18(1):1-19.

Gordon, H.S. 1954. The economic theory of a common property resource: the fishery. The Journal of Political Economy 62:124-142.

Hanna, S. 1995. Efficiencies of user participation in natural resource management. *In* Property rights and the environment – social and ecological issues. Beijer International Institute of Ecological Economics and the World Bank. Washington D.C.

Hardin, G. 1968. The tragedy of the commons. Science 62: 1243-1248.

Hviding, E. and E. Jul-Larsen. 1995. Community-based resource management in tropical fisheries. University of Namibia, Windhoek.

International Institute for Economic Development. 1994. Whose Eden?: an overview of community approaches to wildlife management. A report to the Overseas Development Administration of the British Government. Russell Press, Nottingham, UK.

Jentoft, S. 1989. Fisheries co-management: delegating government responsibility to fishermen's organizations. Marine Policy 137-154.

Lawson, R. 1984. Economics of fisheries development. Frances Printer (Publishers) Limited. London.

Lim, C.P., Y. Matsuda and Y. Shigeni. 1995. Co-management in marine fisheries: the Japanese experience. Coastal Management 23:195-221.

Murphree, M.W. 1996. Possibilities for linking African environmental scholarship, policy and practice. Address delivered to the Pan African Symposium on the Sustainable Use of Natural Resources and Community Participation, 24-27 June 1996, Harare.

Passmore, J. 1974. Man's responsibility for nature. Scribner, New York Scribner.

Pinkerton, E. 1989. Introduction: Attaining better fisheries management through co-management – prospects, problems and propositions. *In* E. Pinkerton (ed.) Co-operative management of local fisheries – new directions for improved management and community development. University of British Columbia Press, Vancouver.

Pomeroy, R.S. and M.J. Williams. 1994. Fisheries co-management and small-scale fisheries: a policy brief. International Center for Living Aquatic Resources Management, Manila, 15 p.

Rettig, R.B., F. Berkes and E. Pinkerton. 1989. The future of fisheries co-management: a multi-disciplinary assessment. *In* E. Pinkerton (ed.) Co-operative management of local fisheries: new directions for improved management and community development. University of British Columbia Press, Vancouver.

Ruddle, K. 1995. A guide to the literature on traditional community-based fishery management in Fiji. SPC traditional marine resource management and knowledge information, Bulletin No. 5:2-6.

Scott, A.D. 1955. The fishery: the objectives of sole ownership. Journal of Political Economy 63:116-124.

Sen, S. and J.R. Nielsen. 1996. Fisheries co-management: a comparative analysis. Marine Policy 20(5):405-418.

Smith, M.E. 1995. Chaos, consensus and common sense. The Ecologist 25:80-85.

The Ecologist (eds.) 1995. Introduction – overfishing: its causes and consequences. The Ecologist 25(2/3):42-45.

Todd, B, J. Kaphuka, S. Kanyanda and R. Chinula. 2002. Malawi: an atlas of social statistics. National Statistical Office, Zomba and International Food Policy Research Institute, Washington D.C.

Socio-economic factors influencing the decline of the Chambo

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Abstract

Various biological studies and analyses have been conducted to develop management interventions for managing the Chambo fisheries. These studies have drawn attention on the broader biological factors that have contributed to the decline of the Chambo fishery. However, there have been very few socio-economic studies to generate the necessary information on the social, cultural, livelihoods and economic aspects of the fisheries. This paper addresses the socio-economic factors that have, directly or indirectly, influenced the decline of the Chambo fishery in Malawi. Nine broad socio-economic issues are reviewed: migration; cultural preference for and acceptance of the Chambo as a major food fish; demand and supply; unregulated effort; transfer of inappropriate technologies; limited alternative incomes; lack of proper plans in the development of lakeshore areas; lack of understanding of "fishery" as a system; and lack of political patronage for the asset and income base of lakeshore communities. To address these problems, there is a need to develop a compensation scheme and encourage alternative forms of income sources apart from fishing, mount public awareness campaigns to lobby the political will, and promote demand-driven research and appropriate transfer of technologies.

Introduction

The inland fisheries in Africa provide a major source of subsistence and income in many countries including Malawi. The fisheries sector in Malawi plays a significant role to Malawi's population currently estimated at 11 million people. Townsley (1998) reported that recent studies in rural areas located near the shores of Lake Malawi highlighted the fact that in these areas the fisheries sector plays an important role as one of the few economic activities that generate some surplus. Agriculture in many of these areas is extremely underdeveloped and is constrained by limited farming inputs.

In terms of economic importance, the Chambo (*Oreochromis* spp.) remains one of the most valuable fish species in Malawi. However, catch statistics indicate a serious decline of the species, especially in the South East Arm of Lake Malawi, Lake Malombe, and the Upper Shire River since late 1980s. Apart from the biological assessments conducted to understand the cause of this decline, little information is available about the socio-economic factors that might have contributed to this decline. However, an emerging interest in socio-economic studies, mainly from the last decade, provides an opportunity for a more understanding of the fishing communities in terms of their income and asset base, cultural aspects and livelihood strategies among other areas.

Historical background of fishing

Fishing gear appeared in very primitive times, with early people using lances, arrows, spears, stones, teeth of animals and hooks. In our time, the emergence of nets made of fibrous materials was an important development in the field of fishing. The concurrent development of fishing gear with seamanship and navigation revolutionized the whole fishing systems. In

Malawi, there are now a number of fishing gears such as gill nets, bag nets, lift nets, seine nets (*chilimira*, beach seines, and purse seine nets) and trawl nets.

The fisheries resources of Malawi had been exploited by traditional methods for a long time. Commercial fishing started around 1935 with the introduction of the purse seine net on Lake Malawi. Trawling was introduced in 1968. The local fishers have employed a variety of more efficient fishing gears in recent years to improve the efficiency of their fishing effort. Some of the fishing technologies in use now have evolved over the years through interactions between or among various fishing communities. In Malawi, the *chilimira* fishery is believed to have originated from the northern Lake Malawi, especially Nkhata Bay. The fishers modified the original *chilimira* net introduced by Arab traders in the 1870s (Jennings 1993). The Lower Shire fishers adapted certain fishing technologies from Mozambicans such as the use of the cast net (*chavi*).

In Malawi, fishing and fish trading (Kalk et al. 1979) have been increasing since the Second World War in response to the increase in population. The introduction of nylon thread in 1958 to make nets by machine in a Blantyre factory instead of fibres of local plants was the most dramatic innovation in the history of the fishing economy. In the making of fishing gear, it equalled the introduction of the iron axe and later, the steel adze, which permitted the felling of trees and their being shaped into dugout canoes.

Seymour (1988) attributed the peak in catches from Likoma and Chizumulu Island fisheries in the mid-1970s to the increased use of nylon for *chilimira* nets, replacing the heavy yarns made by twisting fibres of the shrub *chopwa* (*Pouzolzia hypoleuca*). The manufacture and repair of the old heavy nets did not cost money but required enormous amounts of labor. The fisheries of the islands changed over to nylon during 1970-75. The advent of nylon nets changed the fisheries in two ways. Firstly, since the nets were much lighter, they could be used to fish more times per day and more days in a week, and could be carried offshore to fishing grounds previously out of reach. The fishing capacity of the *chilimira* fleet, therefore, increased dramatically. Secondly, the change to nylon brought the fishery into the cash economy although there were and still are limitations due to a number of factors including natural causes such as lake level changes, biophysical aspects, i.e., rocky pinnacles found around the islands as *chilimira* fishery mostly targets utaka, (*Capidochromis* spp.) and economic causes (pricing levels).

Socio-economic characteristics of the fishing communities

Household income

Fishing and fish trading play a major important role to rural households. Data were compiled for the mean annual household and per capita income by socio-economic groups at three major fishing villages on Lake Malawi, namely at Msaka, Lifuwu and Tukombo (Table 1). Among four groups, comprising resident farmer-fishers, migrant boat owners, resident fishing labor providers and resident farmers, the migrant boat owner group realized the highest mean annual household income while for the lowest category it was either the resident fishing labor provider group or the resident farmers (Mvula 2002). In a survey conducted by Ganter et al. (2001) it was noted that at Msaka, gear owners experienced wide income variations from MK 60 000 to MK 500 000 per year. Crew-members earned from MK 35 to MK 200 daily, lower than the previous

Table 1. Mean annual household and per capita income by socio-economic groups at Msaka, Lifuwu and Tukombo, Lake Malawi (Allison et al. 2002).

Main occupation of HH head	Resident farmer-fisher	Migrant boat owner	Resident fishing labor provider	Resident farmer
HH Mean income (MK)				
Msaka	50 389	78 868	9 679	12 341
Lifuwu	72 667	172 130	5 231	11 817
Tukombo	19 116	52 489	11 098	14 865
Mean per capita income (MK)				
Msaka	7 845	24 977	4 605	3 304
Lifuwu	11 125	39 691	1 212	3 190
Tukombo	3 196	6 404	3 100	3 391

years. Agricultural laborers earned MK 100-150 per day or did piece work for MK 80 per day. This supports an observation that fishers who own assets such as fishing nets earn more than laborers involved in farming activities. Ganter et al. (2001) noted that women were strongly involved in fish drying and trading.

In terms of economic profiles, trading in Chambo fish earns more than other fish species owing to its high prices and preference (Horn 1987; Dorsey and Mukumbwa 1996).

Ethnic group composition

FAO (1993) reported that the ethnic composition of Lakes Malombe and the SEA of Lake Malawi is dominated by the people of Yao origin, who form the majority of fishers-entrepreneurs (79%). Tonga and Tumbuka settlements are also found, especially north of Monkey Bay. A few Chewa, Lomwe and Nyanja fishers spread throughout the area. Ganter et al. (2000), citing Friis (2000), presented the following ethnic composition (Table 2) based on the nature of fishing related activities at Chembe.

Table 2. The ethnic group composition (%) of different categories of people involved in fishing (FAO 1993).

Ethnic group	Crew members	Fish Dryers	Fish Traders	Capital Owners
Chewa	73%	30%	11%	80%
Lomwe	-	13%	61%	-
Ngoni	-	17%	11%	-
Nsena	-	-	4%	-
Nyanja	20%	37%	-	20%
Tonga	3%	-	-	-
Wemba	-	3%	-	-
Yao	3%	-	14%	-

Migration

Migration is a common feature among fishers along Lake Malawi beaches. They migrate to areas where the catch is good, especially of fish species such as *usipa* (*Engraulicypris sardella*), *utaka* (*Capidochromis* spp.) and *ncheni* (*Ramphchromis* spp.). In a survey conducted at Msaka, Ganter et al. (2001) noted that some of the settlers had initially come to Msaka for a short period because they heard from fellow fishers about good catches in the area and then decided to make Msaka their permanent base. All settlers reported that the amount of catch around Msaka had compared favorably to that of their home beaches until recently. During the times of good fishing there were also about 10-15 migrant fishers (all of them Chewa) who came from other places and used Msaka as a base camp. However, as fish stocks decreased, outsiders ceased to come.

Allison and Mvula (2002) indicated four striking features of lakeshore livelihoods in Malawi. These were the degree of monetization in the fisheries sector, the relative wealth of those with access to fishing-related assets and the resources themselves, the importance of mobility in specialist fishers, and the degree to which fishing is an integral part of the livelihoods of settled farmer-fishers.

In the case of settled farmer-fishers, decreasing availability of land and the marked decline of livestock in Malawi (due to theft and lack of veterinary support services) is reducing the diversity of the economic base for lakeshore dwellers. This may push more of this category of people into full-time fishing, thereby increasing the number of migrant fishers with a high level of dependence on fishing. Increased dependency on fishing is not desirable in the long run even if it may be profitable in the short run. Restoration of the "tri-economy" based on cropping, pastoralism and fishing is perhaps the overall most important means of sustaining both fishing-based livelihoods and fish resources.

Ganter et al. (2001) reported that the migrants play an important role in the villages where they live as consumers of agricultural produce, patrons of various service industries (bars, restaurants, shops, etc.), and employers of crew-members from the resident farming households. They attract fish traders into the villages, which further stimulates economic activities. Policies to exclude migrants on the grounds of ethnic differences or a strict interpretation of community-based management risk undermining these productive rural linkages (Ganter et al. 2001).

Asset possession by fishers

Assets are a major determinant of the livelihoods of both individuals and households. This section looks at the household assets of fishers at Lake Malawi. Mvula (2002) indicated that fishers make considerable investments in fishing assets. Since these assets can only be used for fishing, it would be very difficult for fishers to move away from the fishing endeavors. Hence, in formulating management options, recognition should be made of the fact that it may not be easy for these people to change their occupations because of the investment they have made.

Major socio-economic issues

Migration

This is a serious problem when fishers migrate to some areas that do not allow use of certain gear types such as *nkacha* on Lake Chiuta. Most of the reported cases of conflicts are due to migratory fishers who move from one fishing area to another. While Allison and Mvula (2002) support formulation of policies to consider the need for migration, it may not be a suitable arrangement in situations where limited entry is advocated. Therefore, it is important to examine these issues before drawing up recommendations.

Cultural preference and acceptance

Horn (1987) documented that Malawian people find the taste and texture of Chambo fish appealing. Njaya (2001) noted that the costs of fish (apart from the Chambo) that were relatively lower than other animal protein sources, makes it the best choice for low-income urban and rural populations. In terms of preference, the Chambo is the widely acceptable fish, especially in the southern and central regions.

Demand and supply

It is widely known that there is high demand for fish in the country and that crude projections indicate that by 2010 the demand of fish would need an annual production of over 70 000 t (Njaya 2001; Weyl 2003). The dwindling volumes of exports indicate that the local demand is not being met. However, for more informed planning of the fisheries sector, formal demand and supply studies are required.

Unregulated effort

Fisheries resources in the country have been mostly characterized by its common property and open access nature. FAO (1993) reported that the artisanal fishery in Malawi is of an open-access character. Although a licensing system exists which permits an individual to fish, licenses are issued without any access restrictions. If the sector remains unregulated, profitable fishing operations will attract further investment that would result in dissipating resource rents due to expansion in the fishing effort. Campbell and Townsley (1994) noted that the resulting competition for available resources increases the need for existing operators to mechanize fishing units beyond what is required for efficient harvesting. This has led to entrepreneurs over-capitalizing within the sector with a consequent misallocation of scarce capital and skilled labor resources, resulting in increased operating costs as more and more effort is required to obtain the same level of catch. Moves towards greater motorization in order to access more distant resources have increased dependence on imported engines, spares and fuel. Fuel supply shortages and increased prices in many countries have had a major impact on the mechanized fleet in terms of decreased fishing time and increased operating costs.

There seems to be little in the way of currently recognized tenure systems in relation to the resource although more interest is being shown in this as resources become stressed. Some temporary tenure seems to be established where fishers clear an area of beach for seining and visiting fishers may be requested to pay for use of the beach by giving some of the catch to the village headman (Campbell and Townsley 1994). In Malawi, however, the cases of Lakes Chiuta and Malombe have shown potential in community participation. These communities have tried to limit entry into the fisheries by formulation of regulations that exclude use of some fishing gears. For example, in Lake Chiuta the open water seine net (*nkacha*) is not allowed. This shows that, with proper arrangements on devolution and decentralization processes, definition of property rights and boundaries, the community can impose control over access to, and exploitation of the resource.

Transfer of inappropriate technology

Campbell et al. (1993) indicated that the introduction of new technology should take into consideration the financial viability and suitability of the technology. The technology should be at a level that conforms to the capacities of the recipients to use, adapt and sustain it without unnecessary alienation of the recipients from the tools of their trade. When introducing new technology, the increased direct and indirect dependence of foreign exchange generation to support such introductions such as boats and engines should be borne in mind.

It was further recommended that projects should be aware of the possibilities that technology provided can selectively disadvantage certain groups on ethnic, national, social or gender grounds and this should be avoided where possible. A new technology introduced should be compatible with supplies in the country in terms of spare parts, and repair services should not aim to compete with the private sector. Where possible, attempts should be made to promote local production of technology or promote existing private sector suppliers.

Limited alternative income sources

Dependence on fishing as a means of economic activity for the lakeshore population in Mangochi has resulted in increased fishing pressure. This has contributed to dwindling catches in Lake Malombe, Upper Shire and South East Arm of Lake Malawi. It is, therefore, important that some alternative sources of income, such as those identified by Dorsey and Mukumbwa (1996), be implemented. Yet, some policies should be put in place such as encouraging loan schemes with lower interest rates for start-up capital of the prospective entrepreneurs.

Lack of appropriate plans in the development of lakeshore areas

The problems with inter-sectoral linkages are likely to worsen and may result in decreased opportunities for the whole sector. Understanding how the problems and development possibilities of the coastal, river and lakeshore zones fit together as an integrated approach is not just a fisheries problem, it encompasses all sectors. In most cases, however, the artisanal fisheries sector is the one that suffers most from poor inter-sectoral co-ordination and, therefore, the one which is forced to act first.

Projects can assist in taking a more integrated approach to the planning and management of Lake Malawi's coastal areas and help the Department of Fisheries to conduct resource use assessments and impact studies, develop resource use policies and plans, provide institutional support to create management frameworks and to co-ordinate government and donor inputs, as well as encourage greater education and training in integrated zonal approaches to aquatic resource management. It is expected that in certain areas a development-coordinated framework should be put together encompassing fisheries, agriculture, wildlife, tourism, water, rural development and other relevant sectors.

Lack of understanding of "fisheries" as a system

Townsley (1998) compared fisheries systems in early planning approaches. The initial approaches tended to look at fisheries as a combination of resources, the technology required to exploit them and the economic forces driving demand for fisheries products. However, it has become increasingly clear that a far wider range of factors combine to make up a fisheries system and that they all need to be considered in order to formulate interventions that are appropriate and do not irremediably damage the system. Besides the resources and technologies that are directly utilized by the sector, interactions with other sectors are clearly significant – lakeshore based industries can affect water that can affect biodiversity; forest management in the hills affects water quality in rivers that also affects fish, both in rivers themselves and in the sea into which those rivers flow. Understanding of the economic context of fisheries has also been broadened and deepened to take into account the environmental and economic connections that can link even the smallest scale artisanal fisher to global markets for both fisheries and other products.

The complexity of the system surrounding the use of fisheries is practically open-ended, with many elements constituting sub-systems in their own right, which may require detailed analysis. The social and cultural factors that affect the people participating in the fisheries sector are particularly complex as they connect the system focused around the use of fisheries resources to a far broader system that determines the ways in which people interact with one another. Many past failures in fisheries development and management have been attributed to the failure of those responsible to understand the wide range of social and cultural factors in the lives of people involved in the sector and their effects on fisheries interventions. The social structure of the fishing communities, the type of institutions governing the resource base, the patterns of decision making among resource users and the historical and cultural background of the fishing communities can all have a profound influence on the way innovations in fisheries are perceived or how management initiatives are accepted, regardless of how appropriate those innovations or initiatives might seem to analysts and decision makers themselves (Townsley 1998).

Lack of political patronage

Despite the importance of fisheries through its contribution to food security in Sub-Saharan Africa, the sector is often accorded a low priority because of the marginal socio-political role of coastal communities and the relatively small contribution of fisheries to the GDP and rural employment, when compared to other rural sectors such as agriculture. As a result, sectoral budgets are low, leading to poor policy formulation, planning, resource management and extension services; the provision of appropriate infrastructure is inadequate; inter-sectoral linkages are poor; and ancillary industries necessary for sectoral growth are poorly supported. The low political priority of the sector may limit the effectiveness of fisheries departments in co-operating in regional management programs for shared stocks (Campbell et al. 1993).

Asset and income base

It is argued that assets are a major determinant of the livelihoods of both individuals and households. The implication is that it would be very difficult for fishers to move away from the fishing endeavors. It is, therefore, recommended that, in formulating management options, recognition should be made of the fact that the investment these fishers have made may not make it easy for them to change occupations.

Impact of new governance structures on the proposed interventions

The promotion of co-management arrangements in Malawi has been most actively targeted at Lake Malombe, Chilwa and Chiuta. The main partners are local level institutions called Beach Village Committees (BVCs) and the Department of Fisheries (DOF). The experiences with these arrangements in changing fisheries governance on livelihoods have been mixed and require further detailed analysis as reported by Hara et al. (2002).

In relation to the above proposed interventions, many people will be driven out of fishing activities, resulting in socio-economic implications. It is, therefore, recommended that a compensation strategy and loan schemes for various alternative income sources should be focused on. The DOF and other NGOs should also look at the capacity of the newly formed BVCs, Area Fisheries Committees (AFCs) and Management Units (MUs) on Lake Malombe in terms of their service delivery. The roles of the DOF and communities need to be clearly spelt out for an effective co-management arrangement.

Proposed interventions

The results of the livelihoods research in Malawi are in accord with findings in other developing countries, where several studies have suggested that fishers cope with fluctuations of fishery collapse through geographical and occupational mobility (Bailey 1982; Haakonsen 1992; Geheb and Binns 1997; Sarch and Allison 2000; Béné et al. 2000). Fisheries management strategies focusing on optimal catch rates ignore both the role that inland fisheries play in the livelihoods of many Africans and the inherent stock fluctuations that have shaped such livelihood strategies.

Proposals to manage fluctuating fisheries need to be based on a better understanding of fishers' livelihood strategies. It is relatively straightforward to outline what management approaches should not be taken, less easy to identify appropriate management support for sustainable livelihoods from fluctuating or collapsing fisheries. While removing unnecessary impediments to sustainable opportunistic exploitation strategies is one important step, it may not be enough, given the increasing pressures on resources and livelihoods in Africa. Common property institutions that have evolved mechanisms, such as reciprocal access agreements among migrants, should be considered as more appropriate than territory-based approaches as a way of implementing any effort-limitations deemed necessary. Even when embryonic and of limited functionality for resource conservation, such institutions can be built upon, rather than replaced by externally conceived "perfect" ones.

Formal recognition, in both national policy and legislation, of the legitimacy of opportunistic livelihood strategies, coupled with active removal of barriers to mobility and livelihood diversification would seem to be appropriate policy responses at national or district level in Malawi. Active support for livelihood diversification (not the same as providing incentives for people to diversify and stop fishing altogether) is another management option.

"Modern" fisheries management has often consisted of setting stock conservation objectives, and then finding means of modifying fishers' behavior or investment to fit these objectives (Mahon 1997). This has usually meant imposing closed seasons, closed areas, size limits, gear restrictions, and access or "fishing effort" restrictions. While there has been concern for the effects of different regulatory options on fishing communities, there has usually been little systematic research on their effects on fishers' livelihoods. Fisheries management is becoming more consultative, and fishing communities now have greater participation in management, sometimes through co-management arrangements (Pomeroy and Berkes 1997). There is still little systematic discussion on the effects of different management options on livelihoods. There is a requirement for both participatory research to help to identify acceptable management solutions to fishery problems and further studies of livelihoods to understand how fishers cope with and react to both inherent collapse and changing externalities.

An important intervention would be to offer training for the fishery sector. Allison and Mvula (2002) contend that fishers and fish traders are an important group of rural entrepreneurs in Malawi. It is suggested that training be re-oriented towards learning about traditional conservation-sensitive fishing techniques, running a small business and integrating fishing with other activities. Such training could include an aspect sensitization about the dangers of overfishing.

Allison and Mvula also suggest the involvement of NGOs in the fisheries sector. This is because mechanisms for delivery of support and services to the fisheries sector are currently weak and ineffective. The Fisheries Department has a difficult dual task of delivering both services and enforcing compliance with regulations. It currently finds itself devolving both functions to under-trained community groups under co-management initiatives. There is also a service vacuum at the local level as the private sector has yet to step in where the government has withdrawn. The NGOs and some social institutions, including religious ones, are highly rated as providers of social and advisory services. This may be the time to bring them on board to save the Chambo.

There is a need to revisit and enforce the banning of trawling, open water seining (*nkacha*) and beach seining in the SEA of Lake Malawi, and limiting the size of *chirimila* nets. To mitigate any socio-economic ramifications, the government should develop a compensation scheme and encourage alternative forms of income sources apart from fishing. It is also important to mount public awareness campaigns to lobby the political will. In particular, there should be a deliberate policy on the "save the Chambo campaign" at the Ministry level. There should be a Presidential decree for an effective campaign.

The Fisheries Research Unit should monitor the recovery of the Chambo and make recommendations on the exploitation of the resource through demand-driven research and appropriate transfer of technologies. Socio-economic studies should be conducted to monitor impacts of the proposed measures on the communities and resource. A strong enforcement unit should be instituted within a co-management set up. The DOF should continue to be responsible for carrying out enforcement tasks.

The DOF should consider zoning the target area (the SEA of Lake Malawi) for licensing as a way of controlling access. This arrangement should be made in consultation with the communities for legitimacy of the process. In the same way, there is a need to develop management plans for recovery and, where possible, increase catches of various valuable fish species such as *mpasa* (*Opsaridium microlepis*) and *ntchila* (*Labeo mesops*). These species can be good alternatives of the Chambo as commercial species. Finally, the fishery should be viewed as a system by focusing on fisheries as a combination of resources, technology and economic forces. There is also a need to look at interactions with other sectors that affect catchments and lakeshore development.

References

Allison, E. and P. Mvula. 2002. Fishing livelihoods and fisheries management in Malawi. Ladder Working Paper No 22.

Allison, E.H., P.M. Mvula and F. Ellis. 2002. Competing agenda in the development and management of fisheries in Lake Malawi, p. 49-88. *In* K. Geheb and M-T. Sarch (eds.) Africa's inland fisheries: the management challenge. Fountain Books, Kampala, Uganda.

Bailey, C. 1982. Small-scale fisheries of San Miguel Bay, Philippines: occupational and geographical mobility. ICLARM Technical Reports 10, 57 p.

