INTEGRATED CO-MANAGEMENT OF ZAMBEZI / CHOBE RIVER FISHERIES RESOURCES PROJECT

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Lake Liambezi, Namibia: fishing community assumes management responsibility
July 2011

Recording catches at Shamahuka, Lake Liambezi

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Fishing craft at Shamahuka, November 2010

Flooded village, Lake Liambezi, February 2010

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Technical Report no. MFMR/NNF/WWF/Phase II/4

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The lake and its history

The Caprivi Region in Namibia is a narrow strip of land extending eastwards from the northeastern corner of the country, and is bordered by Angola and Zambia to the north, Botswana to the south and Zimbabwe to the east (Figure 1). The region is flat and characterised by numerous swamps and slow-flowing rivers (Mackenzie, 1946; Seaman *et al*., 1978). A major swamp system is centred on Lake Liambezi (Figure 1). This lake receives water from several sources (van der Waal, 1976). To the west, the Kwando River originates in the Angolan Highlands and forms the boundary between Angola and Zambia. Passing through the Caprivi Strip, the Kwando then percolates through the Linyanti swamps on the Namibia-Botswana border before feeding into Lake Liambezi. Rainfall and run-off from the area to the north of the lake also feed the lake. Floodwaters from the Zambezi enter the lake from the east during high flood years from two directions. The Chobe River reverses flow direction annually when the Zambezi floods and enters the lake from the southeast, while the Bukalo channel enters the northeast of the lake from the Caprivi floodplain. Outflow from the lake via the Chobe River when floodwaters recede is intermittent and dependent on lake level.

The entire lake area comprises about 300 km^2, of which 100 km^2 is open water when the lake is full. The lake is highly variable in extent. Maps made prior to 1950 show only swamp, while the current Google Earth image dating from June 2006 shows a dry, largely burnt lake bed with several rectangular crop fields clearly visible in the centre of the lake depression (Figure 2). Surrounding swamps show numerous but very small patches of open water.

Lake Liambezi supported an important subsistence fishery in the 1970s (van der Waal, 1976) and early 1980s but dried up in 1985. Earlier, Child (1968) reported a booming trade in fish from Lake Liambezi to Botswana in 1963 following high floods in 1957, 1958 and 1962. For long periods from the 1980s until the 2000s the lake remained dry, to such an extent that underground fires caused by surface fires in reedbeds infiltrated the extensive root systems. This created a serious hazard for cattle, wildfire and humans that fell through the surface crust into the fires below. Several human fatalities were recorded. Some inflow was recorded during the 2000 and 2003 floods, and since 2007 the lake has received more floodwater, culminating in April 2009 in a major flood that filled the lake, matched by the 2010 and 2011 floods. Consequently, fishery activities are again taking place in Lake Liambezi.