Bene, C., K. Midjimba, E. Belal and T. Jolly. 2000. Evaluating livelihood strategies and the role of inland fisheries in rural development and poverty alleviation: the case of the Yaere floodplain in North Cameroon. Proceedings of the 10th International Conference of the Institute of Fisheries Economics and Trade, 9-14 July 2000, Corvallis, Oregon.

Campbell, R.J., S. Sen and B. Uyttendaele. 1993. Evaluation study on private initiative in artisanal fisheries projects in Africa south of the Sahara. Commission of the European Directorate General for Development. Series No. 4. Brussels.

Campbell, J. and P. Townsley. 1994. Participatory and integrated policy: A framework for small-scale fisheries in sub-Saharan Africa, 3 p.

Dorsey, J. and E. Mukumbwa. 1996. Income generating activities. Document prepared for the GoM/FAO/UNDP Capture Fisheries Project, Rome.

FAO. 1993. Fisheries management in south east Lake Malawi, upper Shire and Lake Malombe. CIFA Technical Report 21, FAO, Rome, 113 p.

Friis, C. 2000. Rapid appraisal of the profitability structure of catch, processing and distribution of the small-scale fishing sector in Chembe village. NARMAP Survey Report No. 3.

Ganter, E., J. Chisambo, K. Mawakiyongo, M.J. Ngochera, W. Namoto, M.M. Manase, O.C. Mponda and G.Z. Kkanyerere. 2001. Msaka Village – Summary of preliminary results. NARMAP Socio-Economic Survey Report No. 1.

Geheb, K. and T. Binns. 1997. Fishing farmers or "farming fishermen"? The quest for household income and nutritional security on the Kenyan shores of Lake Victoria. African Affairs 96:73-93.

Haakonsen, J.M. 1992. A regional policy on fishermen migration in West Africa. Seminar on artisanal fishermen migrations, Cotonou, Benin, 3-5 December 1991. Marine Policy 16(3):237-238.

Hara, M.M., S.J. Donda and F.J. Njaya. 2002. Lessons from Malawi's experience with fisheries co-management initiatives, p. 31-48. *In* K. Geheb and M-T. Sarch (eds.) Africa's inland fisheries: the management challenge. Fountain Books, Kampala.

Horn, H.J. 1987. Fisheries development strategy study. Horn-Consultants, Federal Republic of Germany.

Jennings, R. 1993. Likoma Chizumula Artisanal Fisheries Development Project final report (unpublished).

Kalk, M., A.J. McLachlan and C. Howard-Williams. 1979. Lake Chilwa: studies of change in a tropical ecosystem. Monographiae Biologicae 35, Junk, The Hague.

Mahon, R. 1997. Does fisheries science serve the needs of managers of small stocks in developing countries? Canadian Journal of Fisheries and Aquatic Sciences 54(9):2207-2213.

Mvula, P.M. 2002. Fluctuating fisheries and rural livelihoods at Lake Malawi. University of East Anglia, Norwich, UK. Ph.D. Thesis.

Njaya, F.J. 2001. Fish marketing study report. Final report submitted to FAO (unpublished).

Pomeroy, R.S. and F. Berkes. 1997. Two to tango: the role of government in fisheries co-management. Marine Policy 21:65-480.

Sarch, M-T. and E.H. Allison. 2000. Fluctuating fisheries in Africa's inland waters: well-adapted livelihoods, maladapted management. Proceedings of the 10th International Conference of the Institute of Fisheries Economics and Trade, 9-14 July 2000, Corvallis, Oregon.

Seymour, A.G. 1988. Likoma and Chizumulu Islands: production, processing and trading in the chilimira fishery. Fisheries Department/GTZ Rural Growth Centres Project.

Townsley, P. 1998. Social issues in fisheries. FAO Fisheries Technical Paper 375. Rome.

Weyl, O. 2003. Position of aquaculture in fish supply-demands. Paper presented at the GoM/JICA Master plan Consultative Workshop, 16-17 April 2003, Lilongwe.

A review of fisheries research and extension in Malawi

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Abstract

Research and extension are the major hubs for sustainable fisheries management. Research provides information input into extension programs that in turn enhance informed fisheries resources management and utilization. Effective linkages between research and extension are crucial for implementing fisheries management.

In this paper, critical analysis of fisheries research and extension show that fisheries research and extension in Malawi have never been effective and, consequently, fisheries science has never been translated into practical fisheries extension messages for use by the fishers. The paper proposes the development of an effective interface between research and extension, development of appropriate dissemination strategies and the implementation of an extensive capacity gap analysis within the fisheries research and extension sectors.

Fisheries research

Fisheries research studies in Malawi started in the 1960s. Most were taxonomic in nature although some fish biology studies were undertaken. However, fisheries research started more than 50 years ago when Bertram, Borley and Trewavas (1942) conducted the first fishery surveys on Lake Malawi in 1939. This was followed in 1945-47 by some biological research work on the Chambo, *Oreochromis* spp. of the Southeast Arm of Lake Malawi (Lowe 1952). The Chambo studies started after the operations of purse seining that was introduced into Lake Malawi in 1943 solely for the exploitation of the Chambo.

A major breakthrough in fisheries research and development came in the mid-1950s with the formation of the Joint Fisheries Research Organization (JFRO) in 1954. This was a research body that was shared by Malawi (then Nyasaland) and Zambia (then Northern Rhodesia). In Malawi, it had the mandate to carry out research work on Lake Malawi. This research was based at Nkhata Bay, where most studies covered fish taxonomy, biology and limnology.

Because of the need for fisheries research to address national food supply issues and fisheries development, the research was shifted in 1962 to Monkey Bay in the south of Lake Malawi where new laboratories had been constructed. At first, the new station continued some of the work initiated in Nkhata Bay. This included physical limnology, fish taxonomy and biology, gradually focusing more on the biology of *Labeo mesops* (*nchila*) and *Bagrus meridionalis* (*kampango*) and gillnetting trials (Tweddle 1991).

Various projects were undertaken to strengthen the research programs on Lake Malawi fisheries. Experimental trawling was introduced in the South East Arm (SEA) of Lake Malawi in 1965 and this led to the development of commercial trawling in 1968. This trawling was observed to target virgin stocks of cichlid species unknown to science before. Detailed stock assessment work began in 1969 and was aimed at monitoring the effort being applied on the fish stocks and explored the potential for trawl fisheries in other parts of the lake. However, the first regular trawl surveys were undertaken by the Food and Agriculture Organization (FAO) Project on Integrated Fishery Development (FAO 1976). The main aim was to undertake studies on stock assessment to determine the optimum sustainable yield of the newly introduced mechanized trawl fishery in the southern part of Lake Malawi. It operated on the premise that the stocks being exploited by the trawl fisheries were limited, hence effort had to be monitored and management measures put in place to ensure the sustainability of the fishery. In addition to studies on the trawl fisheries, the FAO project analyzed the artisanal fisheries of the SEA and South West Arm (SWA) of Lake Malawi. Management recommendations included restriction of the number of licenses to be issued in each demarcated area of the southern part of Lake Malawi and the setting of a 38 mm minimum mesh size restriction for the trawl cod-end. A recording system for the traditional fisheries in the country, the Catch Assessment Surveys (CAS), was put in place, and is still being used except in the Mangochi fisheries district area in the southern part of Lake Malawi. When the regular surveys were discontinued, changes in exploited stocks were monitored through catch and effort data from the trawl fisheries. The results of the analysis of the data showed that the numerous demersal haplochromine species being exploited were sensitive to commercial fishing operations and the average size of fish caught was decreasing. Also observed were an increase in the use of illegal mesh sizes, and fishing in prohibited inshore areas.

In line with the fisheries development agenda of the 1970s that focused on maximizing fish production from Lake Malawi and other water bodies in the country, a series of research projects funded by donors were implemented. These included the United Nations Development Programme (UNDP)/FAO Fishery Expansion Project (FAO 1982) that explored opportunities for fisheries development in the central and northern parts of Lake Malawi. Recognizing that inshore stocks were overfished, the project concentrated on the biology of the deep-water fish, such as *Engraulicypris sardella* (*usipa*), *Copadichromis* spp. (*utaka*), *Ramphochromis* spp. (*ncheni*), *Diplotaxodon* spp. (*ndunduma*) and *Opsaridium* spp. (*sanjika*), phytoplankton dynamics and characterization of the physical environment. Results showed that the *E. sardella* was characterized by extreme differences in the abundance of year-classes and this posed a problem for commercial exploitation. Acoustic surveys reflected that fish densities were lower in the northern and central parts of the lake than in the south. Subsequent trawling indicated a low potential catch rate and limited trawl able bottom in the north. It was summarily concluded that pelagic fish resources were not sufficient to support a mechanized commercial fishery. As a result, the recommendation was that long-term studies on all aspects of the pelagic zone limnology and ecology be undertaken. This recommendation led to the conception of the United Kingdom/ Southern Africa Development Community (UK/ SADC) Project, which conducted comprehensive studies to assess the fishery potential of the pelagic zone (Menz 1995).

The UK/SADC Lake Malawi pelagic fisheries assessment project of 1991-94, a regional project between Malawi, Mozambique and Tanzania, studied Lake Malawi as one ecosystem. The aim was to assess the fishery potential of the pelagic zone through various studies that included fisheries biology, stock assessment, trophic dynamics, and quantification and determination of economically sustainable yields from new fisheries targeted at pelagic fish species. An assessment of the standing biomass for the pelagic zone was made as well as its fishery potential. The lake was shown to be a major component of the main energy pathways. Description of the physical and chemical characteristics of the lake provided baseline data for subsequent studies including monitoring of the lake environment.

This project was followed by the Global Environmental Facility (GEF)/SADC Lake Malawi/ Nyasa Biodiversity Conservation Project. The goal was to create a scientific, educational and policy basis for conserving the biological diversity of the lake and to enable the riparian states to establish higher levels of sustainable production from the Lake's resources consistent with preserving its biodiversity and unique ecosystem. The outputs from the project included taxonomic reviews of certain taxa, documentation of benthic macro-invertebrates in the rocky near-shore zone of Lake Malawi/Nyasa, ecological and biological studies on selected species (Duponchelle 2000), description of physical characteristics of the lake and the development and execution of a Lake Malawi biodiversity awareness program. It was then recommended to continue monitoring the parameters that had been studied and use the subsequent results to develop an early warning system for the changes taking place in the aquatic environment.

In support of the objective of effective management of the lake system while maximizing production, a FAO/Technical Cooperation

Project (TCP) on data recording systems was commissioned under the FAO Chambo Fisheries Project. This led to the development of the Malawi Traditional Fisheries (MTF) and Catch Assessment Survey (CAS), a boat- and gear-based computerized data collection system for the SEA, the Upper Shire River and Lake Malombe (Alimos et al. 1990). The system is a cost-effective way of monitoring changes in effort and catch per unit of effort (CPUE). An evaluation of both the MTF and CAS led to the recommendation that the MTF be adopted throughout the country. However, the MTF has not been extended to other parts of Lake Malawi due to logistical constraints on the part of the Department of Fisheries. However, Coulter (1993), referring to the need to review data collection systems, noted that statistical data are very important for monitoring purposes and recommended the adoption of a robust recording system.

Several socio-economic studies have been conducted, especially since the 1990s. Notable studies include the following:

- Socio-economic studies of the fishing communities around Lake Malombe that led to awards of a M.Sc. and two Ph.D.s (1996-2002) with support from ODA, IFM and Danida.
- Evaluation studies on the Lake Malombe Participatory Fisheries Management Program with support from the WorldFish Center and IFM (1996-2003) and the National Aquatic Resources Management Program (NARMAP) (1996-2002).
- Study on the regenerative capacity of small-scale fisheries through the Management-No management and Co-management Research Project (1999).
- Livelihoods studies on Lakes Malawi and Chilwa by Mvula (2002).
- State of the Environment study on Lake Chilwa by Danida (EAD and Danida 2000).
- Co-management evaluation studies on Lakes Chiuta (1995-2003) with support from IFM, WorldFish Center (ICLARM) and IUCN.

Extension services

Past extension activities

Extension provides a communication medium between the regulators of the fisheries resources and the users. The overriding objective of extension is to maximize the sustainable benefits accrued from fisheries resources for economic growth and poverty alleviation. Knowledge arising from improved resource exploitation, processing and marketing, coupled with the efforts achieved from research and training as well as issues arising from various programs of fish farming all provide valuable inputs to the development of extension programs. Many of the past extensions activities relied on the use of traditional extension methods as opposed to currently advocated participatory approaches. Fisheries development activities in Malawi did not achieve their goals and impacts because they lacked the application of participatory approaches and research, extension and training linkages. Training, extension and research should be linked cohesively to provide the basis for fisheries technology development and transfer and to identify fisher-generated technologies and practices that could have impacts on the fisheries and the implementation of government management recommendations. The future role of fisheries research and extension in Malawi, therefore, ought to be that of identifying existing problems, generating information to provide solutions to identified problems and translating this information into messages and technologies that can be easily understood and adopted by the user communities.

Extension messages and dissemination strategies

Fisheries extension services in Malawi became prominent in the late 1960s, specifically from 1965 to 1971 (Meleke 1982) when the objective of fisheries management was to maximize fisheries production and to develop new processing and preservation technologies. The major technological messages that were extended to fishers during this period were:

- Use of actellic to control blowflies during the rainy season;
- Use of smoking kilns to improve the quality of fish processing; and
- Use of fish drying technology using drying racks.

These technologies were disseminated mainly through demonstrations that were undertaken by a mobile extension unit in strategic areas. This approach, though less diversified, assisted the extension services to disseminate technological initiatives. In the early 1980s, the need for extension messages to emphasize fisheries management and conservation became evident as the resource started to show signs of over-exploitation. Then the emphasis included prohibition of night fishing in Lake Malombe, banning of the use of small-size meshed nets, observance of closed seasons and prohibition of catching immature Chambo (*kasawala*).

After the advent of the Malawi German Fisheries and Aquaculture Development (MAGFAD) project in 1985, radio programs were initiated as a means of disseminating fisheries exploitation and conservation messages to fishers and the general population. Despite these extension activities, the Chambo fisheries in Lake Malombe declined and finally collapsed. Critical assessment shows that both the regulators, the Department of Fisheries (DOF), the users, communities and fishers, all contributed in one way or another to the collapse of the Chambo fisheries in Lake Malombe. Firstly, despite the socio-economic significance of the Lake Malombe fisheries to the country, the DOF conducted very little stock monitoring work. Most of the monitoring was concentrated on Lake Malawi, thereby allowing an unmonitored increase of fishing effort. Secondly, due to weak linkages between research and extension, the information that was being generated by research could not effectively be disseminated to the target groups. Thirdly, initiatives to translate the research findings into easily usable forms by the community were lacking and this situation exists up to the present. Effective information dissemination strategies such as the use of fact sheets on fish reproductive biology and ecology, threats of habitat degradation to fisheries sustainability, demonstration of the dangers of using small-size meshed nets are all non-existent. The lack of effective information dissemination strategies has, therefore, contributed to the lack of impact of research and extension on fisheries management in Malawi.

Progress, shortfalls and way forward

Realizing that the existing research and extension approaches were not having positive impacts on fisheries management, the DOF instituted changes that included participatory fisheries management. Only limited progress on fisheries management, research and extension has been achieved, and some shortfalls in research and extension still exist (Table 1).

Towards an effective fisheries management system

The recovery of the Chambo as well as sustainable management of fisheries resources will require a holistic management approach, the development of effective linkages between research and extension, the implementation of an extensive capacity gap analysis within the research and extension sectors and a holistic approach to environmental management and protection. The sustainable management of fisheries resources is threatened by a number of environmental factors, such as habitat destruction, increasing soil erosion and siltation and shoreline conversion, most of which originate outside the sector. Currently, the collaborative linkages among sectors whose activities impinge on the fisheries sector are weak. Intensification and effective monitoring of the use of appropriate fishing gears, stocks fluctuations and effort levels are required.

The approaches to extension need to be reviewed to respond to the current challenges. Appropriate research and extension methods that put the

Table 1. Summary of progress and shortfalls in fisheries research and extension in Malawi.

	Progress	Shortfalls
Research	• Vast research work has been carried out on stock assessment, exploratory surveys, limnological and ecological studies. • The section has been boosted through the upgrading of posts, availability of office space and equipment. • Efforts are underway to delocalise research work from Monkey Bay to satellite stations. • The sectoral policy and strategic plan is in place.	• Research work mainly donor-dependent • Insufficient funding • No research staff at satellite stations • Research work not user/ community driven • Weak extension – research linkage
Extension	• There has been a review of the extension policy to emphasize participatory management. • Fisheries extension handbook published. • Functional monitoring system in place. • Locally community based institutions in place. • Restructured extension services headed by the National Extension Coordinator.	• Inadequate skills in planning and monitoring • Insufficient staff motivation • Lack of capacity to carry out needs assessment • No effective message dissemination strategies in place

resource user at the center must be developed through consultations with extension, research and target groups. Extension tools such as participatory rural appraisals are important in this process.

References

Alimoso, S. B., M.D.B. Seisay and N.P. Van Zalinge. 1990. An efficient method for catch-sampling of the artisanal Chambo fisheries of the Southeast Arm of Lake Malawi, the Upper Shire River and Lake Malombe. FI: DP/MLW/86/013 Field Document 6.

Bertram, R., H.J.H. Borley and E. Trewavas. 1942. Report on the fish and fisheries of Lake Nyasa. Crown Agents, London, 181 p.

Coulter, G. W. 1993. Report on Fisheries Research and Management Strategies. ODA/FRAMS Project, Malawi, 58 p.

Duponchelle, F. (ed.) 2000. Fish Ecology Report. SADC /GEF Lake Malawi/Nyasa Biodiversity Conservation Project, Ministry of Natural Resources and Environmental Affairs, Lilongwe, Malawi.

EAD and Danida. 2000. Lake Chilwa Wetland State of the Environment. Environmental; Affairs Department, Lilongwe, Malawi, 89 p.

FAO. 1976. Promotion of Integrated Fishery Development, Malawi: project findings and recommendations. Terminal Report, FAO, Rome, 36 p.

FAO. 1982. Fishery Expansion Project: findings and recommendations. FI:DP/MLW/75/019, FAO Technical Report, Rome, 21 p.

Lowe, R.H. 1952. Report on the *Tilapia* and other fish and fisheries of Lake Nyasa 1945-47. Part 2 Fish. Publ. Colon. Off. London, 1(2):1-126.

Meleke, S. 1984. Early fisheries development in Malawi. Unpublished, Department of Fisheries, Lilongwe, Malawi.

Menz, A. (ed.) 1995. The fishery potential and productivity of the pelagic zone of Lake Malawi/ Niassa. Natural Resources Institute, Chatham, UK.

Mvula, P.M. 2002. Fluctuating fisheries and rural livelihoods at Lake Malawi. University of East Anglia, Norwich, UK. Ph.D. Thesis.

Tweddle, D. 1991. Twenty years of fisheries research in Malawi. Fisheries Bulletin No. 7, Fisheries Department, Ministry of Forestry and Natural Resources, Malawi.

Case for compliance studies to improve management of the Chambo on the south east arm of Lake Malawi

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Abstract

The paper reviews the scientific basis for fisheries management approaches used in the South East Arm of Lake Malawi, their implementation and reasons for non-compliance of these regulations by fishing communities. Fisheries regulations used in the South East Arm are based on standard techniques of regulating effort by establishing closed seasons, banning gears with small-mesh size and restricting the maximum headline length of the Chambo seines. The paper points out that there has been lack of compliance to these regulations due to resource and budgetary constraints to enforce fishing regulations and the lack of expediency and legitimacy of the fishery management regulations. The paper concludes that more research effort should be put on research that influences the non-compliance of fishing regulations, economic and social organization of fishing units, and improving the content and legitimacy of the fisheries management regime.

Introduction

The science of fisheries management strives to replace chance with control and uncertainty about the future with a reasonable degree of predictability. Gulland (1974) proposed that fisheries managers are usually faced with the following main questions.

a) How large is the resource and how much fish can be caught each year while maintaining the stock for the future?
b) Given the potential catch, how should this be used for the greatest benefit of society?
c) What action needs to be taken to achieve these objectives?

This paper looks at the scientific basis for fisheries management approaches used in the South East Arm of Lake Malawi from a historical perspective to the present experience in implementing the regulations. The paper poses three main questions, namely: What have been the scientific bases for regulatory measures used? How were these measures derived? What has been the reality of implementing these measures?

Lowe work – The foundation for scientifically derived management measures

The first real scientific basis for deriving fisheries management measures for the South East Arm was the research and survey by Lowe from 1945 to 1947, whose report was published in 1952. Lowe's work was preceded by the visit of Trewavas and her team in 1939 (Trewavas 1942). The Second World War disrupted the work of the latter and the team was not able to fulfil its mandated task (FAO 1993). Lowe's two-year research laid the foundation for the scientific knowledge of the Chambo and thus the biological basis for the management measures for the fisheries. The value of her work can be seen in that most of what she had recommended remains the backbone and substantive basis of the scientific knowledge base for the regulations on the South East Arm.

The reason for the colonial government commissioning the surveys by Trewavas and Lowe was the worry that the Chambo, the most valuable species, was being over-exploited, especially with the increasing levels of exploitation by both African and non-African fishers in the 1930s and 1940s. Lowe's brief was to come up with recommendations on the status and management of the Chambo. Her recommendations led to the enactment of the 1949 Fisheries Ordinance by the Governing Council, three years before her report was published in 1952.

In order to study the systematics, breeding, growth and life histories of the Chambo, Lowe used samples, data and information from fishers (both African and non-African) and other useful information Trewavas and her team had collected a few years earlier. She also looked at the effects of fishing on the Chambo. In her preamble, Lowe backed her recommendations by outlining the biological basis for the management of fisheries, that "a rational fishery is one in which the best yield may be cropped each year over an indefinite period. To maintain the best yield over an indefinite period means that enough fish must be left for the stocks of fish to be maintained at a level required to produce the optimum yield per year" (Lowe 1952:60). Lowe's rationale had its basis in the theory of Maximum Sustainable Yield (MSY), a concept that was becoming prominent in the 1930s and 1940s, a time when fisheries biologists were beginning to understand the population dynamics of fish stocks and the dominant thinking was the conservation of wild fisheries (Gulland 1974). Lowe went on to recommend that "in Lake Nyasa, the long-term policy should aim at allowing all the *Tilapia* the chance to breed and rear one brood of young before they are caught". At the same time she noted that "*Tilapia* in Lake Nyasa are vital to the whole economy of the lakeshore. Their loss would constitute a real disaster for Nyasaland and that it could not have been too strongly emphasized that drastic steps needed to be taken to guard against such a happening" (Lowe 1952:61).

Lowe's findings

Lowe's evidence showed that there were three key species of the Chambo in the South East Arm, namely *Tilapia squamipinnis*, *T. saka* and *T. lidole*. The three species bred at different times of the year and in different places. Her studies indicated that the *Tilapia* took three years to reach breeding maturity, meaning that each fish must be protected for three years before it can be caught. Another important finding was that the sizes at maturity were different for each of the three species. She also found that the *Tilapia* bred only once a year. In addition, the *Tilapia* brood its young, meaning that whole broods of young may be destroyed with the parent if these are caught at this stage. Lowe further found that the *T. squamipinnis* and *T. saka* tended to live inshore while the *T. lidole* was to be found more offshore. At the time of her survey, there was evidence that the two inshore species were overfished while the *T. lidole* had remained relatively unexploited. In her opinion, this could have been due to a combination of factors including changing lake water levels or heavy fishing pressure. Based on her findings, she recommended the following measures (Lowe 1952):

- *Minimum size regulations*: This was the minimum size of the Chambo that could be caught in order to protect the immature fish that had not bred as yet (locally called *kasawala* or *zeya*). Owing to the fact that the different species bred at different lengths (varying between 23 to 28 cm), she recommended a minimum size of 26 cm for the Chambo.
- *Fixed minimum mesh size for Chambo gears*: In her calculations, the 26 cm minimum size of the Chambo would have been obtained by enforcing a minimum mesh of four inches diagonal stretch.
- *Protection of the fish on the breeding (spawning and brooding) grounds*: Apart from the capture of spawning fish, intensive fishing on the spawning grounds would also have been undesirable if it disturbed the nest making. Two approaches could be used:
  i. prohibiting fishing in certain areas, either altogether or during the breeding season; and
  ii. prohibiting fishing during the breeding seasons through an introduction of closed seasons.
- *Control of fishing effort*: Lowe also suggested that the amount of fish to be caught and/or the intensity of fishing each year should to be controlled. This should include curtailment of large-scale fishing and the use of more efficient gears such as ring nets.

Lowe's (1952) work culminated in the enactment of the first fisheries legislation in Malawi, the 1949 Fisheries Ordinance, with most of her recommendations coming under Part VI – Miscellaneous. It suffices to say that most of the intervening years that followed between 1950 and the country's political independence in 1964 were marked by political instability. This had great effect on the possible success of implementing the regulations, despite the fact that the first Fisheries Officer for Mangochi (then called Fort Johnston) had been appointed and put in place by 1945. An independent Malawi re-enacted a new Act in 1973, leading to the establishment of the Department of Fisheries (DOF).

Management techniques applied on the South East Arm

The modern-day DOF was established by an act of Parliament in 1974.[1] The Act outlined the general restrictions and prohibited fishing methods and the offences and penalties thereof. As to the South East Arm, most of the regulations largely returned the fervor of conservation of the Chambo (*Tilapia*) using technical regulations. In this sense, a lot of emphasis was put on enforcement of the regulations to ensure the biological sustainability of the Chambo. Table 1 shows the regulations drawn up for management of Chambo artisanal fisheries on the South East Arm under the 1974 Act.

The regulations in use on the South East Arm are based on the standard techniques for regulating effort indirectly and can be grouped into four categories:

- Minimum mesh size restrictions for the gillnets and Chambo seine nets;
- Closed season; and
- Maximum headline length for the Chambo seine nets. In addition to maximum headline length, the Chambo seine nets have depth restrictions.