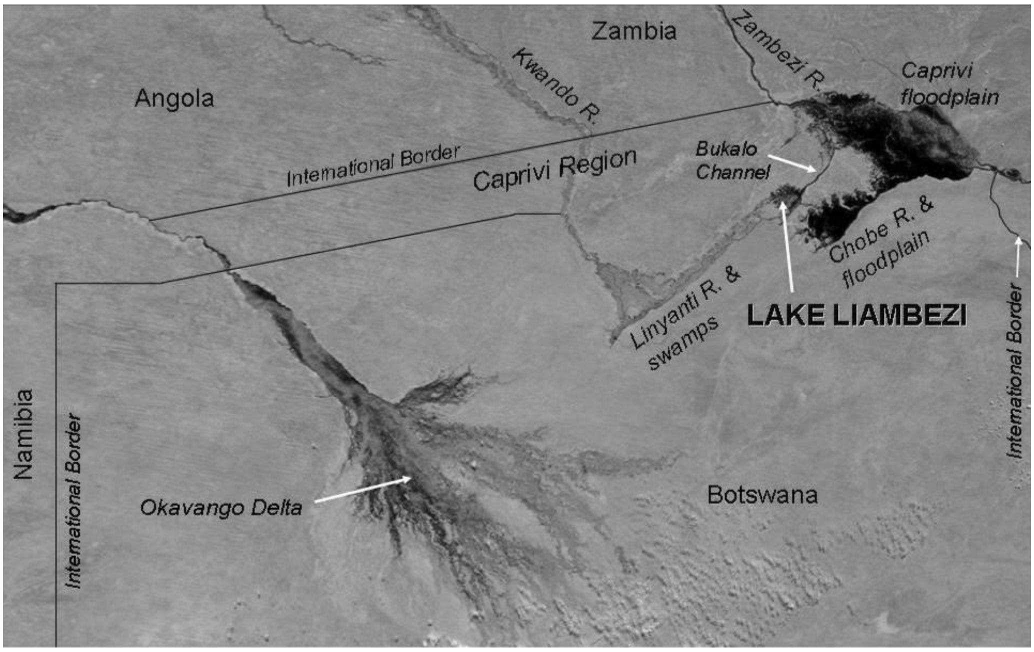

Figure 1. Satellite photograph of the Caprivi region taken at high water in May 2009, showing the position of Lake Liambezi in relation to its inflowing rivers and floodplain channels. © NASA Earth Observatory.

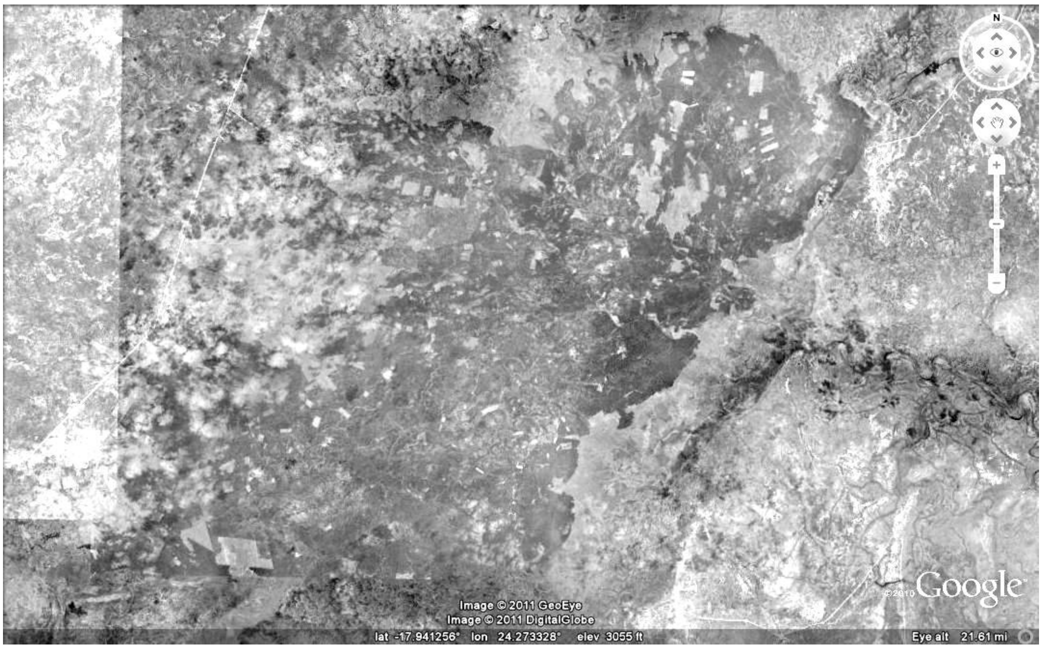

Figure 2. GoogleEarth© image of the dry lakebed of Lake Liambezi in 2006. The lake is fed from the Zambezi River by the Bukalo Channel (top right), Chobe River (lower middle right), and from the Linyanti through swamps at top and bottom left.

The fish fauna

Floodwaters entering the lake basin in the large Zambezi flood of 2009 brought with them opportunistic pioneer species. Most were small *Barbus* spp., characins and catfish (*Clarias* spp.), but the invaders also included inoculants of the tilapiine cichlids *Oreochromis andersonii*, *O. macrochir* and *Tilapia rendalli* and the predatory largemouth cichlids *Serranochromis robustus jallae* and *S. macrocephalus*. These thrived in the new lake, benefiting from high nutrient availability from the flooded terrestrial vegetation and soils, similar to the high productivity seen in newly inundated reservoirs such as Lake Kariba following dam construction (e.g. Machena *et al*., 1993). The composition of the fish fauna is changing over time (Peel *et al*., 2011 and in prep.). Current composition (2010/11), based on a graded gillnet fleet with stretched meshes from 12 – 150 mm (Table 1) shows high diversity with small species of low economic value, particularly *Brycinus lateralis*, most abundant in the lake.

The fishery

Fishing started in the lake with catches in 2009 dominated by *Clarias gariepinus* (Plate 1, left) with relatively few tilapiines. The tilapiines, however, rapidly multiplied and by 2010 a major fishery had developed for them with *Oreochromis andersonii* and *Tilapia rendalli* comprising over 90% of the catch (Plate 1, right), despite their relatively low IRI in experimental gillnets.

Catch assessment surveys were initiated in 2010 and data on the fish catches from the lake are collected twice a week at Shamahuka, the main fish landing for the Muyako community. Daily records are also kept for all fish passing through the Katima Mulilo urban market for transhipment to the Zambian urban areas of Livingstone and Lusaka, and beyond as far as the Democratic Republic of the Congo. By the end of 2010, on average 3 $t.day^{-1}$ of fresh fish passed through the Katima Mulilo market *en route* to Zambia, approximately 90% of which came from Lake Liambezi. In addition, some fish is sold locally at the market and in surrounding villages. The new lake is therefore estimated to be yielding in excess of 1000 $t.yr^{-1}$ of high value tilapias.

The fisheries problem

As the tilapiine cichlids multiplied, grew rapidly and began to appear in gillnet catches, there was an influx of fishermen from outside the area, primarily from Zambia but also from Democratic Republic of Congo. The situation rapidly developed to the point that some fish traders owned several makoros (dugout canoes) (Plate 2) and employed Zambian fishermen to fish for them. The catches from these fishermen were exported directly across the Zambian border to the major urban areas of Livingstone and Lusaka, with no benefits accruing to the local community. By mid-2010, the fishing effort was so high that it was difficult to move by motor boat on the lake because of all the gillnets in use.

Table 1. Catch composition in order of Index of Relative Importance of the species in an experimental gillnet fleet used on Lake Liambezi, 2010-11.

Species	**%IRI**
Brycinus lateralis	53.756
Schilbe intermedius	27.112
Rhabdalestes maunensis	5.454
Petrocephalus catastoma	3.249
Marcusenius altisambesi	2.993
Tilapia sparrmanii	2.627
Serranochromis macrocephalus	1.026
Clarias gariepinus	0.659
Pharyngochromis acuticeps	0.627
Barbus radiatus	0.477
Synodontis spp.	0.424
Hepsetus odoe	0.283
Barbus poechii	0.277
Pseudocrenilabrus philander	0.215
Oreochromis andersonii	0.166
Tilapia rendalli	0.160
Barbus paludinosus	0.139
Sargochromis codringtonii	0.137
Clarias ngamensis	0.076
Oreochromis macrochir	0.071
Labeo cylindricus	0.025
Mormyrus lacerda	0.012
Pollimyrus castelnaui	0.011
Barbus bifrenatus	0.010
Synodontis nigromaculatus	0.009
Barbus uniteniatus	0.002
Sargochromis carlottae	0.002
Barbus barnardi	0.001


Plate 1. Left: Catch of *Clarias gariepinus* and *C. ngamensis* from the lake, in March 2009. Right: 206 kg catch of *Oreochromis andersonii* (>90%), *O. macrochir* and *Tilapia rendalli*, in November 2010.