The high profits from large catches during the closed season have acted as an incentive for the violation of the closed season in the past, making this regulation one of the most commonly violated in the area. Lowe (1952:63) had foreseen this problem when she stated that "one of the peculiar features of the Tilapia fishery in Lake Nyasa is that the main fishing season is also the main spawning and brooding season". In terms of area restrictions, the trawlers are not allowed to fish within one kilometer from the beach. This is to protect the juvenile Chambo, which spends most of its early stages near the shore. As can be seen from the preceding discussion, most of the regulations in application on the South East Arm, namely mesh size restrictions, time closures, closed areas and minimum fish size limits, are based on the biological conservation of the Chambo. The assumption is that a combination of all these technical regulations will achieve biologically sustainable levels of exploitation of the Chambo, even without regulating the amount of fish taken, effort applied and access into the fishery.

Table 1. Gear regulations for regulating the Chambo on the South East Arm of Lake Malawi (DOF 1993).

Gear type	Restriction	Minimum	Maximum
Gillnets	mesh size	95 mm	-
	headline length	-	no restriction
	net depth	-	no restriction
	closed areas	-	no restriction
	closed seasons	-	no restriction
	number of licenses	-	no restriction
Chambo s/net	mesh size	90 mm	-
	headline length	-	1 000 m
	net depth	-	18 m
	closed areas	-	no restriction
	closed seasons	-	1 Nov. - 31 Dec.
	number of licenses	-	no restriction

Fisheries management framework

The western ideal type of fisheries management is to a large degree based on the assumption of free access and hence the need to regulate fishing effort in order to obtain biological conservation. This necessitates the establishment of a Fisheries Management Regime (FMR). Hersoug and Paulsen (1996) stipulate that the FMR comprises of three interdependent components namely, a Monitoring Control and Surveillance (MCS) system, a Fisheries Management System (FMS) and a Fisheries Judicial System (FJS). The FMS specifies the regulatory framework for the fishing activities and encompasses the general rules and the different management measures. The MCS component is based on the need to monitor and control the fishing activities. The MCS unit provides data such as catch for the management unit as well as information for the judicial system (e.g., who is entitled to fish what, where and with what kind of gear). The FJS is a part of the general judicial system, sanctioning the alleged violators, indicating both the type and level of possible punishment. The important thing to note is that all the three systems are interdependent; the FMS relies on an efficient MCS and the MCS on a working FJS (Hersoug and Paulsen 1996). The influence also works in the other direction. In order to attain the full benefits from a fishery, a

[1] The 1974 Act states that it is "An Act to provide for the regulation and control of fishing, and for the purchase, sale, marketing, processing, import and export of fish, to provide for the conservation of fish and further to provide for matters incidental to and connected with the foregoing."

co-ordinated and fully functional FMR is required. From a management point of view, the important questions are: whether control and enforcement actually work, to what extent do they contribute to the goals set, be they biological, economic or social, and, finally, what are the costs of control and enforcement activities?

Experience with implementation of the regulations (the 1970s/1980s enforcement wars)

During the 1970s and 1980s, accelerated investment in improved equipment, such as nylon nets, plank boats and outboard motor engines, was catalytic towards increased commercialization of the artisanal fishery. The growing demand and the increasing affluence in towns such as Zomba and Blantyre, which form the main markets for the fish, further fueled increased fishing activities in southern Lake Malawi. The increased commercial stakes in the fishery led to disdain for the regulations among fishers. Inevitably, conflicts with government law enforcement agents resulted. The two decades were thus marked by intense confrontation between fishers and the government's law enforcement agents (fisheries inspectors and the police). Observance of the closed season by Chambo seine net fishers was a particularly thorny issue that caused great strain in relations between the government and this group of fishers supported by their helpers, crew members and other beneficiaries[2] in the villages where they operated their nets.

Incidents of law breaking were reported as far back as 1976 (Mijere 1977). Ng'ombe (1981) reported that during the 1980-81 closed seasons, violation of the closed season was very common. Several fishers from Mponda, Madina and Mtundu beaches were arrested for this offence. According to Alimoso (1984), 18 fishers were arrested, prosecuted, convicted and sentenced to imprisonment ranging from three to six months during the 1983 closed season. The convicted offenders were imprisoned without the option of fines. The magistrate noted in his summation that the imprisonment without the option of a fine was meant as a deterrent as fines (some as small as MK 10) had not proved very effective as a deterrent in previous years. According to Dissi (1998) one of the magistrates of the day (by the name of Mbingwa) even ordered the burning of the confiscated nets in one of the years as a form of extreme and extra punishment in addition to imprisonment. In order to discourage fish traders from buying fish caught illegally during the closed season (locally called *magweta*), the traders caught with such fish whether at the beach, en-route to markets or at the markets, were also arrested and prosecuted and the fish found in their possession confiscated.

Despite this intensification of enforcement activities, illegal fishing continued. The enforcement team was unable to stop these activities completely. By the mid-1980s, fishers had started to resist arrest and had generally become aggressive towards the enforcement agents. Donda (1984) reported that on 17th and 29th November 1984, there was stone throwing and other forms of general physical violence at Chipalamawamba when the inspection team attempted to confiscate seine nets being used. The fisherfolk showed little respect for or fear of the inspectors. Such incidents were becoming common. Dissi (1984) also reported on similar incidents occurring at Madina Beach on 25th November 1982, at Chipalamawamba on 28th January 1983, at Dimu on 5th December 1983 and at Mponda on 12th December 1983. In all these incidents, fisherfolk were found operating their seine nets during the closed seasons and attempts by the inspection team to confiscate the nets were met with violent resistance.

The Fisheries Officer for Mangochi, and the DOF in general, were alarmed at the gravity of the situation. It was increasingly felt that the Department could not adequately deal with the situation alone (Donda 1987and Donda 1998). The Department appealed for assistance from the officials the District Development Committee (DDC), the Police and the Malawi Congress Party (MPC). As a result, the issue increasingly formed part of the DDC agenda at its meetings. Public meetings, to raise awareness about the importance of the closed season, were conducted in the troubled areas by district MCP party officials. Apart from the public meetings, the Police also provided their assistance. Thus from 1986, the inspection team was strengthened by the inclusion of police officers.

However, despite the intensification of the awareness campaign and the involvement of the

[2] Hereafter the term fisherfolk will be used to refer to gear owners and their crew members, helpers, traders and other beneficiaries.

DDC, MCP and the Police in efforts to tackle the problem, the situation continued to deteriorate. The awareness campaign seemed to have been largely ineffectual and even the inclusion of the police officers does not seem to have had the desired deterrent effect on the violence. The more the fisherfolk saw that they could get away with resisting arrest and/or confiscation of their equipment, the bolder they became in their resistance.

By the mid-1980s, a clear pattern had emerged; as far as the fishers were concerned, the commercial stakes were high enough to ignore the regulations and resist any attempts by official enforcement agents to arrest them and/or confiscate their equipment.[3] Thus, as the fisherfolk realized that they could get away with such blatant law breaking with little or no punishment, they became more openly defiant and bold in their resistance. By the 1988 closed season, the fisherfolk were openly challenging the inspection team. The confrontations at Mpondas and Malunda beaches on the mouth of the Shire River in November and December 1988 (Jumpha 1988) exemplify this bold and defiant attitude of the fisherfolk:

- On 21st November 1988 at Mponda beach, the inspection team failed to seize nets found in operation or to arrest anyone and had to go back empty-handed leaving the fisherfolk to continue with their fishing.
- On 23rd November 1988 the team, which included three policemen including the Officer-in-Charge, went back to the Mponda and Malunda beaches. At Malunda they found 10 beach seines in operation, with more than 500 fisherfolk in attendance. On attempting to seize the nets, the team was attacked by the fisherfolk and had to abort the operation.
- In December 1988, the team, which included police officers, went on patrol to the Mpondas and Malunda beaches again. An attempt was made to confiscate the nets found in operation. The fishers openly challenged the team to confiscate the nets. Outnumbered and ill-equipped, the team withdrew to the station without doing anything again.

These failures to carry through decisive actions were both embarrassing and demoralizing for the inspection team. Anxious to do something about this growing lawlessness and increasing defiance among seine net fisherfolk, the Police Officer-in-Charge, in consultation with other officials, decided to solicit the assistance of the Police Mobile Force (PMF). Having been briefed about the existing situation, it appeared as if the PMF had decided that they should give a lesson to the fisherfolk. Thus, in the first patrol they participated in, probably to the two most problematic beaches at Mponda and Malunda, they did not wait for the team to be attacked before reacting. The squad just went on and beat up anyone found at these beaches that could not get away, whether they were gear owners, assistants, on-lookers or traders. Nets, boats and fish were seized in abundance. All in all 10 fishers and 7 traders were arrested, prosecuted and variously fined between MK 50-150. The use of the PMF as a back-up seems to have been successful until the 18th of January 1989. On this date, when the team attempted to confiscate the nets being used illegally at Mbaluku, fishers attacked them with stones, oars and other weapons. It was only after the police fired several warning shots in the air with a machine-gun that the fishers backed off (Ibid.). Two police officers and one fisheries inspector were seriously wounded. Seemingly, use of the PMF with their more physical approach had only served to inflame the situation even more. After this incident, the police withdrew their active support for the second time and the PMF was never used again.

Why was the Malawi Congress Party (MCP)'s Youth League not used or ineffective?

The years when all these conflicts and incidents of violence were taking place were a period when the MCP, with its style of rule, was well entrenched and at its height. One of the defining features of MCP's rule was the power that the party had over the population, especially in rural areas. Whenever there were government regulations to be adhered to, the party could be counted on to use its coercive political power to force the populace to fall in line. The local branches of the MCP Youth League could, therefore, be counted on to help enforce government regulations in their areas. It must have been with this knowledge and hindsight that the DOF had requested the assistance of the MCP to help try and bring order to an increasingly worrying situation on the South

[3] At the same time no effective local control of fishing activities existed. Local leaders had since the 1940s and 1950s lost control of what was happening concerning fishing in their areas.

East Arm of Lake Malawi and in the Upper Shire River. Although the MCP officials conducted public meetings to this effect, the general impact of this usually effective approach was minimal, if not a total failure. The fisherfolk ignored the MCP's threats and pronouncements and openly continued with the illegal fishing activities. What is most curious is that the Youth League seems not to have been used by the MCP to augment its efforts as it would usually have done, especially after seeing that the public meetings had not yielded results. The overall question is why even the MCP failed to bring the fisherfolk into line when, in most cases, their political weight and machinery should have done so. Three possible reasons can be suggested for the failure of the strategy to use the MCP's political clout:

- That there were corruptive elements within the structures of the MCP, which made it difficult for them to take real action. This must include the possibility that some MCP officials were also actively involved in fishing, either as gear owners, crew members/assistants or helpers.
- That the Youth League members were fearful of getting involved in enforcement of fisheries regulations which would have involved them getting entangled with relatives, friends and in general with people they lived with every day in their villages.
- That the MCP genuinely tried to help to bring order but failed just like the government agents had.

According to Dissi (1998) and Donda (1998), while all these might have been contributing factors to the failure of the strategy involving the use of the MCP, the first suggestion contributed the most. The majority of the MCP party officials and members of the Youth League had some self-interest in the fisheries. Thus, while their official rhetoric could have been in line with the government campaign, they were at the same time actively colluding with fisherfolk in undermining the same regulatory regime that they were supposed to have been propping up.

Why did the Chambo fisheries management regime fail?

The question that should be posed is why the management regime for the Chambo seems to have failed, as evidenced by the failure to enforce the regulations meant for its conservation, even though all its three components, namely the FMS, the FJS and the MCS, were fully functional. Three possible explanations can be put forward: resource and budgetary constraints, the regime's lack of expediency and legitimacy among users, and the use of technical regulations as a regulatory framework.

Resource and budgetary constraints

It would be valid to say that during the 1990s, especially after the government was forced to implement the Structural Adjustment Program (SAP) more stringently, the ability of the DOF to implement the existing regulatory framework had been constrained by the shortage of staff, lack of equipment and general budgetary problems (Bland and Donda 1994). The major constraint had been the inadequate budgetary allocations from the Treasury to the DOF, which had declined in real terms over the years, making it increasingly difficult for the Department to fulfil its mandate. However, this does not explain the problems of enforcing the regulations during the 1970s and 1980s when the government had the resources it needed at its disposal. For this reason, we must look for explanation(s) elsewhere.

Expediency and legitimacy?

Young (1979) and Sutinen et al. (1990) suggest that the factors that affect individual compliance decisions are generally very complex. Apart from weighing private economic benefits, individual compliance may also depend on the degree to which the regulations are considered as fair and just, and also on characteristics of the decision context such as social pressure, habit, behavior of others and feelings of obligation. If we restrict our view to considering only the economic factors that affect compliance, the individual fishers' decisions will be based on the following three separate elements: the expected illegal gain of non-compliance, the expected probability of being caught and convicted, and lastly the severity of penalty or sanction if convicted (Sutinen et al. 1990).

Jentoft (1989) points out that the crucial question for the success of any management scheme is "What measures are needed to get fishermen to voluntarily advance their collective interests at the expense of their individual interests?" That is, to what extent fishers are willing to accept the regulations as appropriate and consistent with their persisting values. Jentoft suggests that the legitimacy of a regulatory scheme is related to at least four general hypotheses:

- Content of the regulations: The more that regulations concede with the way fishers themselves define their problems, the greater will be their legitimacy.
- Distributional effects: The more equitably restrictions are imposed, the more legitimate will the regulations be regarded.
- Making of the regulations: The more fishers are involved in the formulation and in the decision-making process in general, the more legitimate the regulatory process will be perceived.
- Implementation of the regulations: The more directly involved fishers are in enforcing the regulations, the more the regulations will be accepted as legitimate.

Thus, there may be at least four ways to improve the legitimacy of fisheries regulations and to increase their prospects of success. Each requires taking into consideration the fishers' point of view. In the first two hypotheses, the content and quality of the regulations are the focal points. The last two hypotheses concern the organization of the decision-making process. Social scientists group these into two forms of legitimacy: "content legitimacy" and "procedural legitimacy" (Jentof 1993). Both content and procedure are important if there is a desire to promote the legitimacy of the regulations. Figure 1 below illustrates this problem.

The figure in each square indicates in which of the four situations one can expect the greatest willingness to abide by the regulations.

In square 1, the fishers accept the regulations and the method by which they have come about. High procedural legitimacy presumes a democratic process in which the fishers themselves have been actively involved. The fishers will then feel that they have a "right of ownership" to the regulations, with the result that they want to identify with them and adhere to them. At the same time, they will feel personally betrayed if their brethren do not.

In square 4, the scoring is low on both content and procedure. Here the fishers are neither satisfied with the regulations nor the methods used to develop them. In this case, it would be reasonable to assume poor adherence to the regulations. Fishers will feel they are fooling the government more than they do one another.

In square 3, there is a positive attitude to the content of the regulations but negative attitude to the procedure.

In square 2, the score is high on procedural legitimacy and low on content legitimacy. Here fishers have critical objections to the regulations, but not to the decision-making procedure followed. They have participated in the decision-making process, but lost in a properly conducted vote.

There is a greater probability of the fishers adhering to the regulations in square 2 than in square 3 for the following reasons. Firstly, square 2 concerns a regular democratic process, where the normal rules of the game require that the minority give in to the majority. Secondly, the decision-making process itself makes it possible for a negative attitude to change to positive because the fishers, through discussions and negotiations, could arrive at a reasonable compromise. There is even hope for consensus, because the parties learn to understand each other's point of view and may be convinced by them. Thirdly, it can be expected that the practical knowledge of the fishers, as

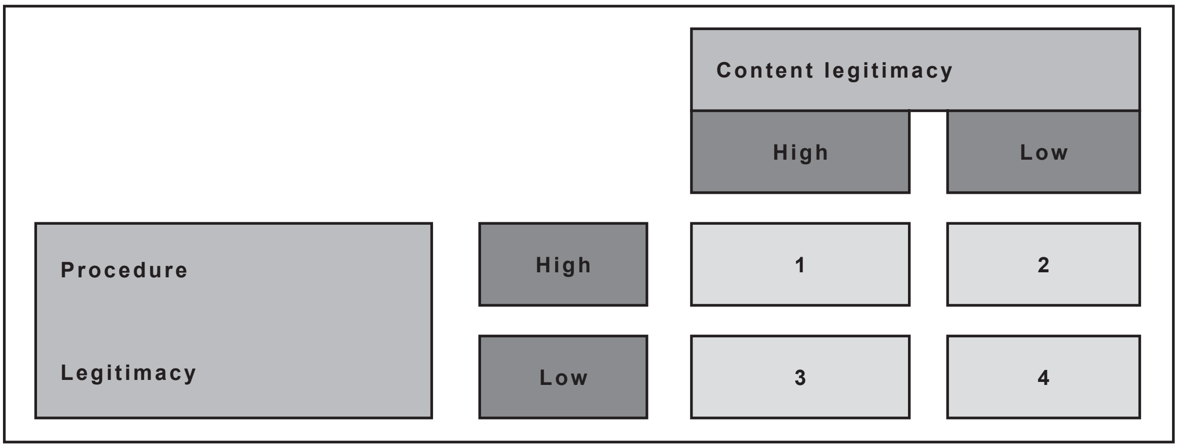

Figure 1. Types of procedure and content legitimacy of fisheries regulations (Jentoft 1993).

well as the overview of local conditions, would permeate the regulatory process. This could lead not only to greater fairness but also to more appropriate regulations. In other words, the procedure has a positive effect on the content because participation by the fishers brought significant knowledge to bear on the decision-making process. It must be noted, though, that there is a limit to how low the content legitimacy may go. If the regulations are sufficiently unfair, they will be sabotaged even if the proper procedures have been followed. Jentoft (1993) makes three conclusions from this. In order for a regulatory system to be effective the fishers must be involved. A regulatory system will never be better than is accepted by the fishers and they will be more inclined to obey regulations if they have helped to formulate them.

More generally, it can be said that a regulatory system that hinges only on content is more vulnerable and more exposed to sabotage by fishers than a regulatory system that also relies on procedure. Regarding the costs of enforcement, regulations introduced against the fishers without their involvement will be extremely hard and costly to enforce. It is in the above context that the problems of enforcing the regulations on the South East Arm could be clearly understood. The DOF formulated and instituted the regulations without consultation with fishers and also was implementing the regulations without the involvement of the fishers.[4] This lack of procedural legitimacy is probably one of the main reasons why the regulations were and have been routinely infringed upon even if they might be appropriate in terms of content.

The 1988-92 Chambo Fishery Management Project: re-inventing the wheel?

Forty one years after Lowe's (1952) pioneering work, another research project that run from 1988 to 1992 was commissioned, with the objective of establishing a suitable management strategy for the Chambo in Lake Malawi, Lake Malombe and the Upper Shire River (FAO 1993).[5] The importance of the project was put in context by the assumption that "the South East Arm was the last major Chambo fishing ground remaining in Malawi, the Chambo fishery in Lake Malombe, the South West Arm and the Upper Shire River having collapsed" (FAO 1993: 1). Just like Lowe earlier, the research focused on biological investigations of the three main species of Chambo. By this time, it had been realized that the multi-species character of the fisheries warranted taking into account the other major stocks involved. The investigations involved stock assessment of the Chambo and other resources, as well as the biology and the taxonomy of the Chambo. In addition, an attempt was made to look at the socio-economic aspects of the exploitation of the Chambo. Indeed, the final report (FAO CIFA Technical Paper 21) entitled Fisheries management in the Southeast Lake Malawi, the Upper Shire River and Lake Malombe provides a detailed summary of the findings based on 26 field documents.

The project findings

Concerning the biology, taxonomy and systematics of the Chambo, not much new knowledge may be said to have emerged from the research project. In terms of classification, the report reveals that the Chambo has now been placed in the subgenus *Nyasalapia* of the genus *Oreochromis* (Trewavas 1983) and also that the *Oreochromis saka*, which was believed to be a different species, during Lowe's(1952) work, is now regarded as a variant of the *Oreochromis karongae* (Turner and Robinson 1990). However, it is admitted in the report (FAO 1993:1) that "Questions of the taxonomy of this complex group had not been resolved."

Most of the findings about the biology of the Chambo just confirmed what Lowe and Trewavas had found forty years before:

- that the average size at breeding maturity for the three species of the Chambo was about 27.5 cm [Lowe (1952) had put the range between 23 to 28 cm giving an average of 25.3 cm];
- that the Chambo were mouth brooders whose female brood the eggs and larvae for about two weeks before before releasing them in shallow water, but continue to protect their young, allowing them to return to her mouth when threatened;
- that the breeding season for the *O. karongae* and *O. lidole* is from September to December

[4] It must be realized that consulting or involving users in the management process can be costly in terms of time and money involved.
[5] Other relevant studies or reports on the Chambo fisheries include Williamson's (1966) assessment of the data for the years 1946-66 and Tarbit's assessment for the years 1969-73.

though the fish may continue to breed until March, while the main season for the *O. squamipinis* is from November to December and may continue until April [Lowe (1952) indicated that the Chambo bred at different times and in different places and suggested November to December as the peak breeding season]; and
- that there was evidence of seasonal migration through the Shire to Lake Malombe. [Lowe (1952) thought that *O. lidole* species did not visit Lake Malombe]. The 1988-92 project reported that they had found spent females of the *O. lidole* in Lake Malombe even though the adults seemed to be rare south of Boadzulu Island. Thus, while there seemed to be such seasonal migration of the *O. lidole* to Lake Malombe, what confounded this finding was that no return migration of immature fish (*O. lidole*) to Lake Malawi had been observed (FAO 1993).

One thing that the project did was to calculate the MSY and biomass for the Chambo stocks in the South East Arm. This was put at 3 510 t and 9 883 t, respectively. At the time, they estimated that the stocks were fully exploited but not overexploited. The project also reported that the closed season had generally been ignored and that the fishing during the closed season was 131% higher. One achievement of the project was the design and implementation (in the project area) of the new gear-based data collection system called the Malawi Traditional Fisheries (MTF), which is described by Alimoso et.al. (1990) and Stamatopoulos (1989). It is said that the new system gives more reliable estimates (Turner et.al. 1992). The project also carried out studies on the socio-economic impact of the various possible management options on gear owners and crew members. In addition, some studies were done on the fish marketing system of the area.

Recommendations

The findings led to the project putting forward the following recommendations (FAO 1993:91):

- The DOF should introduce limited access.
- The gear holdings, both in size and numbers, that existed at the time should not be allowed to increase any further.
- The minimum mesh sizes for gillnets and CSNs should be raised to 95 mm.
- The small mesh size nets such as *kambuzi/chalira* and *nkacha* seines should be banned from Lake Malawi.
- The November and December closed season for CSNs should be abolished.

While there is no doubt about the soundness of the basis of these recommendations for the biological conversation of the Chambo, the practicality and the possible socio-economic impact of implementing them was likely to prove a problem or hindrance. Limiting access or the number of gears in the fisheries would have been politically unpalatable and practically unenforceable. In any case, it would be very difficult and expensive to implement such a regulation in fisheries where fishers can operate from wherever they want and whenever they want. The economics of fishing would have made increasing the mesh sizes very unpopular among fishers, especially with the declining average fish sizes and catch rates. Although the DOF had tried to limit the use of *nkacha* nets on Lake Malawi even before the regulation became law officially, the number of *nkacha* and *kambuzi* nets has continued to grow. The DOF ignored the recommendation to scrap the closed season, arguing that a well observed closed season could help reduce fishing effort even though it might not be useful for conservational purposes (DOF 1993).

Thus, despite fours years of research and the resulting scientifically well reasoned recommendations, most of these remain unimplemented or are unimplementable. This begs the question as to why so many resources (financial, time and human) were spent on repeating work that had already been done 40 years back, only to come up with recommendations that have or might never be put into practice. Was there really any need for more biological, taxonomic or systematics knowledge of the Chambo in order to improve its management? What could have been done instead in order to start improving the management of the said fisheries? Another important question is why the authorities concentrated only on the Chambo again when it was already and increasingly clear that the other species were becoming more and more important in the landed catch? In other words, was this research work of any real value for management purposes or just re-inventing the wheel?

From the problems of implementing and enforcing the existing regulations in the 1970s and 1980s, one important facet that could have been investigated in the 1988-92 project was concerning why there had been so many problems with the Chambo management regime during those two decades. It would have come to light then that the problems did not arise from lack of knowledge of the biology, systematics or taxonomy of the Chambo. In this context, the question of legitimacy and decision making for fishing activities should have formed one of the major aspects of the research and investigations. One must realize that from colonial days up to the present day, there has always been a fixation or obsession with conservation of the Chambo within government circles. As a result, more money has been spent on studying the fish (especially the Chambo) than on the people who depend on it for their livelihoods and the environment of their fishing activities.

Some of the questions that should have been posed are: What is the extent to which the fishing communities are dependent on the fisheries? What are the socio-economic factors that determine the patterns of exploitation that they adopt? Why have the fishers continued to ignore the regulations such as closed seasons, mesh size limits, etc. despite all the awareness raising through extension and enforcement? What drove them to resist violently the enforcement of the closed seasons? Such probing should have started to discover some of the reasons why the previous Chambo management regime had failed and why a new set of even more stringent regulations might not fare any better.