Plate 2. The increase in fishing activity at Shamahuka during 2010. Left: February 2010. Right: November 2010.

Community initiated solution

The young people living around the lake got together, under the leadership of Mr Patrick Thabo. They set up a formal organisation with a committee to spearhead a programme to manage the fishery in the lake and approached the community leaders in the area. Table 2 explains the community leadership structure.

Table 2. Key to community structures and acronyms used in this paper.

Khuta	Traditional Authority (TA)
Subkhuta	Local division of TA
Induna	Head of subkhuta, a Chief or Village Headman
MFMR	Namibia Government Ministry of Fisheries and Marine Resources
NNF	Namibia Nature Foundation
WWF	Worldwide Fund for Nature (in both Norway and Namibia)

The lake falls under two Khutas, Bukalo and Chinchimani. Until recently there has been little communication or discussions on the fishery between the two TAs. The new youth committee undertook to discuss proposals for management of the fishery with both TAs and met the subkhutas for Chief Mamili (Chinchimani TA) on 17th August 2010 and Chief Liswani (Bukalo TA) on 25th August.

Following these meetings, the two subkhutas met in September and the indunas agreed to take steps to manage the fishery. They resolved to limit effort and ensure the benefits from the fishery largely remained within the local communities.

Management steps

Closure of fishery

The Muyako community under Chief Liswani took the initiative and announced a complete closure of the lake fishery from 15 to 22 October, 2010. All fishermen were instructed to remove their nets from the lake during that time.

Registration of fishermen

During the closure a register was compiled of all fishermen who would be allowed to fish when the fishery was re-opened. Registration was restricted to fishermen resident in the area.

A total of 125 fishermen were registered by 19 November. Outsiders who wished to register were informed that they could not do so at present but that consideration might be given to expanding the register in future dependent on the health of the fishery in the next few months.

Restriction in fishing methods allowed

Fishing is restricted to passive gillnets. No seining is allowed, nor the use of bashing the water and vegetation to drive fish into nets. The minimum mesh size is set at 3.5” (89 mm) stretched mesh, noteworthy as the minimum legal mesh size under the regulations for the Inland Fisheries Act in Namibia is 3” (76 mm). It is proposed to increase the minimum mesh size to 4” (102 mm) later in 2011.

Role of MFMR and the MFMR/NNF/WWF Zambezi/Chobe Fisheries Project

Two directorates of the MFMR have responsibilities in inland fisheries management. The Directorate for Aquaculture and Inland Fisheries undertakes research and extension, while the Inspectorate is responsible for enforcement of regulations under the Inland Fisheries Act. Until recently the MFMR had limited capacity and an emphasis on aquaculture. Recognising this, the Zambezi/Chobe Fisheries Project was initiated to support the MFMR in its activities. Its role is to provide experience and guidance to the MFMR on management of the complex Caprivi fisheries. The project seeks to encourage and empower the fishing communities in Caprivi to take responsibility for their fisheries, in partnership with the MFMR. The trans-boundary nature of the fisheries complicates the process and the project therefore helps to coordinate cross-border collaboration.

The Lake Liambezi fishery developed from scratch during the course of the project and was thus an opportunity to implement a co-management programme. Several meetings were held between MFMR, project and the fisheries committee set up at Muyako. The inspectorate provided guidance on the Fisheries Act and regulations but in a collaborative and not adversarial manner, while the project continues to encourage the community in maintaining its own management structures. The project has also set up a research and monitoring programme to assist the community with advice as the fishery matures.