Towards the end of the FAO project, thinking about the management of natural resources had begun to change. The paradigm was shifting towards "participatory management". This shift was marked by a growing body of researchers who were challenging Hardin's Tragedy of the Commons thesis (Hardin 1968) as exemplified by books and conference proceedings such as "Making the Commons Work: Theory, Practice and Policy" (Bromley 1992); "Governing the Commons" (Ostrom 1990); "The Question of the Commons: The Culture of Ecology of Communal Resources" (McCay and Acheson1987); "The Bruntland Report" (World Commission on Environment and Development 1987) and the "1992 World Development Report" (World Bank 1992). While the first three volumes comprised mainly social scientists and anthropologists who were refuting the Tragedy of the Commons theory and started to present evidence that local user communities are able to manage natural resources on their own, the Bruntland and World Bank reports emphasized the need for people's participation and urged governments to recognize people's movements of all kinds as partners in decision-making and implementation. One of the increasing justifications for this shift in the paradigm was the realization that centralized management by governments alone had not been working very well. In that case, why not transfer some of the management responsibilities to the users themselves? In line with this shift, the Fisheries Act (Government of Malawi 1997) had been revised in order to enable and legitimize the participatory approach. Even the policy has shifted away from being fish-centered (Chambo) towards more people-centred and stipulates that the fisheries sectoral policy is "to sustain the contribution of the national fish resources to the upliftment of the quality of life in Malawi by conserving the resources for the benefit of the present and future generations". The general objectives of the revised policy include: protecting the endemic fish fauna; nurturing and promoting sustainable utilization of fisheries resources; and sustaining their production as human food and alternative means of increasing their income and welfare. In turn, this objective is expected to contribute towards the national development objective that expresses the need to "reduce poverty through rapid and sustained economic growth, improvement in income distribution and a reduction in the instability of welfare for both the individual and the nation" (Bland and Donda 1994:1). The revised draft seems more oriented towards social objectives than the original one, which was more towards the MSY goal. In both cases, the heavy influence of fisheries biology (and hence the strong conservation orientation) can still be noted.

Conclusion

A fact well known in fisheries is that if fishers are intent on circumventing the regulations, they can hardly be stopped no matter how strict the regulatory system. Thus, all types of fisheries regulations have to be based on a minimum of *legitimacy* in order to be effective (Hersoug and Paulsen 1996). Flewwelling (1994) has also warned about the problem of creating unenforceable legislation. Unenforceable legislation, or that which is not understood or acceptable to the fishers, rapidly destroys the credibility and support for government in its efforts to conserve fisheries resources.

Such legislation results in active subversion of the regulations by the fishers and the fishing industry.

In the case of the Chambo, there is enough knowledge about the biological and ecological basis for its management. What is needed is research about factors that influence non-compliance; economic and social organization of fishing units and how these influence behavior; and improving the content and procedural legitimacy of the management regime.

References

Alimoso, S.B., M.B.D. Seisay and N.P. Van Zalinge. 1990. An efficient method for catch-effort sampling of the artisanal Chambo fisheries of the South East Arm of Lake Malawi, the Upper Shire River and Lake Malombe. FI : DP/MLW/86/013 Field Document 6.

Alimoso, S.B. 1984. Annual Station Report for 1983 of 9/1/84. Ref. No. D/14/Vol III/16, Department of Fisheries, Lilongwe, Malawi.

Bland, S.J.R. and S.J. Donda. 1994. Management initiatives for the fisheries of Malawi. Fisheries bulletin No. 9. Department of Fisheries, Lilongwe, Malawi.

Bromley, D.W. 1992. Making the commons work. Theory, practice and policy. Institute for Contemporary Studies Press, San Francisco.

Dissi, C. 1998. pers. comm. Zomba Fisheries Station, Department of Fisheries, Malawi.

Dissi, C. S. 1984. Aggression towards Fisheries Enforcement Officers of 24/4/84. Ref. No. E/3/Vol. IV/5, Department of Fisheries, Lilongwe, Malawi.

Donda, S.J. 1998. pers. comm. Department of Fisheries, Lilongwe, Malawi.

Donda, S.J. 1987. Dangerous incidents during the 1986/87 closed season of 26/1/87. Ref. No. e/3/160, Department of Fisheries, Lilongwe, Malawi.

Donda, S.J. 1984. Station report for August-December 1984. Ref. No. D/14/Vol. III/27, Department of Fisheries, Lilongwe, Malawi. [See also Donda, S.J. Station Report for Jan-Feb. 1985 of 1/3/85. Ref. No. D/14/Vol. III/30, Donda S. J. Ref. No. E/3/Vol. IV/203 of 20/11/85 and Donda, S. J. Fisheries closed season 1989/90 of 25/10/89. Ref. No. 5/4/1/vol. VII/8, Department of Fisheries, Lilongwe, Malawi.]

Department of Fisheries. 1993. Artisanal fisheries management plan. Department of Fisheries, Lilongwe.

FAO. 1993. Fisheries management south east Lake Malawi, upper Shire and Lake Malombe. CIFA Technical Report 21, FAO, Rome, 113 p.

Flewwelling, O. 1994. An introduction to monitoring, control and surveillance systems for capture fisheries. FAO Technical paper 338. FAO, Rome.

Government of Malawi. 1997. Revised Fisheries Act. Government of Malawi. Zomba.

Gulland, J.A. 1974. The Management of Marine Fisheries. University of Washington Press, Seattle, 198 p.

Hardin, G. 1968. The Tragedy of the Commons. Science 62:1243-1248.

Hersoug, B. and O. Paulsen. 1996. Monitoring, control and surveillance in fisheries management, 1st edition. University of Namibia, Windhoek.

Jentoft, S. 1993. Dangling lines. Newfoundland: Institute of Social and Economic Research.

Jentoft, S. 1989. Fisheries co-management: delegating government responsibility to fishermen´s organisations. Marine Policy 13(2):137-154.

Jumpha, D.J. 1987. Licensing and enforcement report for 1986/87 closed season of 12/3/87. Ref. No. E/3/6/180, Department of Fisheries, Lilongwe, Malawi.

Jumpha, D.J. 1988. Annual Enforcement report for 1988 of 19/5/89. Ref. No. E/3/Vol. VIII/202, Department of Fisheries, Lilongwe, Malawi.

Lowe, R.H. 1952. Report on the *Tilapia* and other fish and fisheries of Lake Nyasa 1945-47. Colonial Office Fishery Publications Vol. No. 2. Colonial Office. London.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis* and *Danakilia*. London. British Museum (Natural History). 583 p.

Turner, G.F. and R.L. Robinson. 1991. Ecology, morphology and taxonomy of the Lake Malawi *O.* (*Nyasalapia*) spp. flock. Ann. Mus. Roy. Afr. Centr., Sc. Zool. 267: 23-28.

McCay, B.J. and J. M. Acheson (eds.) 1987. The question of the commons: the culture of ecology of communal resources. Tucson, Arizona: The University of Arizona Press.

Mijere, L.K. 1977. Report of M. Mwachumu's case held at 2nd magistrate court. (Ref. No. E/3/14/6/77). Fisheries Dept. Lilongwe. Malawi National Archives. Zomba.

Ng'Ombe, E.L. 1981. Close season report for 1980/81 of 13/4/81 (Ref. No. D/14/vol. VI/12). Fisheries Dept. Lilongwe. Malawi National Archives. Zomba.

Ostrom, E. 1990. Governing the commons: evolution of institutions for collective active. Cambridge University Press. Cambridge. England.

Stamatopoulos, C. 1989. Statistical and computing aspects in developing statistical systems in Malawi. MLW/86/013 Field Document 1.

Sutien, J.G., A. Rieser and J.R. Gauvin. 1990. Measuring and explaining non-compliance in federally managed fisheries. Ocean Development and International Law Vol. 21. UK.

Tarbit, J. 1972. Lake Malawi trawling survey – Interim report, 1969-1971. Malawi Fisheries Bulletin, (2), 16 p.

Williamson, R.B. 1966. Analysis of ring-net catch data from the south-east Arm of Lake Malawi, 1946-1966. Malawi Fisheries Department, 4 p. (mimeographed).

Department of Fisheries strategic plan

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Introduction

Malawi's development policy expresses the need for reduction of poverty, ignorance and disease by the achievement of rapid and sustainable economic growth and an improvement in income distribution. The first National Fisheries Policy and Development Strategy was developed in 1949 and reviewed in 1977. The second major review followed in 1984 that led to the formulation of the Statement of Development Policy 1986-95, in which the aims, strategies and objectives were redefined with greater emphasis put on aquaculture development and post-harvest fish losses in order to conform to the changing environmental conditions (PFM Working Team 2003, personal communication).

The Strategic Plan for the Department of Fisheries is one of eight that present the Strategic Plan of the Ministry of Natural Resources and Environmental Affairs (MNREA). The plan was developed with extensive inputs from staff members across the Department and from contributions of other stakeholders (private sector, parastatal and non–governmental organizations) familiar with the Department's activities.

The process of formulating the Fisheries Sectoral Strategic Plan was consultative and started in 2001. The draft document was reviewed in November 2002. This paper presents a summary of the contents of the Fisheries Strategic Plan as it relates to the National Fisheries and Aquaculture Policy and the Chambo Restoration Program.

Vision

The Departmental Vision indicates that the Department of Fisheries will be "a dynamic, high performance, consultative and client-focused Department that promotes, builds and ensures sustainable development, utilization and management of the fisheries resources in Malawi."

Mission

The Departmental Mission is to provide framework conditions and excellent services for the maximization of socio-economic benefits through sustainable utilization and management of capture fisheries and increased aquaculture production.

Goal

The Departmental Goal is to provide professional services to ensure sustainable fisheries resource utilization and enhanced aquaculture through the principles of good governance.

Operational objectives

Four operational objectives guide the activities of the Department in implementing the National Fisheries and Aquaculture Policy through the Strategic Plan, and these are:

- Update legislation and policy in line with other national policies and legal instrumentation;
- Ensure that fisheries resources are managed according to operational management procedures;
- Strengthen user institutions' capacity for fisheries resource management and governance; and
- Restructure and strengthen the DOF for effective internal, national and international communication.

Major areas of focus

In pursuing its goals, the Department of Fisheries mainly focuses on the following areas in capture fisheries and aquaculture:

Capture Fisheries

- Enhanced production: Focus on unexploited resources and improving efficiency of production for both large and small-scale fishers;
- Post-harvest: Focus on value adding plus processing; and

- Marketing: Focus on improved infrastructure.

Aquaculture

- Enhanced productivity with a focus on identification of viable indigenous species;
- Development of management regimes for different culture systems;
- Conflict resolution;
- Promotion of intensive fish farming;
- Development of technology to promote restocking; and
- Identification of viable and acceptable exotic species, using acceptable guidelines.

Implementation of the Strategic Plan

The implementation of the Strategic Plan in both the capture fisheries and aquaculture sub-sectors focuses on the following:

- Dissemination of research results through extension;
- Promotion of sustainable production in the capture fisheries;
- Promotion of effective enforcement in the capture fisheries – distinguishing the roles of the central government and the local government;
- Devolution of power to District Assemblies and Local Fisheries Management Authorities;
- Facilitation of the formation of local organizations such as the BVCs; and
- Development and signing of management agreements.

However, there are a number of strategies that were developed to aid the achievement of the departmental objectives, and these are outlined below:

Update legislation and policy in line with other national policies and legal instrumentation.

Strategies:
- Policy review and harmonization;
- Legislation review and harmonization;
- Master plan production; and
- Sectoral economic study.

Ensure that fisheries resources are managed according to operational management procedures.

Strategies:
- Develop a Sector Investment Program;
- Enhance post-harvest utilization of fish and fisheries products;
- Enhance aquaculture production;
- Carry out resource assessment programs of exploited stocks;
- Develop management plans;
- Disseminate research findings;
- Promote sustainable production in capture fisheries;
- Implement and ensure effective enforcement; and
- Produce annual status reports per fishery and bi-annual revisions of management recommendations.

Strengthen user institutions' capacity for fisheries resource management and governance.

Strategies:
- Increase the knowledge and skills base for both private and public sectors;
- Review and implement the DOF devolution plan; and
- Develop fisheries management agreements with communities.

Restructure and strengthen the DOF for effective internal, national and international communication.

Strategies:
- Develop and maintain human capacity to manage fisheries resources;
- Enhance timely information exchange at all levels;
- Clearly define the roles, targets and responsibilities of the DOF staff;
- Review the DOF activities in research, management interventions and project objectives and activities;
- Develop and implement performance management plans; and
- Enhance capacity of the DOF administration.

Conclusion

The Chambo restoration program initiative falls under the second Departmental Operational Objective of "Ensuring that fisheries resources are managed according to operational management procedures." It is, therefore, in the interest of the Department of Fisheries and the public as a whole to support the Chambo restoration program as it directly contributes to the achievement of the National Developmental Goals of Food Security and Poverty Reduction.

SECTION 3: CHAMBO RESTORATION STRATEGIES

Assessing the potential for restocking, habitat enhancement, fish sanctuaries and aquaculture to restore the Chambo production in Malawi
Johann Bell and Daniel Jamu

Culture-based production systems: Options for the Chambo in Lake Malawi and Lake Malombe
E.K.W. Kaunda, F. Njaya, D. Jamu and A. Ford

Environmental impacts on the growth and survival of the *Oreochromis karongae* in captivity
O.V. Msiska

Assessing the potential for restocking, habitat enhancement fish sanctuaries and aquaculture to restore the Chambo production in Malawi

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Abstract

The Chambo fisheries in the South East Arm of Lake Malawi have been severely exploited and depleted due to overfishing, habitat degradation and use of illegal gears. The government of Malawi is determined to reverse the decline in order to restore the Chambo fishery so that it fulfils its potential in meeting the food security needs of the country. This paper summarizes briefly the existing experiences aimed at increasing the production of the Chambo in the lakes of Malawi by ways of producing and releasing juvenile fish, enhancing habitats, creating fish sanctuaries, and promoting aquaculture. The paper further describes research planned to assess the potential for the interventions to contribute to the increased production of the Chambo. In the case of restocking, the paper also identifies the protocols required to implement responsible programs if this intervention is demonstrated to have a good potential to fast-track the recovery.

Introduction

The Chambo fisheries in the South East Arm of Lake Malawi and Lake Malombe, which are based on the *Oreochromis karongae*, *O. lidole* and *O. squamipinnis*, have been over-exploited severely. The fishery in Lake Malombe was known to have collapsed (FAO 1993; Palsson et al. 1999; Bulirani et al. 1999) with catches declining from over 4 000 t per annum in the 1970's to about 100 t in 1994 (Bland and Donda 1995). The situation was not much better in the South East Arm of Lake Malawi, where landings had decreased from previous levels of 4 000 t to about 600 t in 1999 (Manase et al. 2002). The government of Malawi is determined to reverse these declines and restore the production of the Chambo so that this important resource can fulfil its potential in meeting the food security needs of the country. However, restoring the production of the Chambo will not be easy because the species are characterized by late maturity, low fecundity and extended parental care (Palsson et al. 1999). These aspects of the biology of the Chambo species indicate that a relatively long period is required for the stocks to recover (Weyl 1999). Recent observations reveal that despite decreases in fishing effort, the Chambo stocks in Lake Malombe and the South East Arm of Lake Malawi still remain low, indicating that reduction of effort alone is unlikely to rebuild the fishery within acceptable time frames.

Some management scenarios for rebuilding the Chambo stocks in Lake Malombe were put forward by the FAO Chambo Project (FAO 1993). These included: (i) halting all fishing in the lake; and (ii) achieving partial recovery of stocks through total closure of the Chambo fishery while still allowing *nkacha* and *kambuzi* seine operators to fish for other species. The second scenario was predicted to result in the recovery of Chambo stocks to levels that would provide an annual yield of 1 000 t within five years. In addition, a recommendation was made to restore the weed beds that help support the Chambo stocks, which formerly dominated the lake. Unfortunately, the management scenarios identified by the Project were never implemented due mainly to their expected negative socio-economic impacts on fishing communities (Weyl et al. 2001).

It is now apparent that the sustained economic losses from the severely over-exploited Chambo fisheries far outweigh the interim hardship required to restore the production of the Chambo to reach its potential. (The government of Malawi (1999) says essentially the same thing albeit in a different manner, i.e., restoration of the Chambo should be considered a matter of greatest importance in view of the economic value of the Chambo.) There is a great incentive, therefore, to find acceptable social and biological methods to intervene in the management of the fishery to restore it to levels at which optimum harvests can be taken each year. Since the FAO Chambo Project was completed, at least three other biologically-based options for rebuilding the Chambo stocks have been considered: (i) release of hatchery-reared juveniles in restocking programs; (ii) enhancement of habitats that support the Chambo, e.g., construction of brushparks; and (iii) use of fish sanctuaries to protect important nursery areas and a proportion of the breeding population. Production could also be increased through cage culture.

This paper summarizes briefly the existing experiences aimed at increasing the production of the Chambo in the lakes of Malawi based on producing and releasing juvenile fish, enhancing habitats, creating fish sanctuaries, and promoting aquaculture. The paper further describes research to be done to assess the potential for these interventions to contribute to the increased production of the Chambo. In the case of restocking, the paper also identifies the protocols needed to implement responsible programs if this intervention is demonstrated to have a good potential to accelerate the recovery of the Chambo fishery in Lake Malombe and/or the South East Arm of Lake Malawi.

Evaluation of past experiences

Release of cultured juveniles

In the past, releases of juvenile Chambo were limited. They are known to have occurred in the South East Arm of Lake Malawi, Lake Malombe and the Upper Shire River, but the actions have been restricted to symbolic liberations of fish, e.g., during the launch of the "Save the Chambo" campaign. Nevertheless, there is capacity to produce and release larger numbers of fish for restocking programs. This was demonstrated in 2002, when the National Aquaculture Center, supported by the Japan International Co-operation Agency (JICA), released 10 000 *ningwi* (*Labeo cylindricus*) into the Upper Shire River.

Habitat enhancement

Interest in habitat enhancement of the lakes of Malawi, through artificial reefs and brushparks, is just emerging. Jamu et al. (2003) reported on the feasibility of improving fish production in Lake Chilwa using brushparks consisting of substrates from *Typha*, bamboo and *Sesbania* sp. Increases in production from such interventions are estimated to range from 0.4 to 0.7 $kg \cdot m^{-2} \cdot yr^{-1}$. Artificial reefs and fish aggregation devices have also been established at several sites in Lake Malombe (Collins Jambo, pers. comm.), although little is known about the abundance and species composition of fish associated with them. These artificial reefs were established to provide sanctuary for juvenile fish and broodstock. However, due to lack of enforcement measures, these additional habitats are currently exploited by fishers. This negates their intended use as the lack of enforcement has made the fish aggregated around the artificial reefs more vulnerable to capture.

Sanctuaries

Local communities have established fish sanctuaries in Lake Malombe but lack of monitoring and means for testing the effects of this potential management measure means that it has not been possible to evaluate its contribution to productivity. Anecdotal reports indicate that fishers in the Makanjila area of Lake Malawi are catching more Chambo from sites where they have placed large logs to prevent trawlers from catching fish (Moses Banda, pers. comm.).

A related example of the potential value of sanctuaries comes from Lake Chilwa. This sanctuary in the lower reaches of Lake Chilwa influent rivers is now used as a source of fish to replenish the lake when it refills after drying. This measure is now used in preference to restocking with hatchery-reared juveniles.

Aquaculture

Although there are successful cage culture operations for related species elsewhere in the Southern African Development Community (SADC) region, e.g., the *Oreochromis niloticus* in Massinjiri Reservoir, Mozambique and Lake Kariba in Zimbabwe (Windmar et al. 2000), there is little experience in rearing the Chambo species in this way. However, preliminary experiments have been done by commercial operators in the

South East Arm of Lake Malawi to produce the *Oreochromis karongae* in cages, and an enterprise expected to produce 3 000 t per year is being planned for the area.

Research needed to assess potential benefits

Restocking

Several pieces of information are required to determine whether releasing cultured juveniles into Lake Molambe and Lake Malawi to augment the remnant wild stock will add value to the other measures normally used to rebuild the spawning biomass to more productive levels. The various types of research needed to assemble this information for each species of Chambo in Malawi are outlined below.

Stock delineation

A thorough understanding of the size and distribution of the stock(s) supporting a fishery is essential to all forms of fisheries management, including restocking. In particular, managers need to know whether the fishery is based on a single homogeneous stock or comprised of multiple, largely self-recruiting, populations. A good indication of stock structure can be provided by a thorough analysis of the genetic population structure of the species, although it should be noted that some stocks can still be divided into relatively isolated units even when gene frequencies are generally homogeneous. Thus, other tools to help determine stock delineation, e.g., multivariate comparison of morphometrics or species composition of parasites, may also be important.

The reason that makes stock delineation so significant is that the objective of a restoration program is to rebuild the spawning biomass and, to be fully effective, the spawning biomass of all population units within the stock needs to be increased. Thus, when a fishery is based on more than one population unit, cultured juveniles will need to be added to all the units. It is also important to note, however, that adding more fish from just one source over the general area of the fishery will not necessarily be effective because each population unit can be expected to have local adaptations. Unless juveniles released into each population are derived from parents collected there, they may not have behaviors that can adapt for effective spawning.

Stock assessment

Once the stock structure of the fishery has been identified, the status (stock size and age structure) of the population(s) must be determined. Only then can managers assess whether the spawning biomass of the population(s) is too low to make it unlikely to recover quickly simply by implementing conventional management measures, or whether a total moratorium on fishing or a restocking program will also be required to restore the number of spawning fish to levels that will once again allow for regular substantial harvests. It is important to note that restocking is normally an expensive option; so restoration of the spawning biomass should be based on other forms of management whenever possible, provided they are effective within acceptable time frames.

An integral part of this process involves modeling to find out how long it will take the spawning biomass of each population to recover with and without restocking. To do this, the desired level of spawning biomass should be identified (e.g., 50% of the virgin level) and data need to be collected that will enable the potential contribution of restocking to be assessed. These data include the remnant stock size, generation times, fecundity, larval dispersal patterns, natural mortality rates at different life history stages, and behavior of the species that may affect spawning success or survival at low population density. Different restocking scenarios, e.g. variations in the frequency, number and survival rate of released animals and the subsequent survival of their F1, F2, F3 progeny, should also be examined. Generally, restocking is likely to be most beneficial when the initial stock size is very low and the generation times are long. In such cases, however, release of a large number of juveniles annually over a number of years may be needed.

Determine capacity of hatcheries to produce sufficient juveniles

If the modeling described above indicates that restocking will be beneficial, provision then needs to be made to ensure that the hatchery has the capacity to produce the required number of juveniles. If this cannot be done, the restocking program will not deliver the expected benefits. However, in cases where the capacity of the hatchery is limited, multiple and successive smaller batches could be produced, although this may mean that the restocking model needs to be adjusted.

Identify requirements of the young fish

To ensure that the cultured juvenile fish have the greatest possible chance of surviving and contributing to the spawning biomass, they must be released in ways and at times where they can avoid predators and find food. This involves a sound understanding of the distribution and abundance of their predators and identification of nursery habitats that provide the necessary protection. Field experiments should then be conducted to identify optimal release strategies (Blankenship and Leber 1995). This aspect of the research should be linked to experiments on how to increase the productivity of the Chambo through habitat enhancement (see below).

Components of a responsible restocking program

If the modeling described above indicates that the stock, or particular population units within the stock of a species, would benefit from restocking, careful attention should be paid to: (i) how the juvenile fish are produced and released; (ii) managing the restocked population(s); and (iii) determining the relative contributions of restocking to the restoration of the spawning biomass (Blankenship and Leber 1995; Munro and Bell 1997). The relevant components of a responsible restocking program are set out below.

Hatchery protocols to maintain the genetic diversity

The measures required to ensure that the natural gene frequencies are represented among the cultured fish are described by Munro and Bell (1997) and references therein. They include using large numbers of broodstock, replacing spawning animals regularly, ensuring that most broodstock spawn and preventing selective breeding among broodstock. If there are problems achieving any of these requirements they can usually be solved by releasing multiple cohorts derived from different parents. This results in a cumulative released population that has gene frequencies representative of the original wild stock. Where the analysis of stock structure indicates that there is more than one population unit in the fishery, juveniles should only be released in the area where the broodstock were collected. This will involve applying the protocols outlined above to separate groups of broodstock from each population unit.

Quarantine procedures

The increased risk of diseases infecting fish reared under intense monoculture in hatcheries is well known. Therefore, all batches of cultured fish to be released should be tested to ensure that they meet acceptable levels of pathogens and parasites existing prior to stocking them in the lake. This will not only help to safeguard the remnant wild Chambo, it will also reduce the risks to other species. Infectious agents are often more pathogenic in atypical hosts (Munro and Bell 1997; and references therein). To safeguard the great biodiversity of fish in the lakes of Malawi, responsible quarantine procedures must be a consistent part of any restocking program used to increase the productivity of the Chambo.

Management measures to maximize benefits

Unless appropriate measures to manage the fish released in a restocking program are implemented, there is a grave risk that the often expensive investment in hatchery production may be wasted. Such measures are usually quite simple in principle. There should be a total moratorium on the catching of the species until there has been replenishment of the spawning biomass to the desired level (Bell 2003). The practicalities are never quite as easy, however, particularly when the species under restoration is part of a multi-species fishery and vulnerable as by-catch. In such cases, gear modifications, and spatial and seasonal closures for fisheries of other species may also be needed to protect the species being restocked.

As outlined in the introduction, an effective moratorium on the capture of the Chambo until replenishment occurs is likely to cause short-term hardship for fishers. It is, therefore, important to explain the long-term benefits to them and the need for restraint, otherwise many people may assume that the release of fish means that there will now be more to catch. This would be a mistake. It is vital that fishers understand that the fish and their progeny need to be totally protected until the spawning biomass has reached to the point where the stock can once again yield sustainable harvests. It is also essential to inform fishers that the level of future sustainable harvest will have to be set at lower levels than in the past; otherwise, overfishing and stock reduction will just occur again.

Allocation of property or access rights to fishers prior to the moratorium will provide them with the incentive to comply because they will be the ultimate beneficiaries. However, the hardship that a restocking program imposes on fishers in the short to medium term needs to be recognized. If necessary, other incentives may need to be provided to target other species or transfer to alternative, related livelihoods, e.g., aquaculture of the *O. karongae*. Where such resources or occupations are unavailable, well-enforced temporary exit arrangements with appropriate financial compensation may be necessary.

Determine the contribution of restocking to the recovery

An important part of the responsible application of a restocking program is to measure the success of the intervention. It is important to be certain how recovery occurred and to determine the contribution of restocking to the recovery of the stocks. A genetic tag can be used for this purpose, because the F1, F2, F3, etc. generations derived from the released animals must be tracked so that their contribution to the restored biomass can be assessed in comparison with those individuals derived from the original remnant wild stock.

Adopt an ecosystem approach

As mentioned above, managers need to identify the desired spawning biomass of one or more species of the Chambo as the target for the restocking campaign. Given the strong demand for these species, however, there may be pressure to favor increasing the production of the Chambo species at the expense of other fish. If so, managers should think about the environmental costs and identify the most desirable species mix and levels of abundance of each species. If, on the other hand, the niche of the Chambo has been filled by other species and efforts to restore the spawning biomass prove to be difficult, managers may need to consider measures to reduce the abundance of competitors or key predators to facilitate the establishment of the desired stock sizes of the Chambo species.

Habitat enhancement

Nursery grounds for the Chambo species are located inshore and include inlets in the lakeshore, mouths of streams and reedy shores of the two lakes and the Shire River as well as clean sandy and rocky shores (Trewavas 1983). Chambo fry live in shallows at the water's edge among reeds in pools and lagoons, whereas juveniles (60-200 mm) live not far from the shore where they feed as adults (Bertram et al. 1942). In the South East Arm of Lake Malawi and Lake Malombe, nursery grounds have been degraded by the clearing of aquatic vegetation to construct beaches in front of resorts and cottages. Dragging seine nets along the substrate has also destroyed the nests built by the Chambo and disrupted their spawning.

Habitat restoration and enhancement, which includes rehabilitation of shoreline vegetation, and the establishment of artificial reefs and brushparks are necessary. The artificial reefs and brushparks, targeting fry and juveniles, are expected to have the twin benefits of reducing fishing mortality by preventing seining and lowering natural mortality by providing more shelter and food for the fry and juveniles.

To determine whether habitat restoration and enhancement will assist the recovery of the Chambo stocks, well-designed field experiments are now needed to assess the differences in abundance of juvenile Chambo associated with restored weedbeds, artificial shelters and bare substrata.

Sanctuaries

The two potential benefits can be envisaged of declaring sanctuaries for the Chambo. First, this should help protect aquatic habitats that provide nursery areas for juveniles, including places where habitats have been enhanced if the research described above was successful. Second, it would also protect a greater proportion of the spawning fish, leading to an increase in the supply of juveniles to areas outside sanctuaries that remain open to fishing. The design of experiments to test the importance of shelter habitats for Chambo described above can also be applied to nursery areas protected in sanctuaries.

The second hypothesis, involving the protection of spawning fish, predicts that the number and average size of spawning fish in sanctuaries should increase relative to fished areas, and that the abundances of juveniles in areas remaining open to fishing, but adjacent to sanctuaries, will be greater than in and around those areas that are not protected. Research to test these two predictions should be based on replicate samples from multiple sanctuaries and multiple areas that remain open to fishing before and after the sanctuaries are declared. The general models for such "before versus after, and impact versus control" sampling designs are described by Underwood (1992, 1995).

Sanctuaries will presumably play their greatest role once the Chambo stocks have been restored and when they can be tested as means of sustaining catches. This will require calculation of the number and area of sanctuaries needed to replenish each population unit within the fishery. However, it may also be necessary to use sanctuaries as part of the restoration process to prevent the fisheries of other species from damaging the nursery habitats.

Aquaculture

The key research questions to determine the potential for aquaculture to increase the productivity of the Chambo are: (i) identifying appropriate production methods and feeds; ii) selective breeding programs to achieve faster growth, better food conversion and disease resistance; (iii) development of criteria to select suitable sites; and (iv) determination of carrying capacity of the ecosystem.

Production methods and feeds

The low fecundity of the *Oreochromis karongae* and the other species of the Chambo, typically <1000 eggs per female annually (Trewavas 1983), poses a potential problem for producing a sufficient number of juveniles for large-scale cage culture. For example, it is estimated that it will be necessary to hold 20 000 broodstock to produce the 15-20 million juveniles needed to rear 3 000 t of the Chambo per year at the preferred market size. However, recent research at the National Aquaculture Center is pointing the way to a possible solution. High-quality juveniles can be obtained from spontaneous spawning of *O. karongae* in earthern ponds. This could pave the way for small-holders with ponds near the shore of the lake to supply juveniles to cage culture enterprises. Such a system would distribute the benefits of aquaculture to the rural poor and provide alternative livelihoods for people removed from the Chambo fishery during any moratorium to reduce effort and support a restocking program.

The viability of cage culture is also likely to depend heavily on the production of a suitable, low-cost feed. This may not be too much of a problem, however, because the Chambo have a planktivorous, omnivorous diet (Trewavas 1983) and so there should be scope for producing a formulated diet based partly on plant protein. This would reduce the cost of feed considerably and alleviate some of the environmental consequences of cage culture by lowering the level of nutrients stemming from aquaculture operations. Research is now needed to identify the minimum nutritional requirements of the Chambo for good growth and the most cost-effective way of producing diets that are based on agricultural products to the greatest extent possible.

Selective breeding

The technology that has been developed to improve *Oreochromis niloticus* through family selective breeding programs needs to be applied to the Chambo species selected for aquaculture. In the case of *O. niloticus*, the growth (body weight) rate was increased by 60% after six generations of selection (Dey 2000). It is essential, however, that the cage culture of the Chambo proceeds with safeguards to prevent the escape of the cultured fish. Otherwise, the fish selected for higher performance in aquculture may interbreed with the wild stock and lower their fitness. This would undermine the other components of the strategy to restore the production of the Chambo. The production of sterile YY males may help to address this problem.

Site selection

Careful thought needs to go into the location of cages for the culture of the Chambo. The criteria for site selection should not only be based on the requirements of the fish for good growth and survival. They should also ensure that the aquaculture operations have a minimal effect on the ecosystem and other fisheries. Measures will also have to be taken to secure access to suitable sites for cage culture enterprises.

Carrying capacity

As aquaculture is just one of the measures that should be used to increase the supply of Chambo, consideration must be given to the interaction between the culture operations and the wild fishery. Some of the relevant issues have been mentioned above. However, the overall carrying capacity of the lakes for the Chambo needs to be estimated so that decisions can be made about the proportion of optimum future production to come from aquaculture and the wild fishery. There is a lesson to be learned here from scallops in Japan, where a successful restocking and aquaculture campaign got out of hand at one stage. The combined biomass from aquaculture and the enhanced fishery caused "unexplained diseases", which reduced production and growth rates by 50% until the combined stocking densities were adjusted to match the carrying capacity of the ecosystem (Ventilla 1982).

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References

Bell, J.D. 2003. Management of restocking and stock enhancement programs: the need for different approaches. Proceedings of the Second International Symposium on Stock Enhancement and Sea Ranching (In press).

Bertram, R., C.K. Borley, H.J.H. Trewavas and E. Trewavas. 1942. Report on the fish and fisheries of Lake Nyasa. Crown Agents, London, 181 p.

Bland, S.J.R. and S.J. Donda. 1994. Management initiatives for the fisheries of Malawi. Fisheries bulletin No. 9. Fisheries Department. Lilongwe.

Blankenship, H.L. and K.M. Leber. 1995. A responsible approach to marine stock enhancement. Am. Fish. Soc. Symp. 15:165-175.

Bulirani, A.E., M.C. Banda, O.K. Pallson, O.L.F. Weyl, G.Z. Kanyerere, M. Manase and R. Sipawe. 1999. Fish stocks and fisheries of Malawian waters: resource report. Government of Malawi, Fisheries Department, Fisheries Research Unit, 54 p.

Dey, M.M. 2000. The impact of genetically improved farmed Nile Tilapia in Asia. Aquaculture Economics and Management 4:107-124.

FAO. 1993. Fisheries management in south east Lake Malawi, upper Shire and Lake Malombe. CIFA Technical Report 21, FAO, Rome, 113 p.

Jamu, D.M., K.M. Chaula and H. Hunga. 2003. A preliminary study on the feasibility of using brushparks for fish production in Lake Chilwa. Naga, The WorldFish Center Q. 26(1):4-8.

Manase, M.M., L.H. Mwenekibombwe, W. Namoto and O. Mponda. 2002. Analysis of catch and effort data for the fisheries of southeast arm of Lake Malawi. Fisheries Bulletin No. 52. Department of Fisheries, Lilongwe, Malawi.

Munro, J.L. and J.D. Bell. 1997. Enhancement of marine fisheries resources. Reviews in Fisheries Science 5: 185-222.

Palsson, O.K., A. Bulirani and M. Banda. 1999. A review of biology, fisheries and population dynamics of Chambo (*Oreochromis* spp., *CICHLIDAE*) in Lakes Malawi and Malombe. Fisheries Bulletin No.38. Fisheries Department, Malawi.

Trewavas, E. 1983. Tilapiine fishes of the genera Sarotherodon, Oreochromis and Danakilia. London. British Museum (Natural History), 583 p.

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impact on populations in the real, but variable, world. J. Exp. Mar. Biol. Ecol. 161:145-178.

Underwood, A.J. 1995. Detection and measurement of environmental impacts, p. 311-324. *In* A.J. Underwood and M.G. Chapman (eds.) Coastal marine ecology of temperate Australia. University of New South Wales Press, Sydney.

Ventilla, R.F. 1982. The scallop industry in Japan. Advances in Marine Biology 20:309-382.

Weyl, O.L.F. 1999. Lake Malombe artisanal fishery catch assessment 1994-98. NARMAP Technical Report No. 1, 23 p.

Weyl, O.L.F., M.C. Banda, M.M. Manase, W. Namoto and L.H. Mwenekibombwe. 2001. Analysis of catch and effort data for the fisheries of Lake Malombe 1976-1999. Fisheries Bulletin No. 45.

Windmar, L., S. Jarding and R. Paterson. 2000. Current status of tilapia aquaculture and processing in Zimbabwe, p. 595-598. *In* K. Fitzsimmons and J. Filho (eds.) Tilapia Aquaculture in the 21st century: Proceedings from the Fifth International Symposium on Tilapia Aquaculture, Panorma da Aqüaculltura, Rio de Janeiro, 682 p.

Culture-based production systems: Options for the Chambo in Lake Malawi and Lake Malombe

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Abstract

The drastic decline of the Chambo in Lake Malawi and Lake Malombe has sparked interest in its restoration to reach its maximum sustainable yield (MSY). The paper reviews several options that are applied worldwide and provides a synthesis of what could be done for the Chambo. Experiences from several countries, especially in Asia, have shown that culture-based production systems have resulted in high production of fish such as Tilapia and hence, if adopted in Malawi, can provide an alternative approach to increased fish production in Lakes Malombe and Malawi. The paper analyzes and compares management and production methods that can be used to enhance the Chambo stock in Malawi.

Introduction

To achieve its national goal and international obligations to restore the Chambo (*Oreochromis* spp.) fisheries of Malawi to their 1980 status by the year 2015 (DOF 2003), the national government is encouraging fisheries practices that will both protect existing stocks and replenish depleted stocks. Protecting existing stocks requires a comprehensive enforcement program while the replenishment of depleted stocks is a function of enhancement. The most common approaches to fisheries enhancement for inland water bodies are to increase the stock size (stock enhancement), introduce new species to broaden the catch structure (species enhancement) and improve the water quality through artificial eutrophication (environmental enhancement). The purpose of this paper is to analyze and compare management and production methods of enhancing the Chambo stock in Malawi. In doing so, this paper will specifically review the following culture systems: pond, pen and cage, tank, and raceway. In addition, the paper will also review the use of fish aggregation devices and their potential in the Chambo production.

Culture systems

Pond culture

Pond culture refers to the stocking of fish in an artificial pond or stream impoundment. Water is supplied from a watercourse diversion, reservoir or groundwater into the pond, which is constructed as a dugout (no dykes) or with dykes made of earth and/or concrete (Figure 1). According to Gietema (1999), ponds vary in size depending on their primary functions, i.e., for broodstock, nursery or on-growing (fattening). Broodstock ponds are used to hold the parent fish and usually range in size from 1 000 m^2 by 1 m deep. Nursery ponds are used for fry rearing and fingerlings and are usually 100-1 000 m^2 in area. On-growing ponds hold maturing fish until they have reached marketable size; they can range in size from 25 m^2 to larger than 100 ha.

In general, there are three main types of pond operations: extensive, semi-intensive and intensive. An extensive system has low inputs and low yields (0.1–0.3 $t \cdot ha^{-1} \cdot year^{1}$). A semi-intensive system requires some management and supplementary feeds to achieve higher outputs (1-5 $t \cdot ha^{-1} \cdot year^{1}$) than extensive systems. An intensive system requires high skill and high levels of inputs to achieve its high output (5-50 $t \cdot ha^{-1} \cdot year^{1}$) (Gietema 1999).

Figure 1. An example of a small-scale pond culture operation (from Coche 2000).

Bimbao and Smith (1988) summarized pond culture production systems in the Philippines reporting 0.4-1.5 $t \cdot ha^{-1} \cdot year^{1}$, although the level of intensification was not identified. For Israel, Sarig (1990) reports 3 $t \cdot ha^{-1} \cdot year^{1}$, 9 $t \cdot ha^{-1} \cdot year^{1}$ and 20-50 $t \cdot ha^{-1} \cdot year^{1}$ in extensive, semi-intensive and intensive ponds systems, respectively. Lazard et al. (1988) studied pond culture in Cote d'Ivore and found yields of 5.2–7.1 $t \cdot ha^{-1} \cdot year^{1}$ depending on the feed type; yields of 15 $t \cdot ha^{-1} \cdot year^{1}$ were also reported. ICLARM and GTZ (1991) report that in Africa yields of 0.1-0.5 $t \cdot ha^{-1} \cdot year^{1}$ and 1.0-5.0 $t \cdot ha^{-1} \cdot year^{1}$ are standard for extensive and semi-intensive systems, respectively.

As a system becomes more intensive, there is an increasing level of risk associated with the capital gains and losses. Capital is needed in the intensive system for infrastructure, processed feeds, skilled labor, higher stocking densities, disease control, fertilization, and machines for aeration and water circulation. Thus, the operation is less accessible to people without financing or expertise (ICLARM and GTZ 1991). In the intensive system there is also a corresponding risk associated with environmental degradation depending on how the inputs are obtained (e.g., stream diversion) and how wastes and other outputs are processed (e.g., downstream impacts) (Edwards et al. 2000). Depending on the design of the pond, possible environmental impacts include the disruption of the hydrological cycle, blockage of sediment transport, and the accumulation of effluents may cause high suspended solid counts and lack of oxygen in the water (ICLARM and GTZ 1991).

Pen and cage culture

Pen culture (Figure 2) refers to the use of framed net structures fixed to the substrate in open water environments (i.e., lake, river or ocean) and are widely used for rearing and fry production in marine "sea-ranching" industries in both Japan and North America (Piper et al. 1982). Cage culture (Figure 3) systems utilize a similar structure as pen culture, only in this case, the structure floats at the surface level and is anchored to the substrate.

Cage and pen culture is applicable where water cannot be drained (i.e., from a pond) or where harvesting a large area is inefficient. The overall costs of constructing a pen or cage is often lower than pond construction (ICLARM and GTZ 1991; Lazard et al. 1988) although finding a suitable site may prove difficult along high-energy shorelines.

Yields vary by a wide range in pen and cage culture systems around the world. Tantikitti et al. (1988) mention results of a pen culture growth experiment of *Tilapia* (*O. niloticus*) in Thailand at 5–17 $t \cdot ha^{-1}$ depending on the feed type. Morissens et al. (1988) report a production of 60 $t \cdot ha^{-1} \cdot year^{1}$ in pen culture systems in brackish waters in coastal Benin. ICLARM and GTZ (1991) state that production can range from 25 to 220 $t \cdot ha^{-1} \cdot year^{1}$ in African cage and pen systems.

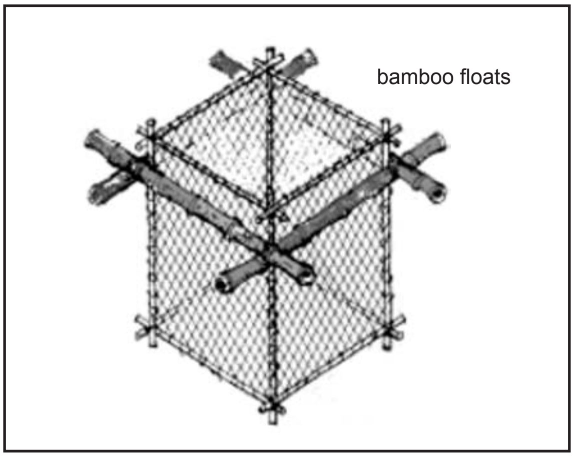

Figure 2. An example of a net cage (from Coche 2000).

While the construction costs of pen or cage culture suggest low start-up capital requirements, there is a risk of incorporating higher costs in other portions of the production cycle and in areas adjacent to the pen or cage itself. With an increase stocking density relative to many pond culture systems, disease management becomes a more

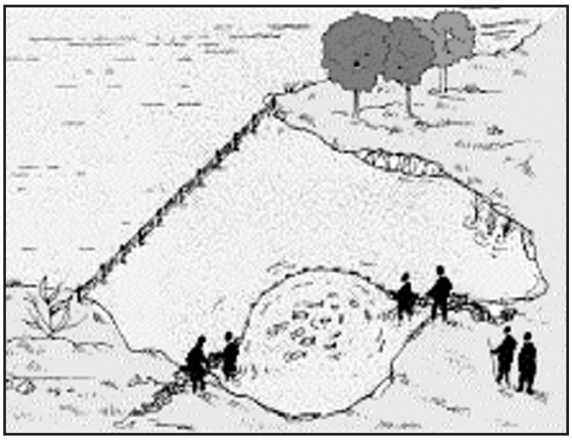

Figure 3. A shoreline fish pen (from Coche 2000).

prevalent issue limiting production and increasing the costs of maintenance (i.e., treatment). Muir et al. (2000) point out that in Israel 30-60% of *Tilapia* spp. aquaculture production is lost due to the *Streptococcus* bacteria in intensive systems. Such intensive systems can also cause anoxia in the benthos where circulation is inadequate, thus, limiting feed, oxygen and nutrient availability (ICLARM and GTZ 1991).

Management of pen and cage culture systems must address the cumulative impact of closely grouped operations or face reduced production in downstream users and other stakeholders in the aquatic resource (e.g., drinking water). Capture fisheries may also suffer if pens are sited in traditional fishing, fry rearing or breeding areas along the shoreline (ICLARM and GTZ 1991).

Tank and raceway culture

The most capital-intensive method of fisheries enhancement is the use of metal or concrete tanks with flow through water, high stocking densities (e.g., 50 $kg \cdot m^{-3}$), processed feeding, and control over physical and chemical water qualities. This system has been in use for *Tilapia* spp. in Kenya since 1975 and in other African countries such as Nigeria, Egypt, and Zambia (ICLARM and GTZ 1991). Productivity of the tank and raceway system is the most efficient means of producing fish protein at 2 000 $t \cdot ha^{-1} \cdot year^{-1}$ (ICLARM and GTZ 1991).

High capital costs for these systems make financing difficult and an ample market demand must be in place to make the venture profitable. The consumption of inputs such as freshwater and electricity (e.g., to operate pumps and quality control equipment) and the removal of waste outputs (i.e., effluents) require consideration in any environmental impact analysis. The suitability of the Chambo to this system is also questionable.

The prevailing view among aquaculture researchers is that the Chambo is difficult to grow to marketable size in captivity due to early maturation. Masuda et al. (2004) argue that if placed in suitable environmental conditions, then *Tilapia* spp. fishes can avoid early maturation and reach marketable size. Tank and raceway culture presents the best opportunity to deliver ideal conditions in intensive production systems as complete control over inputs is possible, unlike cage, pen or pond culture. The economic advantages of this approach must then be compared to ranching for which inputs are less intensive but with reduced productivity as well.

Habitat and fishery enhancement

Fish aggregation devices

Fish Aggregation Devices (FAD) are used in open water systems to attract prey species, target species and increase the production of the aquatic community. In freshwater environments this system is used widely in Mexico, Ecuador, Southern Asia and in some countries in Africa, namely Benin, Madagascar, Liberia, Cote d'Ivore, Sierra Leone, and Malawi (ICLARM and GTZ 1991). While these systems around the world with differ with various cultural and biophysical factors at play, the underlying principle of a FAD is the deliberate manipulation of sub-aquatic structures to attract target species. When it is time to harvest a net is encircled around or placed within the FAD, which is then removed to allow for the capture of the fish.

The main types of FAD in Africa are known as brushparks in West Africa, *acadja* in Benin and *vovomora* in Madagascar (ICLARM and GTZ 1991). In general, these systems utilize woody vegetation 2-2.5 m in length planted in the substrate to attract fish, and use some type of fence surrounding the brush to trap them. Thus, the start up capital is low for infrastructure, and, although supplementary feeding can be utilized, these systems are generally considered semi-intensive.

According to Balarin (1987) production rates from FAD, depending on the design, can range from 5 to 38 $t \cdot ha^{-1} \cdot year^{-1}$. Owing to the addition of brush wood over time, productivity of the brushpark increases as older vegetation decays and adds nutrients to the system. Experiments in Malawi with brushparks in Lake Chilwa (Jamu et al. 2003) and on fish farms (Chirwa 2004) have met with only minor or negligible increases in productivity compared to the control.

With a brush wood replacement rate of 30-75%, the demand for forest products to support the brushwood system is high, up to 60 $t \cdot ha^{-1} \cdot year^{-1}$(ICLARM and GTZ 1991). In coastal Benin where this practice is widely used, deforestation has become a serious problem and the subsequent siltation of the fishing areas has had further drawbacks to the productivity of this aquatic ecosystem. As with the cage/pen systems, occupation of the near shore areas by brushpark operations can reduce the availability of spawning and rearing habitat for capture fisheries.

Fish ranching

Fish ranching is an integration of aquaculture with capture fisheries in which the young are hatched and reared in a controlled environment such as a pond, net cage or pen until they reach a target size, and then they are released into open waters to grow to marketable size. This is a common enhancement technique used in marine fisheries such as the salmon fisheries of North America and the Baltic countries (Piper et al. 1982).

Because fish are released into open waters, productivity is low per unit area, approximately 0.05-0.3 $t \cdot ha^{-1} \cdot year^{-1}$ (ICLARM and GTZ 1991). However, this does not reflect the overall productivity of the fishery as traditional capture fisheries using efficient harvesting technologies can be employed in the open water environment.

Conclusion

The choice of system to adopt must take into account the goals of the operation (i.e., profit, integration, or supplementary diet), availability of resources (i.e., expertise, labour, finances, raw resource inputs or waste disposal resources) and the suitability of the Chambo to be produced within a particular enhancement system. A comprehensive research plan that addresses the suitability of these enhancement systems to the Chambo production must be developed, including the analysis in both closed and open water systems. Furthermore, policy makers, donors and resource managers must carefully examine the impacts of each approach on the surrounding economies and environments where enhancement programs are planned. Lastly, each enhancement system requires a corresponding resource management strategy to ensure its sustainability and compliance with regulations from local communities and external investors. Benefits of enhancing the Chambo stocks in Malawi can be realized but these gains must be weighed against the environmental and socio-economic costs of intensifying production.

References

Balarin, J.D. 1987. Aquaculture practices in Africa: an overview, p. 242-282. *In* Anon (ed.) Proceedings, SADCC workshop "The Development of Village Level and Commercial Aquaculture in the SACC Region", Kariba, Zimbabwe, 29 September-3 October 1986, 373 p. Fisheries Department, Lilongwe. (mimeo).

Bimbao, M. and I. Smith. 1988. Philippine tilapia economics: industry growth and potential, p.539-552. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Mclean (eds.) The second international symposium on tilapia in aquaculture, Bangkok, Thailand, 16-20 March 1987. ICLARM Conference Proceedings 15, 623 p. Department of Fisheries, Bangkok, Thailand, and International Center of Living Aquatic Resources Management, Manila, Philippines.

Chirwa, B. 2004. Preliminary study on the utilization of bamboo substrates to enhance heterotrophic food production in fishponds for the growth of *Tilapia rendalli* in Malawi. Technical Report No. 9:72-76. *In* K. Masuda, B. Chirwa and G. Ntenjera (eds.) A contribution to the development of rearing techniques in fish farming in Malawi. National Fisheries Center, JICA and Domasi, Malawi.

Coche, A. 2000. Handbook on small-scale freshwater fish farming. CD-Rom. FAO Training Series, Rome.

Department of Fisheries. 2003. Ten-year national strategic plan for the restoration of the Chambo fishery in Malawi. National Stakeholders' Consultative Workshop, 14-16 May 2003, Boadzulu Holiday Resort, Mangochi, Malawi.

Edwards, P., C. Lin and A. Yakupitiyage. 2000. Semi-intensive pond aquaculture, p. 377-404. *In* M. Beveridge and B. McAndrew (eds.) Tilapias: Biology and exploitation, Kluwer, 505 p.

Gietema, B. 1999. Fish farming in tropical fresh water ponds: Book 1. STOAS, 175 p.

ICLARM and GTZ. 1991. The context of small-scale integrated agriculture-aquaculture systems in Africa: a case study of Malawi, 302 p.

Jamu, D., K. Chaula and H. Hunga. 2003. A preliminary study on the feasibility of using brushparks for fish production in Lake Chilwa, Malawi. Naga, The WorldFish Center Q. 26(1):4-8.