DISCUSSION

The validity of the newly-imposed management rules for the lake’s fishery

In any management scenario, questions must be asked about the objectives of management and the scientific and economic validity of fishery regulations. Lake Liambezi is effectively a large floodplain lagoon and might be considered an ephemeral fishery as it dries out when deprived of flood waters from its inflows other direct rainfall. Is the imposition of regulations aimed at maintaining a sustainable tilapiine fishery the right path to adopt by the local community, or should fishermen be encouraged to heavily exploit all species in the lake in case it dries up quickly?

There is no easy answer to these questions as the lake's future is dependent on unpredictable annual flood regimes, but parallels can be drawn with (a) the previous history of the lake's fishery, and (b) comparison with tilapiine fisheries elsewhere.

Comparison with the previous Lake Liambezi fishery

During the 1970s, Lake Liambezi supported a thriving fishery similar to that operational at present, based on the large cichlid species, particularly *O. andersonii* (van der Waal, 1976). The present fishing community used the memory of that fishery as the basis for their agreed regulations in the present fishery. The mesh size most in use then was 5" (127 mm) but nets up to 7" mesh were used.

The lake dried up in early 1980s. Without any annual inflow from sources other than local rainfall, the lake took three years to dry out. It is thus a more substantial water body than an annually inundated floodplain lagoon. With a three year lag period before drying out during low flow periods, the lake can sustain a fishery based on slower-growing, larger fish species. In contrast, smaller, ephemeral, floodplain water bodies support fisheries based on the numerous, small-sized, fast-growing pioneering species, and a wide variety of fishing gears should be encouraged to take maximum advantage of such short-lived resources.

Comparison with other tilapiine fisheries in Africa

Most African lakes, particularly in eastern and south-central Africa supported important tilapia fisheries until the 1960s, but in the following decades almost all such fisheries collapsed. In most cases the cause was generally regarded as overfishing, but with detailed information available only in a few cases.

Lake Malombe, Malawi: the collapse of the chambo fishery

Lake Malombe is a small, shallow lake (390 km^2) on the Shire River, 12 km downstream from the outflow from Lake Malawi. Through the 1960s and 1970s, the lake's gillnet fishery, using a minimum 3.5" (87 mm) mesh, focussed on two high value, indigenous *Oreochromis* species, known as chambo, yielding 4,000 $t.yr^{-1}$ (Fig. 2). At that time, extensive weed beds provided cover for predators and prey alike (Tarbit, 1972), as well as supporting epiphytic algae on which juvenile chambo feed (Turner *et a*l., 1991). In the early 1980s, the introduction of small-meshed openwater seines (nkacha nets), as well as much longer shore seines, resulted in a doubling of the overall catch, including an increase in chambo yield (Tweddle *et al*., 1995). Unfortunately this was not sustained. The seine nets removed fish of all sizes, previously protected by the gillnet minimum mesh size, and also ultimately scraped the lake bed clean of vegetation, thus removing shelter and food resource for the juvenile chambo. Catches rapidly declined in the 1990s and consisted of small cichlids that are 20% of the value of chambo by weight (Weyl, 2003). The fishery remained in a depressed state through the period of intensive study and reliable data until 2001 (Figure 3) and resulted in declining overall effort (Figure 3) and loss of employment. Subsequent data are erratic and questionable (Jamu *et al*., 2011). All research and verified catch data (Tweddle *et al*., 1995; FAO, 2003; Weyl, 2008) indicate that the chambo fishery will remain in a state of collapse until all small meshed seine nets are removed and the habitat recovers.