Lazard, J., P. Morrisens and P. Parrel. 1988. Artisanal aquaculture of tilapia in Africa: comparative analysis of different culture systems and their level of development, p. 41-52. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J. Mclean (eds.) The second international symposium on tilapia in aquaculture, Bangkok, Thailand, 16-20 March 1987. ICLARM Conference Proceedings 15, 623 p. Department of Fisheries, Bangkok, Thailand, and International Center for Living Aquatic Resources Management, Manila, Philippines.

Masuda, K., B. Chirwa and G. Ntenjera. 2004. A contribution to the development of rearing techniques in fish farming in Malawi JICA, Malawi, 253 p.

Morissens, P., P. Tauzes, P. Roche and C. Aglenglo. 1988. Net pen rearing of *Oreochromis* spp. in the lagoons of Bénin, p. 587. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Mclean (eds.) The second international symposium on tilapia in aquaculture, Bangkok, Thailand, 16-20 March 1987. ICLARM Conference Proceedings 15, 623 p. Department of Fisheries, Bangkok, Thailand, and International Center for Living Aquatic Resources Management, Manila, Philippines.

Muir, J., J. van Rijn and J. Hargreaves. 2000. Production in intensive and recycle systems, p. 405-446. *In* M. Beveridge and B. McAndrew (eds.) Tilapias: biology and exploitation, Kluwer, 505 p.

Piper, R., I. McElwain, L. Orme, J. McCraren, L. Fowler and J. Leonard. 1982. Fish hatchery management. USDoI, Washington, 517 p.

Sarig, S. 1990. The development of polyculture in Israel: a model of intensification, p. 302-332. *In* J. Shepardand N. Bromage (eds.) Intensive fish farming. BSP Professional Books, 404 p.

Tantikitti C., N. Rittibhonbhun, K. Chaiyakum and R. Tansakul. 1988. Economics of tilapia pen culture using various feeds in Thale Noi, Songkhla Lake, Thailand, p. 569-574. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Mclean (eds.) The second international symposium on tilapia in aquaculture, Bangkok, Thailand, 16-20 March 1987. ICLARM Conference Proceedings 15, 623 p. Department of Fisheries, Bangkok, Thailand, and International Center for Living Aquatic Resources Management, Manila, Philippines.

Environmental impacts on the growth and survival of the *Oreochromis karongae* in captivity

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Abstract

The objective of the study was to determine the interactions of physico-chemical factors on the growth and survival of the *Oreochromis karongae* raised on low cost farm bio-resource inputs. The maximum yield of 618.3 kg·ha·$^{-1}$·225 days^{-1} and the minimum yield of 237.0 kg·ha·$^{-1}$·225 days^{-1} were recorded from inputs of chicken grower's mash plus grass, and grass only treatments. The survival was highest (55-71%) in treatments where morning-dissolved oxygen values were above 5.3 mg·l^{-1} and the lowest yields were obtained where dissolved oxygen was less than 4.5 mg·l^{-1}. Multiple regression analysis showed that chicken mash, napier grass and poultry manure inputs accounted for 72.5% (adjusted r^2=0.72, P=0.038) of the growth variation. In low input treatments, however, the water quality was variable and this adequately explained this growth variation. Phosphorus (adjusted r^2=0.56, p=0.015) explained significant growth variations. The pH and electrical conductivity (adjusted r^2=0.71, p=0.0030) explained growth variations in high input treatments suggesting a general nutrient deficiency in the system. Ammonia, pH and temperature explained variations observed in fish survival (adjusted r^2=0.56, P=0.010). Dissolved oxygen significantly explained variations observed in both growth and survival (r^2=0.76, P=0.002). To confirm these observations, the *Oreochromis karongae* was raised at two sites of different water quality variables: in relatively soft water (pH=6.50, total hardness=70.90 mg·l^{-1}, total alkalinity=20.00 mg·l^{-1}) and hard water (pH=8.96, total hardness=120.90 mg·l^{-1} and total alkalinity=150.00 mg·l^{-1}). The base saturation in soil at the two sites was low (30-70%) and high (80-100%), respectively. Fish growth increased from the average weight of 7-10 g to 80 g and 300 g, respectively, in 290 grow-out days. This growth response translated to specific growth rates of 0.93 and 1.47%. Water quality factors could not explain 27.5% of the growth variations, suggesting a potential for genetic improvement of the *Oreochromis karongae* once environmental and genetic interactions are exploited.

Introduction

Msiska and Costa-Pierce investigated successfully reproduction in captivity of the *Oreochromis karongae* (subgenus *Nyasalapia*) (Msiska and Costa-Pierce 1997). The use of cage nets or "hapas" and exogenous hormones resulted in consistent spawning success. These results might be applied on a larger commercial scale. On the other hand, results of growth performance have been inconsistent (Msiska and Costa-Pierce 1996; Maluwa et al. 1995).

Previous studies have isolated some of the environmental factors vital to fish growth and mortality in both wild and captive populations (Mann 1992, 1993; Mann and Drinkwater 1994) and in fish ponds (Boyd 1990; van Dam 1990a; Prein et al. 1993). Generally, high natural variability of environmental factors and multicollinearity make it difficult to estimate their respective contributions to growth and survival. Pauly (1980) was able to demonstrate a strong relationship among several factors: mortality, growth constant, length and average annual surface water temperature in natural fish populations. This finding has found worldwide application and acceptance (FAO 1993). However, the influence of environmental factors on the performance of the *O. karongae* has yet to be quantified, although high growth rate was demonstrated in ponds (Msiska and Costa-Pierce 1996; Msiska 1998).

The growth rates of wild populations in Lake Malawi and Lake Malombe of the endemic tilapias species of the Chambo group, *Oreochromis lidole*, *Oreochromis squamipinnis*, and *Oreochromis karongae*, are relatively high (Lowe 1952). The mean total lengths of 9-13 cm are attained in the first year, 17-23 cm in the second year, 24-28 cm in the third year and 26.5-30.0 cm in the fourth year. When transferred into ponds and stocked at low densities and fed good quality feeds, the *O. karongae* and *O. squamipinnis* grew to a large size of $L\infty$=23.6-31.3 cm and $W\infty$=537-891 g in 275 days (Msiska and Costa-Pierce 1996). In polyculture, however, there was a significant depression in growth (Maluwa et al. 1995). On average, the *O. karongae* grew from 54 g to 104 g in 112 days. This shows a significant discrepancy in growth performance. The species is naturally pelagic and inhabits open waters of relatively high alkalinity (2.45 $meq \cdot l^{-1}$), pH (7.8-9.0), electrical conductivity (215-230 $\mu S\ cm^{-1}$) and water temperatures of 22.0-29.0°C (Fryer and Iles 1972; Menz 1995). Could water quality factors hold the answer to observed differences in fish growth?

Boyd pointed out that investigating environmental factors can be complicated by the fact that interactions are along both biological and chemical lines (Boyd 1990). For this study, multiple regression analysis determined the critical predictor variables in the growth of captive *O. karongae*. Prein et al. (1993) applied this technique to explain fish growth and showed its robustness in capturing multiple factors implicated in what Pauly and Hopkins (1983) referred to as the "black box".

Alteration of water quality through the addition of lime, fertilizers or manures, feeds or combinations thereof affects tilapia production in ponds (Miller 1975; Boyd 1990). Many studies have shown positive simultaneous effects of environmental factors on the performance of the *Oreochormis niloticus* under various conditions. Boyd (1990), Prein et al. (1993) and van Dam (1990a) conducted the most notable studies. Similar studies were thought to be appropriate for the *Oroechromis karongae* because of the open water preference in lakes of its origin where growth performance is comparable to the best growing tilapia, *Oreochromis niloticus* (Msiska and Costa-Pierce 1996). The study may also enhance knowledge about the most suitable aquaculture system for this fish.

Materials and methods

Source of fry and fingerlings

The parent stocks of *O. karongae* were caught from Lake Malawi and Lake Malombe between September 1989 and March 1990. Since immature fish of three species, namely *O. squamipinnis*, *O. lidole, O. karongae*, occur in the same habitat and are difficult to separate, captured fish were left to grow to over 100 g to allow nuptial colors to develop in order to aid identification. Taxonomic characteristics for separating these fish have been outlined by Turner et al. (1989). First generation offspring raised on the farm were used in these experiments. Each pond of 200 m^2 and 0.8 m depth was stocked with 100 fish weighing 14.2±3.8 g (mean and standard deviation).

Bio-resource inputs into fish ponds

The experiment covered 24 ponds. Combinations of bio-resource inputs comprised: chicken grower's mash; and napier grass and poultry manure were added into the ponds at equivalent rates of 0.04 $kg\ N \cdot day^{-1} \cdot pond^{-1}$, 1.36 $kg\ N \cdot day^{-1} \cdot pond^{-1}$ and 0.23 $kg\ N \cdot pond^{-1}$, respectively. Each treatment was replicated twice using a completely randomized design. The experiment lasted for 225 days.

Sampling of fish

The growth rate was estimated from the average weights obtained from a random sample of at least 15 fish from each pond fortnightly. Every fish was weighed and had its total length measured in centimeters to the nearest one decimal point. Multiple regression analysis was conducted on fish growth and water quality variables.

Determination of water quality factors

Selected water physico-chemical factors were measured from each pond at 05h00-08h00 every fortnight. Values for each treatment were compiled from the replicates. An YSI meter measured the electrical conductivity. Analytical methods were according to APHA (1995). The total hardness and total alkalinity were determined titrimetrically using ethylenediam inetretraacetic acid (EDTA), phenolphthalein and methyl red. The Nessler method estimated the ammonia while phosphorus required the molybdenum complexiometric technique. Both elements were absorbed on a spectrophotometer.

A Horiba meter determined the pH. Within one hour of sampling all analyses were completed to minimize *ex situ* changes.

Comparison of fish growth at two sites: Domasi and Kasinthula (southern Malawi)

In order to confirm differences in fish growth under varying environmental conditions, the growth performance was compared in two unreplicated ponds located at Domasi and Kasinthula, respectively, at a stocking density of one fish (7-10 g mean weight) per 1 m^2. Kasinthula is located in the Lower Shire Valley, which is a wetland extension of the Zambezi River, at 80 m above sea level. It has a mean air temperature of 25°C and a maximum of over 40°C. Soils are of the calcimorphic alluvial type with a base saturation of 80-100%. The pH of the soils is between 7.0 and 8.5. The second site at Domasi is 750 m above sea level. The mean air temperature is 22.1°C with a maximum of over 33°C. The soils are classified as latosols of the ferrallitic type with a base saturation of 30-70%. The pH of the soils varies between 4.0 and 4.5. The two sites are 75 km apart.

The experiment lasted from March 1991 to February 1992. Owing to the distance between the sampling sites, physico-chemical analyses for electrical conductivity, pH, dissolved oxygen, total alkalinity, total hardness, nitrogen and orthophosphate were conducted at the beginning, middle and end of the experiment. The data were sparse and not included in a multiple regression analysis.

Data analysis

The fish growth was calculated by the formula given by Gulland and Holt (1959) as follows:

$\Delta L/\Delta t = L\ (t + \Delta t)\text{-}L\ (t)/\Delta t$

Multiple regression analysis was conducted according to Zar (1984). In order to verify whether the assumptions of linear regression (zero mean error, constant error variance, independent error) were indeed satisfied, residual plots were examined for structural patterns (i.e. plots of residuals against every X and the estimated Y), and the Durbin-Watson statistics (Durbin and Watson 1951; Zar 1984). The Durbin-Watson statistics were compared with dL and du to test autocorrelation.

Growth data of fish from the unreplicated experiment conducted at the two sites were calculated according to the following formula:

$SGR\ \% = \{(\ln W_t\text{-}\ln W_o)/t\} \times 100$

where W_t = final body weight, W_o = initial body weight, and t = time interval.

All statistical tests conducted used Microstat Software (Ecosoft Inc., USA).

Results

Table 1 provides a summary of the fish yields, growth and survival, while water quality results for Domasi and Kasinthula are presented in Table 2.

As expected, the lowest growth rate was recorded in the no input treatment (control) while the highest growth rate was achieved in the grass plus grower's mash treatment (Table 1). A mixed suite of all inputs did not necessarily produce the best production. Instead there was a significant drop ($P<0.05$) in yield from 618.3 to 280.0 $kg \cdot ha^{-1} \cdot 225\ days^{-1}$ when poultry manure was added. When the value of chicken grower's mash input was raised from 2.5% to 5.0% of the fish body weight, yields increased from 320.0 to 431.1 $kg \cdot ha^{-1} \cdot 225\ days^{-1}$.

The overall ANOVA test did not show any significant differences in the fish yield among the treatments ($F_{ratio}=4.05$, $P=0.059$).

A correlation matrix was constructed to identify multicollinearity (Table 3). A cutoff point (±0.499) was included as a factor in the model.

This criterion indicated that the following factors were significantly correlated: initial body weight and ammonia levels; chicken grower's mash and ammonia levels; grass and ammonia levels; poultry manure and alkalinity; poultry manure and dissolved oxygen; poultry manure and phosphorus levels; alkalinity and ammonia levels; initial body weight and dissolved levels; initial body weight and phosphorus levels; final body weight and phosphorus levels; and dissolved oxygen levels and growth rate.

Electrical conductivity was correlated to several physico-chemical parameters (ammonia, pH, alkalinity, dissolved oxygen and phosphorus).

Table 1. Yield and survival of the *Oreochromis karongae* raised at the NAC, Domasi, Malawi, using various inputs. Fish were stocked at 10 000 fish·ha^{-1} in all treatments.

Treatments	Replicate	Initial weight (g)	Final weight (g)	Survival	Net yield (kg·ha^{-1})
No input (control)	1 2	22.0 10.2	45.90 25.5	36.5 74.5	307.5 260.0
	Average	16.6	35.7	55.5	283.0
Chicken grower's mash (2.5% BWD)	1 2	15.1 13.4	35.1 49.4	99.5 42.5	430.0 210.0
	Average	14.3	42.3	71.0	320.0
Chicken grower's mash (2.5%)+ grass	1 2	10.7 13.8	64.3 57.1	31.5 35.0	312.5 250.0
	Average	12.3	60.7	33.3	281.3
Poultry manure	1 2	11.8 4.0	112.9 54.2	17.5 48.0	190.0 290.0
	Average	7.9	78.6	24.0	240.0
Poultry manure + grass	1 2	10.9 15.7	84.6 77.6	26.0 29.0	280.0 340.0
	Average	13.3	81.1	27.5	310.0
Chicken grower's mash (2.5%BWD) + Poultry manure	1 2	13.3 10.1	77.3 69.0	22.0 56.5	200.0 390.0
	Average	11.7	73.3	39.3	295.0
Grass + Poultry manure + Chicken grower's mash (2.5% BWD)	1 2	6.6 13.0	66.7 38.3	13.5 47.0	11.0 450.0
	Average	9.8	52.2	30.3	280
Grass	1 2	9.1 23.1	37.7 40.4	63.5 47.5	280.0 195.0
	Average	16.1	39.1	55.5	237.5
Chicken grower's mash (5% BWD)	1 2	15.8 21.1	66.8 198.8	46.0 23.5	377.5 485.0
	Average	18.5	132.9	34.8	431.3
Chicken grower's mash (5% BWD)	1 2	16.7 20.4	100.9 87.5	56.5 72.5	570.0 666.5
	Average	18.6	94.2	64.5	613.3
Grass + Poultry manure	1 2	19.9 18.2	70.9 116.7	39.5 41.5	230.0 455.0
	Average	19.1	93.8	40.5	367.5
Chicken grower's mash (5%) + Poultry manure + Grass + grower's mash (5%)	1 2	9.2 29.2	73.5 88.9	27.5 13.5	245.5 210.0
	Average	19.2	81.2	20.3	227.3

Table 2. Summary of water quality parameters recorded in *Oreochromis karongae* ponds at Domasi and Kasinthula, southern Malawi. Values are means and standard deviations.

Parameter	Domasi	Kasinthula
PH	6.50	8.96
Orthophosphate (mg·L^{-1})	0.80±0.12	0.50±0.08
Total nitrogen (mg·L^{-1})	1.30±0.28	0.94±0.20
Total hardness (mg·L^{-1})	70.90±0.70	120.9±03.10
Total alkalinity (mg·L^{-1})	20.00±0.99	150.00±5.90
Electrical conductivity (μmho·cm^{-1})	94.60±6.18	163.30±10.50
Calcium (mg·L^{-1})	34.30±2.22	51.70±2.16
Magnesium (mg·L^{-1})	36.60±3.05	68.30±5.70

Table 3. Correlation matrix to identify multicollinearity. Number of cases (12) and number of variables (14).

	sgr	ibw	fbw	rec	mash	grass	manure
sgr	1.000.00						
ibw	-0.39334	1.000.00					
fbw	*0.7522	-0.37233	1.000.00				
rec	-0.28934	0.16304	-0.11086	-0.28421	0.3416	1.000.00	
mash	0.30461	0.27543	0.20654	-0.28421	0.03416	1.000.00	1.000.00
grass	0.05372	0.28949	-0.03949	-0.36996	0.03416	0.16903	*0.57616
manure	0.48609	-0.18161	0.10937	*-0.68188	-0.03835	0.16903	1.000.00
cond	0.26404	0.54129	0.11464	-0.52896	0.48229	0.37497	-0.02814
ammonia	0.21571	*0.70553	0.2093	*-.80201	*0.66073	0.41621	-0.41208
pH	-0.1529	-0.50807	0.10185	0.39091	*-0.08285	-0.53402	-0.52264
alk	0.24621	0.52826	0.13469	0.44361	-0.39567	-0.31809	*-0.73818
do	-0.45679	-0.38918	-0.0936	*0.57132	-0.39567	-0.31809	*-0.73818
temp	0.40074	-0.12812	0.31092	-0.39942	0.01827	0.3489	0.47633
phosph	0.21656	0.33808	0.00658	-0.52326	0.41611	0.06051	*0.628251
	ammonia	**pH**	**alk**	**do**	**temp**	**phosph**	
ammonia	1.000.00						
pH	-0.4194	1.000.00					
alk	*0.70569	*0.59599	1.000.00				
do	*-0.56863	*0.712674	*-0.83692	1.000.00			
temp	-0.19995	0.13086	0.15083	-0.35822	1.000.00		
phosph	0.40435	-0.6152	*0.88242	*-0.81862	0.0341	1.000.00	

Footnotes: 5% Significance > -0.574 or < -0.574.
* denotes significant correlations.
Key: ibw=initial fish body weight (g); fbw=final fish body weight (g); rec=fish recovery (%); mash=chicken layers mash (g); cond=electrical conductivity (μmho·cm^{-1}); do=dissolved oxygen (mg·l^{-1}); alk=alkalinity (mg·l^{-1}); temp=water temperature (ºC); phosph=total phosphorus (mg·l^{-1}).

Table 4. Multiple regression models of specific growth rate as the dependent variable using various inputs in *Oreochromis karongae* ponds.

Independent variables	B		SE	Beta
Initial Body Weight (g)	-0.0178		0.01092	-0.3619
Final Body Weight (g)	0.00347		0.001288	0.51117
Recovery (%)	0.006244*		0.003394	0.5286
Grower's mash (kg/week)	0.0175*		0.008038	0.4692
Napier grass (kg/week)	0.06309*		0.005173	2.4402
Poultry manure (kg/week)	0.02502		0.008562	0.7017
Constant (a)		0.17		
Adjusted R^2		0.72		
F Value		5.661		
Probability		0.0384		
Durbin-Watson		1.2885		

Table 5. Multiple regression models for recovery percentage.

Independent variables	b		SE	Beta
Grower's mash	-2.395		0.962	-0.756
Napier grass	-0.661		0.686	-0.301
Ammonia	72.568**		23.387	1.1352
PH	56.778*		46.241	0.455
Alkalinity	-1.274		1.139	-0.4266
Temperature	-24.17		12.583	-0.4266
Constant		140.171		
Adjusted R^2		0.563		
F Value		3.357		
Probability		0.01035		
Durbin-Watson Test		2.1142		

Table 6. Multiple regression models of the Gulland-and-Holt function as the dependent variable in the grower's mash (5% BWD), poultry manure and grass treatment.

Independent variables	b		SE	Beta
Conductivity	0.021**		0.00507	0.3125
Ammonia	0.212**		0.9	-0.215
Temperature	0.08		0.25	0.0516
Constant		-3.048		
Adjusted R^2		0.652		
F Value		7.232		
Probability		0.015		
Durbin-Watson Test		2.0174		

Table 7. Multiple regression models for grass and chicken grower's mash (5% BWD) inputs.

Independent variables	b		SE	Beta
Dissolved oxygen	0.939**		0.161	1.9556
Phosphorus	-0.247		0.75	1.1023
Constant		-0.507		
Adjusted R^2		0.755		
F Value		16.406		
Probability		0.0015		
Durbin-Watson Test		2.0987		

Table 8. Multiple regression models for chicken mash (5%) and poultry manure treatment.

Independent variables	b		SE	Beta
Dissolved oxygen	0.163**		0.04	0.4013
Phosphorus	-0.018		0.039	-1.013
Constant		0.078		
Adjusted R^2		0.596		
F Value		8.387		
Probability		0.0109		
Durbin-Watson Test		2.1234		

Multiple regression results (Table 4) showed that the fish growth rate was explained mostly by inputs of chicken grower's mash, napier grass and poultry manure (adjusted r^2=0.72, P<0.0384). Mortality was significantly and positively correlated with inputs of napier grass, poultry manure, and negatively correlated with ammonia, pH and dissolved oxygen levels (adjusted r^2=0.563 P<0.0104). In the treatment where 5% of the body weight of chicken grower's mash was added to the poultry manure and grass, conductivity, ammonia, and temperature significantly explained the fish growth (adjusted r^2=0.652, P<0.0150) (Table 7). When the same treatment was repeated with reduced input of chicken grower's mash to 2.5% of the body weight (Table 8), dissolved oxygen was the main predictive variable (adjusted r^2=0.74, P< 0.006). The addition of poultry manure and 5% of the body weight chicken grower's mash led dissolved oxygen to be a significant predictive variable (adjusted r^2=0591, P<0.0259).

Results of unreplicated growth comparisons of the *O. karongae* in two different environments at Kasinthula and Domasi are presented in Figure 1. These results show that the specific growth rate at Domasi was lower (0.93%) compared with that of Kasinthula (1.47%).

Discussion

Considering that relatively high level of inputs of bio-resource inputs were added, the results of fish yields were inferior to experiments done elsewhere (Boyd 1990; Pullin et al. 1989; Pullin et al. 1996). The growth of the *Oreochromis karonage* in the chicken grower's mash treatment was adversely affected by the addition of poultry manure and Napier grass while mortality was affected by dissolved oxygen levels.

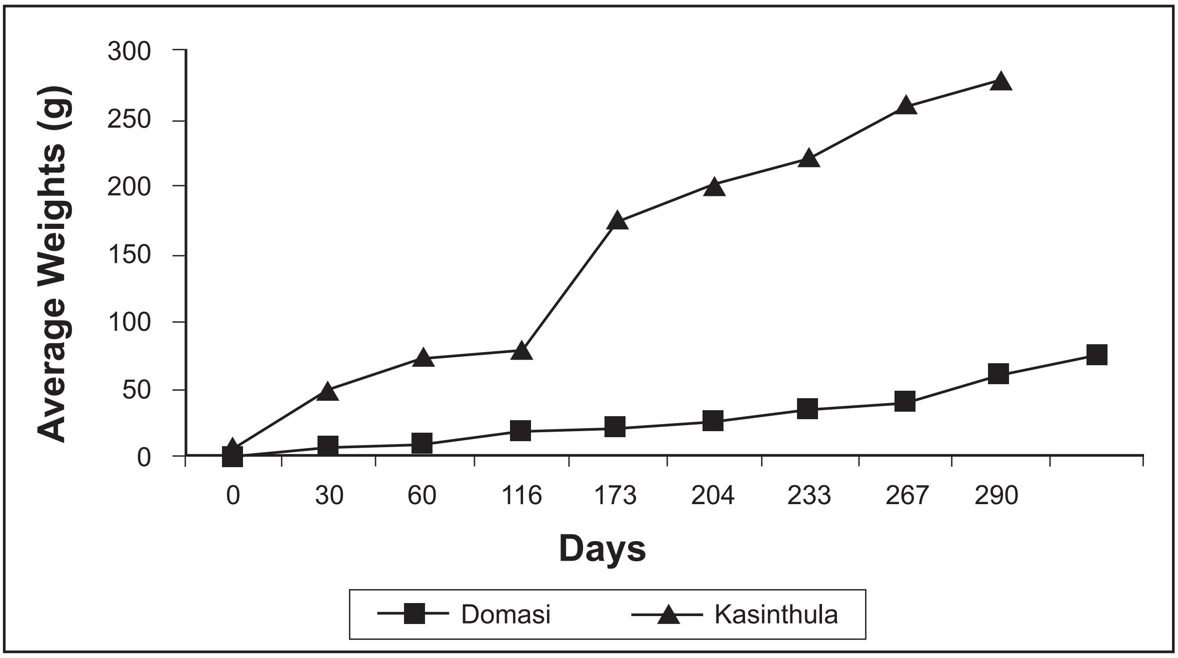

Figure 1. Plot of measures of population variation; mean±se observed (na) and effective (ne) number of alleles for individual Chambo populations.

Water quality factors were generally lower than optimum values reported for other tilapia species (Boyd 1990). Electrical conductivity, total alkalinity, and pH were low at the Domasi site despite high inputs of bio-resources. This may be attributed to low ion exchange capacity in the soil, which has been reported by Jamu (1990) and Jamu and Msiska (1996).

Dissolved oxygen was negatively correlated to specific growth rate, demonstrating that water quality deterioration adversely affected fish growth. The linkage between fish mortality, poultry manure levels and dissolved oxygen confirmed this finding. Phosphorus and electrical conductivity positively influenced fish growth in the low input treatment, indicating a general nutrient deficiency. Phosphorus was negatively related to pH because P is fixed by Al^{3+} under low pH conditions (Boyd 1990). Furthermore, these parameters were attributed to unfavorable water conditions, which were in turn influenced by soil exchange acidity (Boyd 1990). Thus pH differences between the two field stations of Domasi (pH=6.5) and Kasinthula (pH=8.96) were sufficient to elicit significant changes in fish growth. If these results are extrapolated onto the national scale, they offer opportunities for assessing the suitability of sites for fish production and location of facilities for aquaculture for different species and management systems.

Ammonia, pH and dissolved oxygen levels were directly responsible for poor fish survival. It is noteworthy that relatively small ion increases were quantitatively expressed in fish performance. For instance, a change of ammonia concentrations from 0.47 to 1.25 $mg \cdot l^{-1}$ significantly affected growth although they are sub-lethal levels for most tilapias (Boyd 1990). Depending on the species, acute toxicity (96-hour-LC_{50}) for ammonia ranges from 0.08 $mg \cdot l^{-1}$ for salmon to 3.8 $mg \cdot l^{-1}$ for channel catfish (Russo and Thurston 1991). Chemically, the toxicity of ammonia is compounded by factors such as dissolved oxygen and pH.

Considering that 5-10% mortality was reported for the *Oreochromis shiranus* and *Tilapia rendalli* in the same ponds (Chikafumbwa et al. 1993), values of up to 61% recorded in this experiment indicate that this fish is more sensitive to water quality factors. While mortality could not be attributed to one factor, dissolved oxygen was one of the most important factors according to multiple regression analysis. This is inferred from the fact that 4.5-5.0 $mg \cdot l^{-1}$ and 5.3-5.8 $mg \cdot l^{-1}$ dissolved oxygen were associated with 59-61% and 29-45% mortalities, respectively. This further suggests that it is one of the most important ecosystem-induced factors. That this species prefers high dissolved oxygen may be explained by its pelagic lifestyle in Lake Malawi (Turner et al. 1991). Except for the sub-thermocline region, lake water has more that 5 $mg \cdot l^{-1}$ dissolved oxygen values (Msiska 2001).

The effect of water quality variables on fish growth was best illustrated by data obtained at both sites (Domasi and Kasinthula). The two sites were shown to differ in terms of water and soil chemistry. The Domasi site whose soil is classified as acidic resulted in corresponding low water nutrient while Kasinthula soils are alkaline and have high exchange capacity and the water has high alkalinity. The fish growth rate was slower at Domasi than at Kasinthula. The growth differences between the two sites has not been recorded on any commonly cultured Malawian species, the *Oreochromis shiranus* and *Tilapia rendalli*. Environmental factors explained only about 72% growth variation. According to Tave (1995), when phenotypic variation is large, the environmental component of variance is usually larger than the genetic component, indicating that there was unrealized growth potential in the *Oreochromis karongae*. Further research should confirm this.

The best farming potential for this fish appears to lie in sites of high alkalinity, hardness and pH. This finding could assist the drawing of national zonation maps for farming the fish. Previous studies recommended the adoption of exchange acidity as an indicator in selecting soil suitability for aquaculture (Jamu and Msiska 1996).

In summary, satisfactory growth and survival of the *Oreochromis karongae* were achieved in relatively high concentrations of dissolved oxygen, total alkalinity, and hardness and low levels of ammonia. Thus, use of any pond inputs should be carefully considered so as not to cause water quality deterioration of these factors. While this was also true for other tilapias (Pullin and Lowe McConnell 1983), the influence of adverse effects of ammonia and DO appear to be greater for the *Oreochromis karongae*. The tolerance limits for this fish species require further investigations. The study suggests that systems that deliver high levels of dissolved oxygen would be suitable for *Oreochromis karongae* farming.

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References

American Public Health Association, American Water Works Association and Water Pollution Control Federation (APHA). 1995. Standard methods for the examination of water and wastewater, 19th ed. American Public Health Association, Washington, D.C.

Boyd, C.E. 1990. Water quality in ponds for aquaculture. Agriculture Experiment Station, Auburn University, Auburn, Alabama, 482 p.

Chikafumbwa, F.J.K., B.A. Costa-Pierce, D.M. Jamu, W.K. Kadongola and J.D. Balarin. 1993. Investigations on the use of on-farm resources as pond inputs to culture *Tilapia rendalli* and *Oreochromis shiranus* on smallholder farms in rural Malawi. Aquaculture 117: 261-271.

FAO. 1992. Introduction to tropical fish stock assessment. Part 1. Manual by Per Sparre and Siebren C. Venema. FAO Fisheries Technical Paper 306/Rev.1.

Fryer, G. and T.D. Iles. 1972. The cichlid fishes of the Great Lakes of Africa: their biology and evolution. T.F.H. Publications. Neptune City, New Jersey, USA, 641 p.

Gulland, J.A. and B.J. Holt. 1959. Estimation of growth parameters for data at unequal time intervals. J. Cons. CIEM 26:215-222.

Jamu, D.M. 1990. Studies on ash as liming agent in fishponds. Dept. of Biology, University of Malawi, 193 p. M.Sc. thesis.

Jamu, D. and O.V. Msiska. 1996. Liming of fishponds in Malawi: a comparative study of limed and unlimed ponds, p. 54-61. *In* R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly (eds.) The third international symposium on tilapia in aquaculture. ICLARM Conf. Proc. 41, 575 p.

Lowe, R.H. 1952. Report on Tilapia and other fish and fisheries of Lake Nyasa, 1945-47. Fishery Publs. Colon. Off. 1(2):1-126.

Maluwa, A.O.H., A. Brooks and B. Rashidi. 1995. Production of the Malawi Chambo, *Oreochromis karongae* association and *Oreochromis shiranus* in polyculture with the African *Clarias gariepinus* (Burchell, 1822). Aquaculture Research 26:103-108.

Mann, K.H. 1993. Physical oceanography, food chains, and fish stocks; a review. ICES J. Mar. Sci.50:105-119.

Mann, K.H. 1992. Physical influences on biological processes: how important are they? *In* A.I.L. Payne, K.H. Brink, K.H. Mann and R. Hilborn (eds.) Benguela trophic functioning. S. Afr. Mar.Sci. 12:107-121.

Mann, K.H. and K.F. Drinkwater. 1994. Environmental influences on fish and shellfish production in the northwest Atlantic. Environ. Rev. 2:16-32.

Menz, A. (ed.) 1995. Fishery potential and ecology of the Pelagic Zone of Lake Malawi/Niassa. Scientific Report of the UK/SADC Pelagic Fish Resource Assessment Project), Chatham, UK: Natural Resources Institute.

Miller, J.W. 1975. Fertilization and feeding practices and warm water fish culture in Africa. CIFA. Tech. Pap. 4, Suppl. 1:512-535.

Msiska, O.V. 1998. Reproductive biology and growth of *Oreochromis* (*Nyasalapia*) *karongae* in ponds and open water in Malawi. Dept. of Biol., Chancellor College, University of Malawi, 196 p. Ph.D. thesis.

Msiska, O.V. and B.A. Costa-Pierce. 1996. Growth performance of *Oreochromis lidole*, *Oreochromis squamipinnis* and *Oreochromis karongae*, new candidate fish species for aquaculture in open waters and fishponds, p. 129-134. *In* R. S. V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly (eds.) The third international symposium on tilapia in aquaculture. ICLARM Conf. Proc. 41, 575 p.

Msiska, O.V. and B.A. Costa-Pierce. 1997. Factors influencing the spawning success of *Oreochromis karongae* in ponds. Aquaculture Research 28:87-99.

Msiska, O.V. 2001. A review of limnology of Malawi, p. 121-189. *In* R.G. Wetzel and B. Gopal (eds.) Limnology in developing countries Vol. 3. International Association of Theoretical and Applied Limnology.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. CIEM 39(2):175-192.

Pauly, D. and K.D. Hopkins. 1983. A method of analysis of pond growth experiments. ICLARM Newsletter 6(1): 10-12.

Prein, M., G. Hulata and D. Pauly (eds.) 1993. Multivariate methods in aquaculture research: case studies of tilapias in experimental and commercial systems. ICLARM Stud. Rev. 20, 221 p.

Pullin, R.S.V. and R.H. Lowe-McConnell (eds.) 1983. The biology and culture of Tilapias. ICLARM Conf. Proc. 7, 482 p.

Russo, R.C. and R.V. Thurston. 1991. Toxicity of ammonia, nitrite and nitrate to fishes, p. 58-89. *In* D.E. Brune and J.R. Tomasso (eds.) Aquaculture and water quality. Advances in world aquaculture, volume 3. The World Aquaculture Society Baton Rouge, LA, USA.

Tave, D. 1995. Selective breeding programmes for medium-sized fish farms. FAO Fish. Tech. Pap. 352, Rome, Italy.

Turner, G.F., T.J. Pitcher and A.S. Grimm. 1989. Identification of Lake Malawi *Oreochromis* (*Nyasalapia*) spp. using multivariate morphometric techniques. J. Fish Biol. 35:799-812.

Van Dam, A.A. 1990a. Multiple regression analysis of accumulated data from aquaculture experiments: a rice-fish culture example. Aquacult. Fish Manage. 21: 1-15.

Van Dam, A.A. 1990. Is ANOVA powerful enough for analyzing replicated pond experiments? Aqua byte 3(3):3-5.

Van Dam, A.A. 1995. Modeling studies of fish production in integrated agriculture-aquaculture systems. Wageningen Agricultural University, Wageningen, The Netherlands, 163 p. Ph.D. thesis.

Zar, J.H. 1984. Biostatistical Analysis. Prentice Hall Inc., Englewood Cliffs, New Jersey, 718 p.

SECTION 4: THE CHAMBO RESTORATION STRATEGIC PLAN

1. Background of the problem

2. Strategic context and policy framework

3. The Chambo restoration strategic plan

4. The way forward

1. Background of the problem

1.1 The national importance of fish and the Chambo

Fish in Malawi has traditionally played a very important role as a source of food, income and employment. The importance of fish in Malawi, particularly the Chambo, can be measured from the following facts:

- Fish contribute 4% to the Gross National Product (GNP) of Malawi;
- The total "beach" value of Lake Malawi fish was USD 15 million in 2002;
- 300 000 persons are employed in the fishery and allied sectors;
- 14% of lakeshore communities are involved in fishing, which represents 52% of their livelihoods;
- 1.6 million people derive their income from fishing, fish processing, marketing and trading, boat and gear making and allied industries;
- 70% of animal protein, and 40% of the total protein, in rural and urban diets was derived from fish prior to the collapse of the Chambo stocks; and
- 800 fish species, comprising 14% of global freshwater fish biodiversity, occur in Lake Malawi.

1.2 Chambo biology

The Chambo (*Oreochromis karongae, O. squamipinnis* and *O. lidole*) are endemic to Lake Malawi and are found nowhere else in the world. They have been studied since 1939. Some of their main biological characteristics include the following:

- *Sexual maturity at about 24 cm and an age of 3 years*: The female incubates up to 325 eggs in her mouth. Only about 1% survive to adulthood and, generally, each female produces only one batch of eggs annually.
- *A unique breeding pattern, uncommon in other "tilapia"*: The Chambo breeds in deep water in collective nesting areas called "leeks" or arenas, at depths of 5-40 m, with individual nests of up to 3 m in diameter.
- *Migration of juveniles*: After release from the mouth of the female parent, juveniles migrate to nursery grounds in shallow waters where they seek refuge amongst oxygen-rich weeds and reed beds. Juveniles remain in this area until large enough to join the main stock in the open water.

Taken together, these attributes mean that Chambo will have difficulty recovering quickly from overfishing compared to other species of "tilapia", e.g., *Oreochromis niloticus*. Recovery will also be dependent on adequate nursery habitats (aquatic vegetation) in the shallow waters of the lake.

1.3 Statement of the problem

Fish landings peaked in Malawi at 80 000 t in 1990. Since then, dramatic changes have taken place:

- Fish consumption averaged 14 $kg \cdot capita^{-1} \cdot year^{-1}$ in the mid-1970s, but at present is below 6 $kg \cdot capita^{-1} \cdot year^{-1}$.
- As a consequence, the contribution of fish to human protein intake has also declined by over 50% from a peak intake of 70% of the total animal protein.
- Average total fish landings declined from about 65 000 $t \cdot yr^{-1}$ in the 1970s and 1980s to 50 000 $t \cdot yr^{-1}$ in the late 1990s.
- The losses to fishery resources due to environmental degradation estimated in the National Environmental Action Plan (NEAP) of 1994 was USD 4 million.
- The Chambo, at a peak of 9 000 $t \cdot yr^{-1}$, once made up 50% of the total Lake Malawi catch. Today it is less than 13%.
- Of all species, the Chambo fishery has exhibited the single most significant decline. From 1980 to 2000, there has been a total average loss in yield of about 8 to 9 000 t per annum. At current market prices, this is equivalent to an annual USD 15 million loss in revenue to the industry.
- This unsustainable high off-take led to the collapse and the MSY is now only between 6-8 000 $t \cdot year^{-1}$.
- Owing to the scarcity in the market, the wholesale price of Chambo has risen from MK 2.5 per kilogram in the early 1990s to MK 130 per kilogram in 2002 (See Figure 2). It is now unaffordable for the majority of Malawians.
- 300-400 Beach Village Committees (BVC) have been formed since 1990 for the purpose

of participatory fisheries management. None are a legal entity nor a formal partner in co-management arrangements to protect the Chambo.

A result of the declining fishery and the concomitant high rise in prices are that fish are no longer as readily available in the diet of most rural poor Malawians. Acknowledging that animal protein is vital for healthy growth and development of the young, the loss in national protein intake threatens to have long-term adverse effects on the health and mental capacity of future generations. Clinical trials conclusively show that children deprived of animal protein, especially fish, do not develop their full mental potential. From a food security perspective, therefore, in Malawi the traditionally emotional statements that "fish is brain food" and "fish is life" are true! Hence, every effort must be made to restore the loss in production in order to revitalize the health of the people!

1.4 Factors affecting the Chambo fisheries

Several factors have affected the Chambo fisheries, notably:

Overfishing: There has been an ever-increasing number of entrants into the fisheries in terms of gears and fishers. Since 1995, the number of gears on Lake Malawi and Lake Malombe has doubled. In addition, there has been no limit to the numbers of fishing licenses issued. Rather, the fisheries of Malawi have been "open access", free to all entrants. There are now more gear and fishers than the fisheries can sustain!

Poverty: As a result of poverty and limited economic opportunities elsewhere, crop failure and drought, and enticed by the rising price of fish, more and more people are entering the fisheries as an alternative income generating activity to farming. The level of poverty has raised political sensitivity to any attempts to try to halt this trend and to limit the over-capitalization in gear. This has exacerbated the problem!

Illegal fishing: Most of the fishing gears in use are illegal. A 1999 survey of the South East Arm of Lake Malawi found that 100% of the beach seine nets used had illegal small meshes, 96% of gillnets were undersized, 57% of the *nkacha* nets and 35-40% of the *chilimila* and *kambuzi* nets had illegal mesh sizes. As a result, catches are dominated by juveniles and immature fish, thereby not only reducing the potential production levels, but also eliminating future breeding stocks. The use of illegal gear is a result of poor enforcement (e.g., in 2002 no one was prosecuted for illegal fishing whereas hundreds of people were prosecuted for poaching in national parks and reserves). It is also a result of the failure of participatory fisheries management and community empowerment to regulate fishing effectively.

Habitat destruction: Removal of submerged aquatic vegetation beds in shallows exposes juvenile Chambo to predation and makes them prone to being netted. Beach seines and *nkacha* nets have caused physical damage, removing completely the once vast oxygen-rich weed beds in the South East Arm of Lake Malawi and in Lake Malombe. The damage is so extensive that many former juvenile nursery areas no longer exist. The juvenile Chambo have nowhere to hide.

Violation of closed seasons: There has been a gross violation of the closed breeding seasons for the Chambo. Consequently, because of the concentration of the Chambo when they breed, fish are easily caught while trying to spawn. This, in conjunction with the loss of nursery habitat, has reduced the recruitment rate dramatically.

Violation of protected areas: Malawi was unique in having aquatic parks to protect its fish biodiversity, notably the Lake Malawi National Park (LMNP) and the Liwonde National Park (LNP), which have been shown to protect stocks allowing for re-population. However, these protected areas are under threat from encroachment and poaching. The fish sanctuaries are being violated, further reducing Chambo recruitment.

Property rights: When a fishery is "everyone's property, it is no one's responsibility", the "tragedy of the commons" occurs. The fishery licensing system has not been used as a tool to restrict entrants and to convey exclusive and limited fishing rights. Even after 10 years of participatory fisheries management, including co-management with Beach Village Committees (BVCs), has failed to halt the demise of the Chambo. The BVCs have not been empowered by any legal status and do not have legal rights. They can take no recourse to enforce regulations. They are not part of the local government administration and legal system. The legal instruments to empower the BVCs are not in place (i.e., District by-laws, constitutions, fishery management authority, fishery management plans and fishery management agreements, etc.). The BVCs cannot be sued, nor sue offenders. The BVCs should be provided with incentives to restore the fisheries and manage them well. It is recommended that the best way would be to give the fishers an effective form of property rights to own and protect the exclusive fishing zones of Lake Malawi and Lake Malombe.

Poor tax-based economic system: The fishery licensing system has not been equitable to the value of the fisheries resources. Therefore, the DOF does not derive adequate revenue to enforce the law and to operate effectively. This can be seen clearly from the fact that the DOF collected less than USD 10 000 (< 0.07%) in license fees in 2002 while at beach prices the fisheries were worth USD 15 million. The informal business nature of the bulk of the fishery industry implies that the government has been subsidizing the over-exploitation of the fisheries. Only large operators such as Maldeco pay corporate tax. The environment, therefore, is not being treated as national "economic goods"; it is free to be exploited by anyone. This is contrary to Malawi's Community Based Natural Resource Management (CBNRM) Strategy and violates the first principles of a tax-based economy whose foundation for economic growth is "user pays", that is, to charge a fair tax for consumptive use of national resources. The tax revenue collected allows the government to better service the tax payer and enables it to act to restore any potential over-use that may result. The more tax the government collects, the better equipped it is to serve the tax payer and the better the economic growth cycle will be. There is a need, therefore, to revisit the license revenue system as a tax base for funding rehabilitation of the fisheries.

Catchment damage: Soil erosion and siltation are problems in Lake Malawi and Lake Malombe, but these are not believed to have affected the Chambo fisheries adversely.

2. Strategic context and policy framework

Restoration of the Chambo fisheries, as part of Malawi's National Strategy for Sustainable Development (NSSD), would be supported by the following policy initiatives:

2.1 Global goals

Commitments made by Malawi at the 2002 World Summit on Sustainable Development (WSSD), including:

Preparation of a National Strategy for Sustainable Development.
- By 2004, prevent, deter, and eliminate illegal fishing.
- By 2010, apply an ecosystem approach to the sustainable development of fisheries.
- By 2015, restore depleted fish stocks to maximum sustainable yields.

Malawi's goal, as shown in the underlying objectives of this national initiative, is to meet the country's international obligations to restore the Chambo fisheries to pre-1990 levels, by 2015.

2.2 Regional goals

The three riparian countries of Lake Malawi (Malawi, Mozambique and Tanzania) are signatories to the Southern African Development Community (SADC) Protocol on Shared Watercourse Systems and the SADC Protocol on Fisheries. Under this agreement, Malawi's commitments include:

- Member States lying within the basin of the shared watercourse system will maintain a proper balance between resource development for a higher standard of living for their people and conservation and enhancement of the environment to promote sustainable development; and
- State Parties will take appropriate measures to regulate the use of living aquatic resources and protect the resources against over-exploitation, while creating an enabling environment and building capacity for the sustainable utilization of the fisheries resources.

These commitments have now become part of the wording of a Lake Malawi/Nyasa/Niassa Convention to create a Lake Basin Commission to uphold the wise management of the natural resource and its catchment. The Chambo Restoration Strategic Plan should become an integral part of this Convention.

2.3 National goals

It should be recalled that Malawi's Vision 2020, Poverty Reduction Strategy Paper (PRSP), the Fisheries Policy, the Fisheries Act, the National Biodiversity Strategy and Action Plan (NBSAP), the

Community-based Natural Resources Management (CBNRM) Strategy, the National Environmental Action Plan (NEAP), the Ministry of Natural Resources and Environmental Affairs (MONREA) and the Department of Fisheries' Strategic Plans (2002-2006) and the National Strategy for Sustainable Development, all have the same underlying goal, viz., poverty reduction through sustainable development and economic growth.

In support of this goal, the "National Save the Chambo Campaign" was subsequently instituted with the following aims:

- To mobilize all Malawians towards a program of sustainable use of the Chambo;
- To attract more foreign and domestic funding to restore stocks to the pre-1990 level; and
- To work towards achieving commitments made at the WSSD, to restore depleted stocks of the Chambo fisheries by 2015.

The Chambo Restoration Strategic Plan aims to implement these interventions as part of Malawi's National Strategy for Sustainable Development. However, an overarching policy would be Malawi's Poverty Reduction Strategy (PRSP). With respect to natural resources, the PRSP emphasis is on the following focal strategies:

- To strengthen the legal and institutional framework for decentralization of environmental management and to create political will to achieve CBNRM;
- To develop alternative livelihood strategies to take the pressure off natural resources and to start treating the environment as economic commodity, with market values and income generating activities; and
- To create mass awareness on sustainable natural resource use and best management practices.

The objectives of the CRSP, therefore, should strengthen institutions for community co-management, offer alternative income generating opportunities and create mass awareness of best practices. When aligned with the 2002-2007 Fisheries Strategic Plan, these goals translate into the following key objectives:

- To strengthen the institutional framework, governance structures and instruments for sustainable Environment and Natural Resource Management (ENRM);
- To stimulate sustainable economic growth;
- To promote sustainable ENRM and use; and
- To promote co-operation in sustainable ENRM at the national, sub-regional, regional and international levels.

The Chambo Strategy has been developed along the lines of these national objectives.

3. The Chambo restoration strategic plan

3.1 Strategic objectives

The objectives of the CRSP are:

- To restore the Chambo fisheries of Lake Malawi and Malombe to their maximum sustainable yield by 2015; and
- To supplement the fishery production and meet food security needs by enhancing the Chambo production through aquaculture.

3.2 Guiding principles

The guiding principles of the CRSP are:

In view of the fact that fish play a strategic role in food security and significantly influence the health, mental and development growth of Malawi's poor, especially its youth, the serious and chronic decline in fish intake is now a national disaster affecting every Malawian. This situation must not continue. If left unaddressed, at risk is the health of Malawi's people and the potential loss of its most valued food security heritage. Decisive and drastic actions are needed in the national interest, even if it involves hardship for a minority in the short-term.

Recognizing that 300 000 people derive an immediate livelihood from fishing and acknowledging that a total ban or moratorium on the Chambo fishing is one solution to the problem but that this may create adverse hardship conditions and may not derive the results required, Malawi must, nevertheless, take action. This will require some hard choices, such that full political support is essential if this strategy is to succeed.

Because the CRSP should not be a stand-alone initiative, but an integrated, cross-sectoral approach, all activities must be tangible, doable and achievable. The strategy must become an integral part of the DOF and MONREA on-going sector development plans, the National Strategy for Sustainable Development (NSSD) and the PRSP, and it needs to be effected under the on-going decentralization initiative.

Since the main reason for the demise of the Chambo is overfishing caused by open access, inadequate participatory fisheries co-management and poor enforcement of regulations concerning gear, season and size limits, successful restoration will depend on effective implementation of property rights and state/community co-enforcement of laws. If property rights of the BVCs are assured and their legal status anchored in local, district and national law, fishers will be empowered to treat the environment as an economic commodity. They must establish effective fisheries co-management plans and agreements with government, e.g. establishing exclusive fishing zones and sanctuaries to protect the Chambo breeding and nursery grounds. Such management plans could also use artificial reefs and brushparks as "sleeping policemen" to prevent illegal fishing where necessary, to protect Chambo breeding and nursery grounds and to enhance production. Protected areas such as Lake Malawi National Park (LMNP) and Liwonde National Park (LNP) must be maintained for non-consumptive use as fish sanctuaries and breeding areas. If necessary, a complete moratorium on catching the Chambo should be considered.

It is a fact that even when the wild fishery recovers to its maximum potential, human population growth has resulted in a scenario that national food security needs now exceed the potential maximum natural supply of the fish. Therefore, every effort must be made to establish an enabling policy, conducive legislation and fiscal incentive schemes to encourage local and foreign investment in large-scale commercial aquaculture to replicate developments in Lake Kariba. Cage-culture of the Chambo in Lake Malawi and Lake Malombe offers a high potential to increase the production of these species beyond historical levels. However, much research is needed to identify sustainable methods and environmental safeguards.

Despite the knowledge that natural resources have been constantly under-valued, the government of Malawi has been unable to collect sufficient resources to fund its intervention. The country has a "tax-based economy", but the fisheries still remain on the informal economy. The government must collect adequate revenue from people harvesting fish in order to be able to restore the damage done. It must adopt the principles of a fair and equitable license-fee system based on the value of the resource and the cost to rehabilitate it. The Department of Fisheries will collect license fees and penalty fees, and retain a portion in its Fisheries Fund for further capacity development of the Department and BVCs. As advocated in Malawi's National Report to the World Summit, the Fisheries Fund could be strengthened by a "general environment or carbon tax on petroleum products."

With a realization that none of the principles outlined above will be successful unless the people of Malawi understand the importance of the Chambo to their livelihoods and well-being, a massive awareness and political campaign to "Save the Chambo" must be implemented. All walks of life need to be made aware of the status of the fisheries and the reasons for the decline so that they can be called upon to act responsibly to enforce this strategy. The emergence of a local political force at the Assembly level must be mobilized to support the strategy.