The South East Arm of Lake Malawi, Malawi: the collapse of the chambo fishery

During the 1940s, a small-scale subsistence fishery for chambo in the southern part of the South East Arm of Lake Malawi was joined by a commercial operator using relatively large offshore purse seines with 4” (102 mm) mesh. The inshore gillnetting, with a minimum mesh size of 3¾” (95 mm), caught mainly *O. karongae* and *O. squamipinnis,* while the offshore ringnets targeted *O. lidole*, but with some overlap (Lowe, 1952). The combined chambo fisheries consistently yielded on average 5000 $t.yr^{-1}$. Midwater trawling, operating further north in the South East Arm, added to the fishing effort from the early 1970s. The catch data from the 1940s beginning of the commercial fishery showed excellent relationships between catches and total effort, and also influence of changes in lake level, attributed to resultant annual changes in productivity (Tweddle & Magasa, 1989).

Despite very heavy and increasing fishing effort, total annual catches remained relatively stable, even though small meshed shore seines caught unacceptable numbers of juvenile chambo. From the late 1980s, however, the long-established catch-effort relationship (Tweddle & Magasa, 1989) began to break down, with cpue lower than predicted by the model. FAO (1993) stated that the fishery was fully-exploited and suggested reducing effort, but only by 30%. Unfortunately the publication of this statement coincided with the start of a rapid collapse of the fishery in that year. The most offshore species, *O. lidol*e, now appears to be almost extinct in the southern part of the lake (G.F. Turner, pers. comm.).

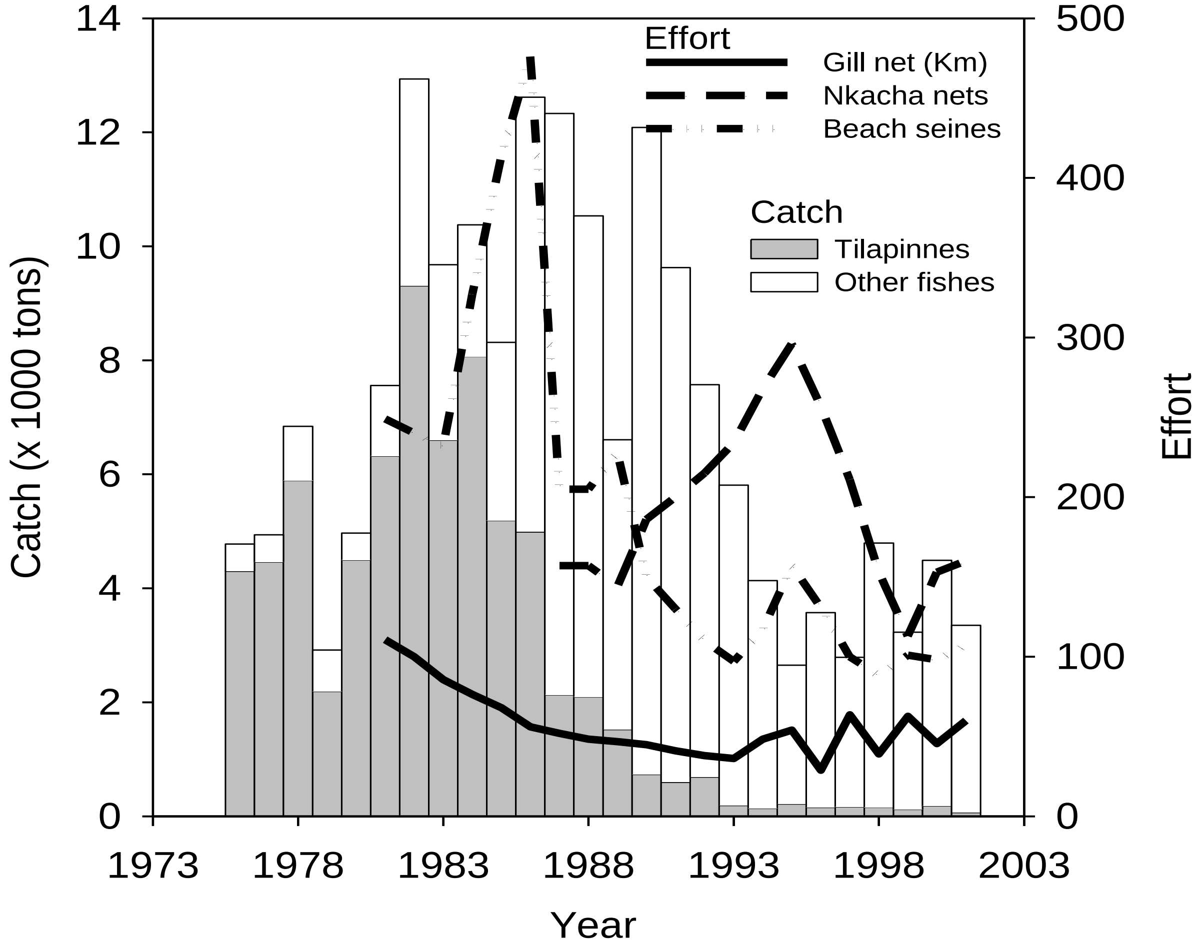

Figure 3. The rise of the fishery for small cichlids using small meshed beach and nkacha seine nets in the late 1970s increased catch of small fish species but resulted in the collapse of the tilapiine fishery in Lake Malombe, Malawi in the mid 1980s. Subsequently, even the fishery for small species crashed and the lake now yields much less than the overall tonnage when the fishery was based on tilapiines.

As overall yields from the combined South East Arm chambo fisheries had appeared stable for decades despite increasing fishing pressure and resultant lower individual cpues, what had changed to cause the collapse? In the 1980s, a new fishing method was introduced, i.e. open water, small-meshed seining using light attraction at night. Catch and effort data (Figure 4) indicate the rapid rise in the use of gear characterised as purse seines after 1980. This category is primarily "chirimila" nets, a gear traditionally used during the day for shoals of small zooplanktivorous cichlids, *Copadichromis* spp, but now being used at night with light attraction, and renamed "kauni".