Finally, it should be recognized that any strategic response must be within the framework of international and national guidelines as laid down in the Conventions to which Malawi is a signatory, notably the Convention on Biological Diversity, SADC Protocols for Shared Water Bodies, etc.

3.3 Expected outputs

The CRSP targets that, by 2015, Malawi will restore the Chambo production to the pre-1990 MSY through the following outputs:

- *Restoration of the Chambo fisheries in Lake Malawi and Lake Malombe to the maximum sustainable yields of 6-8 000 t·year^{-1}*. Of this, 50% will come from the creation of protected areas and enforcement of the law. An additional 50% will come from enhancement technologies such as artificial reefs, sanctuaries, etc.
- *Enhancement of the Chambo production through aquaculture production of 7 000 t·year^{-1}*. Of this, 5 000 t·year^{-1} will be from the promotion of commercial aquaculture. The balance of 2 000 t·year^{-1} will be from genetic enhancement of the Chambo to improve its growth rate.

3.4 Action plan

The above guiding principles have been elaborated in the action plan. The strategic actions required under the DOF Strategic Plan are outlined briefly below.

Strengthening the institutional framework

(i) Policy review

To pave the way for the plan to restore the production of the Chambo on a sustainable basis, a review of policies is required to:

- Establish the legal status of the BVCs to enforce the law in co-management with the DOF and mainstream the institution of the administrative structure of District Assemblies and local authorities (i.e., fishers, associations).
- Assign exclusive fishing zones, under the Lands Act, to the BVCs and fishers' associations, and the rights to limit entry of additional fishers as per quotas set by the government.
- Set up protected areas and sanctuaries, and confer the rights to communities to protect these areas in line with approved Fisheries Management Plans.
- Encourage the private sector and foreign investment in aquaculture and provide fiscal incentives for investors and researchers to pioneer new production systems for the Chambo.
- Establish a Code of Conduct in line with FAO Regulations for Responsible Aquaculture to regulate the fisheries and aquaculture sector in Malawi, especially to control introductions and convey rights for cage farming.
- Recognize the Chambo as endangered and register it in the IUCN Red Data Book for Endangered Species.

(ii) Review of legislation

Revisions to the Fisheries Management Act will be made to incorporate the following initiatives to:

- Establish a comprehensive legal tool-box for the BVCs and Area Management Committees to convey property rights and empower them with co-management responsibility for law enforcement under Participatory Fisheries Management (PFM) stipulations.
- Revise the constituent members of the BVCs to correspond with those of the "fishing industry" as in the Act and ensure that their legal status in co-management is understood, recognized and upheld by the local authorities.
- Set up a democratic process to elect the BVC sub-committees and align the structure of fishers' associations to represent the collective interests of the fishing industry to correspond to the local government structure. Separate Associations should represent commercial and artisanal fishers with the hierarchy that can lobby the government.
- Empower District Assemblies, through fisheries by-laws, to enforce the Fisheries Management Act through the police and local magistrate courts.
- Establish property rights and exclusive fishing zones, clearly defining what is a Fisheries Management Agreement and a Fisheries Management Authority and devolve powers to the appropriate level to enforce the Fisheries Management Plan (and set limits to entrants and gear types).
- Enact laws for protected areas and sanctuaries and for physical zoning of the fisheries, permitting the use of artificial reefs as "sleeping policemen".
- Prohibit certain gears effectively or institute a mechanism of "gear buy-out".
- Set up, for aquaculture, a legal framework for Environmental Impact Assessment, in order to set standards, issue rights through permits and licenses to operate in particular areas, especially to enable cage culture.
- Demarcate aquaculture investment zones with clear guidelines and fiscal incentives for investors.
- Establish a fair tax-based revenue system on fishing permits and licenses and heavy fines and penalties for infringements.
- Collect all revenues from licenses, fines/penalties into a Fisheries Fund for use by the DOF to raise awareness of the strategy to save the Chambo by offering study tours, training, etc. and to enforce the laws.
- Establish an "Environment Fund" or "carbon tax" on petroleum products for environmental rehabilitation, a portion of which should be earmarked in the Fisheries Fund to support the Chambo Strategy.

(iii) Produce a Chambo master plan

The Chambo Strategy will be made into short- and long-term plans, prioritizing actions to save the Chambo. The CRSP will become the master plan for the restoration of the Chambo fisheries. The JICA-assisted Aquaculture Master Plan will be the basis for future development of aquaculture of the Chambo, including cage culture.

(iv) Increase private/public sector capacity

There is a need for mass awareness of the situation, the biology of the Chambo and of the public responsibility. Mass awareness and political campaigns will be organized to:

- Increase public knowledge about the demise of the Chambo, the reasons for the decline and the need to comply with the measures being put in place to restore its production.
- Sensitize all politicians, ward councillors and traditional authorities of the situation, appraise them of options and win support to implement and enforce the CRSP.
- Translate the 60 years of science done on the Chambo into a technical tool-box for fisheries management and aquaculture and train the BVCs, DOF and private sector on the biology of the Chambo.
- Develop a technical tool-box for aquaculture, especially recipes for intensive systems such as cages, pens and ponds.
- Conduct research and develop a technical tool-box for fisheries enhancement and culture-based fisheries such as artificial reefs, brush parks, etc.
- Conduct research on Chambo genetic selection and disseminate stocks to develop a faster growing, better performing aquaculture candidate.

(v) Decentralize the DOF

District Assemblies will be empowered to:

- Uphold and enforce the Fisheries Management Act, jointly with the DOF through District level by–laws; and
- Maintain an outreach campaign to promote aquaculture widely.

(vi) Research program to support the CRSP

During the course of the consultation, it was noted that much of scientific knowledge is still required to contribute to the effective management of the Chambo. The following list highlights some of the topics that need further investigation:

Little is known about the Chambo biology. Research needs to answer the following questions:

- Why does the Chambo choose to breed the way it does?
- How do the brooding parents and juveniles migrate from breeding grounds to nursery areas and back?
- What is the annual recruitment rate?
- Are there enough spawner biomass remaining to restore the fishery?

Chambo enhancement technologies such as artificial reefs have not been tested. Research needs to examine and answer these questions:

- What will be the most cost-effective structures?
- How best could the habitats be restored?
- Does the artificial structure enhance the fisheries or does it act like a fish aggregating device?
- Does oxygen-rich weed matter in the nursery area of the Chambo?

Non-compliance of the law has adversely affected the fishery, but what is not known is why. Research would have provide answers to these questions:

- What is the social organization of the fishing community and how to influence behavior change?
- Will the introduction of property rights and community co-management solve the problem?
- How should institutional reforms be anchored in the mainstream of local administration?
- Can local communities enforce the law, and if so, how?

Re-stocking potential is unknown. The following questions must be answered.

- Which management practice would best contribute to a rapid recovery in stocks (i.e., a moratorium, exclusive fishing zones, protected areas, breeding sanctuaries, artificial reefs, etc.)?
- Is re-stocking the Chambo viable?
- Should the fishery in Lake Malombe be dissuaded away from the Chambo fisheries?

Economic analysis of the fisheries is unknown. Answers are needed for the following questions:

- Who benefits from the fisheries and by how much?
- What is the benefit of gear owners versus operators?
- How does the price increase affect the buying power of communities?
- What is the maximum sustainable economic yield?

- If the Chambo is restored, what will it do to price, supply and demand?

Sustaining livelihood strategies

(i) Enhancing the capture fisheries

Fisheries enhancement techniques will be used to restore productivity and habitats that have been damaged. Through this intervention, a potential total Chambo recovery of 4 000 t·year^{-1} in 10-12 years is projected. The best techniques to use will be selected based on a comprehensive analysis of the options and subsequent research where this is required. They are likely to include the following:

- Establishment of community-managed exclusive fishing zones, protected areas and/or Chambo sanctuaries to protect the Chambo breeding and nursery grounds.
- Development of artificial reefs and brushparks to provide additional refuges for juvenile Chambo, to restore damaged habitats and deter fishing in protected areas ("silent policemen").
- Restoration of nursery habitats such as oxygen–rich weed beds.
- Re-stocking hatchery-reared juveniles to create a critical level of spawning fish, but only after modeling to show that this will have a net benefit in addition to other forms of management dedicated to protecting the Chambo until replenishment occurs.

(ii) Enhancing aquaculture production

Aquaculture has great potential to increase the currently low production of the Chambo, provided various criteria are met for sustainability, and practical methods are developed to overcome the relatively slow growth and low fecundity of the species. The components of the strategy to promote aquaculture of the Chambo species will include the following developments:

- Cage culture industry in Lake Malawi;
- Aquaculture of the Chambo in ponds and farm dams; and
- Introduction of a genetically-improved variety of the Chambo.

This last development should eventually result in significant and sustained increases in the growth rate and egg production, but it needs to proceed with caution to avoid contamination of the gene pool of the wild fish.

When creating the infrastructure to supply very large numbers of juveniles needed for large-scale commercial cage culture, there is scope for smallholders to be involved in the supply of fingerlings.

Promoting sustainable use

(i) Obtaining feedback information for management

A monitoring and evaluation (M&E) system will be established to measure the impact of the CRSP along the period of its implementation; modification and adaptation will be made accordingly.

(ii) Implementing management plans

There is a need to develop management plans for exclusive fishing zones along the lines of local administrative boundaries down to the ADC level and managed by local Area (i.e., ADC) Fisheries Management Authority/Committees. Over 60 years of fisheries science needs to be in the hands of the user groups through user-friendly training materials (i.e., Technical Tool-box) and incorporated in Fisheries Management Plans. The Fisheries Management Plans should be instituted through Fisheries Management Agreements and enforced by the local authorities at the District, ADC and VDC levels. Exclusive Fishing Zones need to be established, demarcated and enforced.

(iii) Empowering Fisheries Management Authorities (FMAs)

The provisions of co-management in the Fisheries Management Act need to be legalized and implemented as follows, with full political support from the Assembly:

- Area Fisheries Management Authorities/Committees formed at the ADC level and empowered to enforce the Area Fisheries Management Plan.
- Fisheries Management Agreements need to be signed with the BVCs to respect the Chambo strategy.
- The BVCs are to be empowered with rights through new licenses as co-management authorities to work with the DOF to enforce the Chambo strategy.
- The local authorities are to be empowered to enforce the law through District Assembly by-Laws that devolve certain powers from the DOF to the Assembly, ADC and VDC.
- The Assembly, Ward Councillors, Area Fisheries Management Authority, ADC, VDC, BVC should be trained in the implications of the Chambo strategy.

Strengthening national, regional and international co-operation

Although the Chambo is still very much a national problem, there is evidence of Malawi fishers migrating to foreign waters to catch fish. In anticipation that this will in time become a regional problem, action is required to:

- Sign a Lake Malawi/Nyasa/Niassa agreement for better co-operation to protect stocks.
- Develop an investor's pack for international investments in Chambo aquaculture.

3.5 Assumptions and risks

To effect the Chambo strategy, the following assumptions have been made:

- The CRSP will have full political support and a major political campaign will be launched to enforce the strategy and support the local authorities and BVCs to implement aspects of this strategy.
- The Ministry of Lands is willing and can under the Land Act confer and enforce the exclusive fishing zones and property rights of the BVCs and Area Fisheries Management Authorities/ Committees.
- The District Assembly has the capacity and political will to enforce the fisheries by-laws.
- The Treasury agrees to the fair license fee, penalties and fines and that the DOF may retain a percentage of the Fisheries Fund.
- The Cabinet agrees to establish an Environment Fund from revenue from a carbon tax on petroleum products.

4. The way forward

4.1 Management authority

The implementation of the Chambo Strategy will be managed by the Cabinet Committee for Natural Resources and Environment (CCNRE) as the policy and political body of the NSSD. The DOF will be the Secretariat to the CCNRE to see that the directives are implemented. The Assembly will uphold the by–laws, and the Area Fisheries Management Authorities and the BVCs will enforce the local laws. To achieve this, the BVCs must register as legal entities with the Deeds and Trust Act according to the constitution. The BVCs will develop a democratic process to establish a hierarchy of representation through the Fishers' Associations at the VDC, ADC, Assembly and National levels to lobby for their rights and for legal support as required.

4.2 Funding support

It is anticipated that the Chambo Strategy will enter the Fisheries Sector Investment Plan and will be in part funded from ORT and HIPC resources. Donor support is also expected. Various partners will assist the DOF in implementing the CRSP. The development partners that are already assisting the DOF to implement different parts of the CRSP are cited in the attached table. It is also expected that under the NSSD, this CRSP could receive support from some of the international partners that are committed to the WSSD objectives.

However, Malawi realizes that the need and urgency to act are critical to the future food security, well-being and mental development of its people. With this in mind, the strategy envisages self-financing from revenue generated from increases in the fish license fees and taxes collected from the sector. If 10% of the sector's total informal revenue of USD 15 million could be recovered in fair valuation and taxation, Malawi could generate USD 1.5 million annually to re-invest in the strategy. In addition, if the Environment Fund could be established as a carbon tax and a portion could be invested in the Chambo Strategy, Malawi could generate adequate resources to implement the plan in its entirety.

4.3 Short-term action plan

The following are short-term actions required to set this plan in motion:

- Mid-2003: The CCNRE approves this strategic plan.
- Mid-2003: Mass political campaign launched to "Save the Chambo".
- End-2003: Policy, laws/legal instruments required to implement the plan are in place.
- Mid-2004: Property rights, protected areas and sanctuaries are established.
- Mid-2004: Pilot trials prove that artificial reefs/brushparks are viable for enhancement.
- End-2004: First commercial cage culture farm established.

Annex 1: Save the Chambo Campaign (Integral to the MONREA and DOF Strategy: 2002-2007)

MONREA goal:

Coordinate, facilitate and promote full participation in sustainable development, utilization and management of environmental and natural resources (ENR) for socio-economic development and poverty reduction.

Ministry objectives:

1. To strengthen the institutional framework, governance structures and instruments for sustainable ENRM.
2. To stimulate sustainable economic growth (through development of ENR).
3. To promote sustainable ENRM and use (through poverty reduction).
4. To promote cooperation in sustainable ENRM at national, sub-regional, regional and international levels.

Campaign objective:

To restore the Chambo fisheries of Lake Malawi and Malombe to their maximum sustainable yields by 2015.

Chambo restoration strategic plan: 2003-2015

Sl	Ministry and DOF	Outputs (OVI)	Where/Ecosystem outputs			Target ($t \cdot yr^{-1}$)	By whom	By when	Partners	Risk/ assumption/ constraint
No	Objectives and Strategy/Action		L. Malawi (Sea)	L. Malombe	Aquaculture					
1	To strengthen the institutional framework for sustainable ENRM									
1.1	To strengthen legal/ institutional arrangements for PRSP:									
1.1.1	Policy review	New policy								
	a. Establish fishing zone property rights (BVCs)		Policy on BVC rights	Policy on BVC rights			DOF	12/03		MOLands support rights
	b. Ban illegal gear, establish protected area (PA)		Policy on protected areas	Policy on protected areas			DOF	6/04		Needs political support
	c. Establish an enabling aquaculture policy				Investor fiscal incentives		DOF/CC		JICA	Needs political support for fishing industry
					License/Rights		P.Sector		COMPASS	
					Code of conduct		Finance		FAO	
					Tax/duty-free status		EAD			
	d. Political commitment to enforce regulations		Political campaign	Political campaign	Political campaign		MONREA PCE/CC	12/03		Will need political will

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Sl No	Ministry and DOF / Objectives and Strategy/Action	Outputs (OVI)	Where/Ecosystem outputs: L. Malawi (Sea)	L. Malombe	Aquaculture	Target (t·yr^{-1})	By whom	By when	Partners	Risk/ assumption/ constraint
1.1.2	Legislation review	New laws								
	a. Laws/By-laws ban gears, protect areas, restock and regulate physical development		BVC Rights	Moratorium/ PA		4 000	DOF	6/04		Needs political support
			Buy out/ban gear	Ban illegal gear			Police D/ Assembly			
			Legal tool box on rights	Legal tool box on rights					COMPASS	
			Distict by-laws in place	Distict by-laws in place						
	b. Establish aquaculture legal framework				Aquaculture zones		DOF /CC	6/04	JICA	Needs political support
					EIA standards		Justice		COMPASS	
					License/ permits		Fin/EAD			
	c. Fair revenue for fish licenses to Fishery Fund		Tax-based licenses	Tax-based licenses						Treasury agrees on revenue retention in Fishery Fund
1.1.3	Master plan produced	Sectoral M/ Plan								
	a. Effect a Save the Chambo Campaign		Strategic Plan	Strategic Plan	Strategic Plan		DOF S/holder Politicians	6/03	COMPASS WFC IFPRI	Needs financial support from polluter-pay fine on petroleum
	b. Develop Aquaculture Master Plan				Aquaculture Master Plan		S/holder	6/05	JICA	
1.1.4	Infrastructure updated	New infrastructure								
	a. Establish coastal physical development plan		Physical plans				DOF/ Lands			Scientific proof needed
	b. Rehabilitate aquaculture breeding centers			For restocking			DOF	12/04		Not cost-effective
1.2.	To strengthen sector capacity									
1.2.1	Increase private/ public capacity	Increase knowledge								
	a. Mass awareness campaign		Increase knowledge	Increase knowledge			DOF			
			Political campaign	Political campaign	Political campaign		MONREA	12/03		
	b. Training of BVC, DOF, P/ Sector in the Chambo		## Trained	## Trained	## Trained		DOF			
	c. Research, manuals and training in aquaculture				Cage/pen tool box		DOF		WFC	Needs pilot trials
					Ponds tool box		BC/CC		JICA (2)	
					Artificial reef tool box		P/sector		UNDP/ FAO	

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Sl	Ministry and DOF	Outputs (OVI)	Where/Ecosystem outputs			Target ($t \cdot yr^{-1}$)	By whom	By when	Partners	Risk/ assumption/ constraint
No	**Objectives and Strategy/Action**		**L. Malawi (Sea)**	**L. Malombe**	**Aquaculture**					
					Chambo genetic stock		PCL		MI/CIDA Malaysia WWF Fin MEET	
1.2.2	Decentralize DOF	DOF devolves power								
	a. District Assembly enforces by–laws		By-laws enforced	By-laws enforced			D/ Assembly police	12/10		DA capacity is limited
	b. Develop District aquaculture extension services				## Outreach		DOF D/ Assembly	12/10	HIPC NGOs	Needs support
1.2.3	Develop staff performance system	Performance system	NA	NA	NA					
1.2.4	Develop DOF administration capacity	Admin. developed	NA	NA	NA					
2	To stimulate sustainable economic growth									
2.1	Promote sustainable livelihoods strategies:									
2.1.1	Enhance capture fishery	Improve efficiency	NA							
	a. Develop PA, sanctuary, artificial reefs, B/ parks, etc.	Exploit unused stock	## PA/ sanctuary	## PA/ sanctuary		4 000	DOF/CC	12/10	P/sector	Needs political input
	(Hand in hand with laws)		## Art. reef/ B/park	## Art. reef/ B/park			Land/ water			Needs research support
			## Habitat restored	## Habitat restored			Police			
			## Exclusive zones	## Exclusive zones			D/ Assembly ADC/BVC DNPW			
	b. Restock/ranch the lakes (hand in hand above)		## Restocked	##Restocked		(4 000)	DOF	12/10		May not be cost effective?
	c. Develop offshore deepwater stocks		30 000 $t.yr^{-1}$				DOF	12/10	ADB	May not be cost effective?
2.1.2	Enhance post–harvest	Value-added products and improved market/Std.	NA	NA	NA					
2.1.3	Enhance aquaculture production	Indig. fish culture								
	a. Develop Chambo cage-culture industry	New culture systems	## Lake cages		## Dam cages	5 000	PCL		JICA	Support P/ sector
		Intensive systems					Namiteti			
		Restocking					Chipoka			
		Exotic fish culture								
	b. Develop ponds/Chambo culture				## Chambo pond	200	GK Aqua MDC		FAO, JICA Malaysia	

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Sl	Ministry and DOF	Outputs (OVI)	Where/Ecosystem outputs			Target (t·yr⁻¹)	By whom	By when	Partners	Risk/ assumption/ constraint
No	Objectives and Strategy/Action		L. Malawi (Sea)	L. Malombe	Aquaculture					
	c. Develop fast growing Chambo by selection				## Genetic selection	2 000			WFC	Risk genetic pollution
	d. Develop other aquaculture systems				- 2 000 $t \cdot yr^{-1}$		DoF		JICA (2)	Slow track record
3	To promote sustainable ENRM and use									
3.1	Information for management plans									
3.1.1	Assessment of unexploited stocks	Survey new stock	NA	NA	NA					
3.1.2	M&E exploited stocks	Stock/market survey								
	a. Review M&E and monitor re-stocking		M&E system	M&E system			DOF	2004		
3.1.3	Develop management plans	Fishery Mgmt. plans								
	a. Develop fish management plans (FMP)		FMP in place	FMP in place			DOF	12/03	COMPASS NARMAP	Needs legal tool box
3.2	Implement management plans (Fish/ aquaculture)									
3.2.1	Disseminate Research	Information to users								
	a. Capture 60 yr research put in User Manual		Training material	Training material			DOF			A vital activity
			Conduct research	Conduct research	Conduct research					Needs a research plan
3.2.2	Promote sustainable capture fishery	Regulations aware								
	a. Implement FMP and enforce regulations		Enforcement	Enforcement			D/ Assembly			DA capacity?
3.2.3	Implement Fishery Management	LFMA enforced by law								
	a. Develop exclusive fishing zones (EFZ)		EFZ licensed	EFZ licensed			D/ Assembly			MOLands to enforce
3.3	Devolve to fisheries management authorities (LFMA)									
3.3.1	Formation of LFMA	LFMA formed								
	a. Empower LFMA to enforce S/Plan		LFMA enforced	LFMA enforced			LFMA Police			Needs political support.
3.3.2	Develop capacity of LFMA	LFMA trained	See 1.2.1	See 1.2.1	See 1.2.1					
3.3.3	Management agreements signed	Agreements signed								
	a. Sign FMA to include the Chambo	Honorary officers	License BVCs	License BVCs			BVCs			BVCs have political support

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Sl	Ministry and DOF	Outputs (OVI)	Where/Ecosystem outputs			Target (t·yr⁻¹)	By whom	By when	Partners	Risk/ assumption/ constraint
No	Objectives and Strategy/Action		L. Malawi (Sea)	L. Malombe	Aquaculture					
		Fish by-Laws	BVC Co-Mg. D/Ass. enforce Laws	BVC Co-Mg. D/Ass. enforce laws			D/ Assembly police			
3.4	Capacity building for sustainable fish mgmt.									
3.4.1	Develop Human Resources	Training courses	See 1.2.1	See 1.2.1	See 1.2.1					
4	National, regional and international cooperation in ENRM									
4.1	Strengthen cross-sectoral linkages									
4.1.1	Information exchange	Information Center								
	a. Develop Tanz/ Moz/Malawi linkages	Region Fora/ Pcol. conventions	LMNN convention				Tanz/Moz		WWF	Not relevant to the Chambo
	b. Promote international aquaculture investment				Investors pack		DOF/MIPA		JICA	
	Total					**15 200**				

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Acronyms

ADC	Area Development Committee
BioEROC	Biotechnology Ecology Research & Outreach Consortium
BVC	Beach Village Committee
CBNRM	Community-based Natural Resource Management
CBO	Community-based Organization
CCNRE	Cabinet Committee on Natural Resources and Environment
COMPASS	Community Partnerships for Sustainable Resources Management
CRSP	Chambo Restoration Strategic Plan
CURE	Co-ordination Unit for Reconstruction of the Environment
DA	District Assembly
Danida	Danish International Development Assistance
DC	District Commissioner
DDF	District Development Fund
DDP	District Development Planning
DEAP	District Environmental Action Plan
DESC	District Environmental Sub-committee
DFO	District Fisheries Officer
DLG	Department of Local Government
DNPW	Department of National Parks and Wildlife
DOF	Department of Fisheries
DSOER	District State of the Environment Report
EAD	Environmental Affairs Department
EDO	Environmental District Officer
EFZ	Economic Fishing Zone
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
ENR	Environmental and Natural Resources
ENRM	Environment and Natural Resource Management
ESP	Environmental Support Program (Malawi)
FAO	Food and Agriculture Organization
FMA	Fisheries Management Agreement
FMP	Fisheries Management Plan
GNP	Gross National Product
GOM	Government of Malawi
IFPRI	International Food Policy Research Institute
LDF	Local Development Fund
LFA	Logical Framework Analysis
LFMA	Local Fisheries Management Authority
LGA	Local Government Act
LGFC	Local Government Finance Committee
LMNP	Lake Malawi National Park
LNP	Liwonde National Park
M&E	Monitoring and Evaluation
MEET	Malawi Environmental Endowment Trust
MK	Malawi Kwacha
MOAI	Ministry of Agriculture and Irrigation
MONREA	Ministry of Natural Resources and Environmental Affairs
NARMAP	National Aquatic Resources Management Project
NBSAP	National Biodiversity Strategy and Action Plan
NEAP	National Environmental Action Plan
NGO	Non-governmental Organisation
NRC	Natural Resources College
NRM	Natural Resource Management
NSOER	National State of the Environment Report
NSSD	National Strategy for Sustainable Development
OVI	Objectively Verifiable Indicators
PCE	Parliamentary Committee on the Environment
PCR	Project Completion Report
PFM	Participatory Fisheries Management
PRA	Participatory Rural Appraisal
PRSP	Poverty Reduction Strategy Process
SADC	Southern Africa Development Community
SOER	State of the Environment Report
TA	Traditional Authority
UNDP	United Nations Development Program
USAID	United States Agency for International Development
VDC	Village Development Committee
WESM	Wildlife and Environment Society of Malawi
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund for Nature