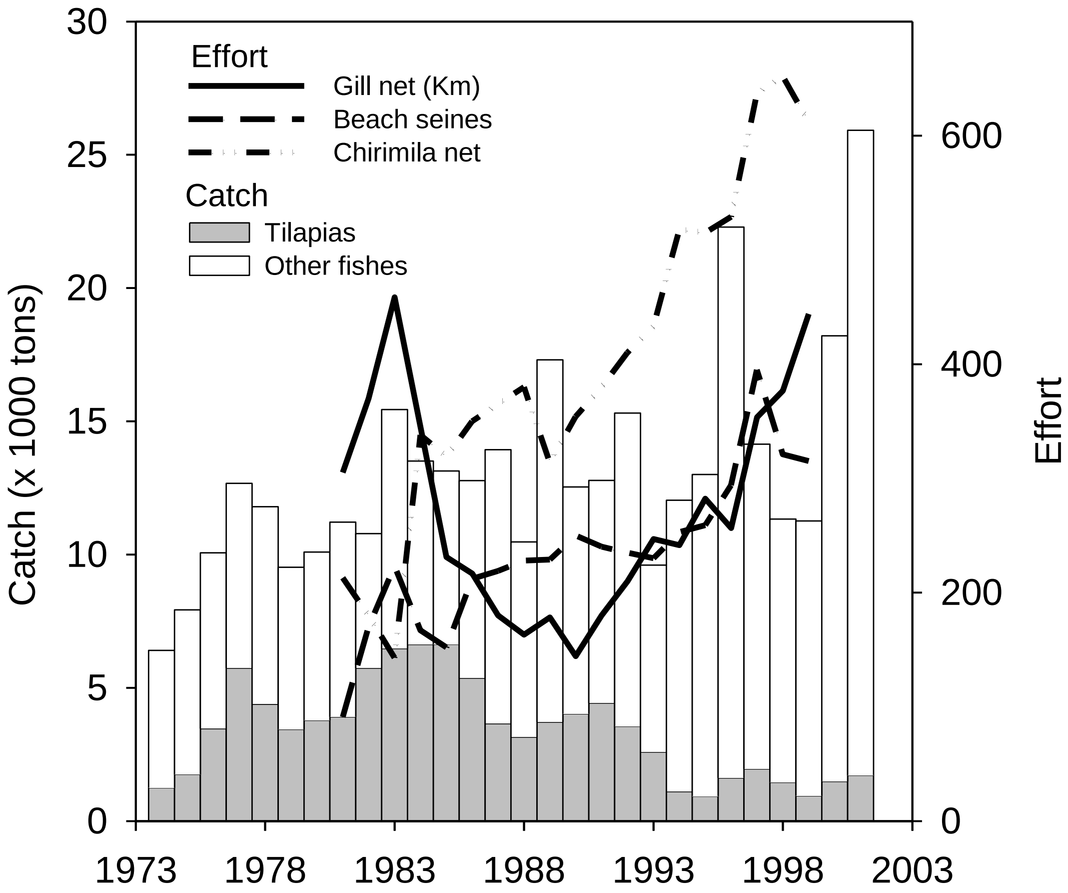

Figure 4. Catch and effort for the southeast arm of Lake Malawi. This fishery was fairly stable until the rapid increase in chirimila net effort in the late 1980s which, used with light attraction (kauni), resulted in the collapse of the fishery for large tilapias. Increased effort in both the beach seine and gill net fishery uses smaller meshed gears that harvest small cichlid species and the small cyprinid *Engraulicypris sardella*.

The addition of the kauni nets changed the fishery dynamics, as they targeted 2-year old fish between 15 cm (the legal minimum size) and 23 cm TL with a modal length of 20 cm (Weyl *et al.*, 2004a). Until the advent of kauni, this year-class was relatively immune from capture as the fish were too far offshore to be caught in shore seines, and were able to pass through 3¾–4" meshes of offshore gears.

As in the case of Lake Malombe, the collapse coincided with the introduction of fishing gears that targeted the smaller, 2-year old fish. Prior to that, yields from the fisheries were stable despite high fishing pressure with larger meshed nets combined with a shore seine fishery that inadvertently caused high mortality of small juveniles.

The implications for Lake Liambezi fishery management

Mesh size regulations

The above examples from Malawi demonstrate that while tilapiine fisheries can withstand intensive fishing pressure, the fish need protection during the fast-growing phase of their life-cycle before maturity. They can withstand high natural mortality on the small juveniles, but once they have reached a size (15-20 cm TL) where they emerge from cover and are relatively immune to predation by predators such as tigerfish, *Hydrocynus vittatus*, they need protection until close to the size at maturity. Both Lake Malombe and South East Arm of Lake Malawi tilapiine fisheries collapsed when this size range of fish was first targeted. The current legal minimum mesh size of 3” (76 mm) in Namibia is wrong as it catches almost entirely immature fish (Fig. 5). The Liambezi fishing community’s choice of 3.5” (89 mm) minimum mesh, with plans to increase to 4” (102 mm), makes perfect sense.

Prohibition of destructive fishing gears

The community is implementing the Inland Fisheries Act regulations prohibiting destructive fishing gears, i.e. seine nets and active use of gillnets by driving fish into them. In addition to preventing excessive fishing effort, the ban on seining helps to avoid the destruction of tilapiine habitats, as seen in Lake Malombe.

Effort limitation

The Malawi examples demonstrate that tilapiines can withstand high levels of fishing effort, although individual cpue declines with increasing effort. Despite the temporary fishery closure and fishermen registration exercise, effort on Lake Liambezi remains high. Catches such as the 206 kg in one canoe (Plate 1), despite the lake being virtually dry two years before, demonstrate that the stocks have high reproductive potential. Community decisions about rules to be followed, registration of fishermen, and regular cooperation with the Inspectors of MFMR to ensure the rules are followed, are of greater value than effort limitation in controlling access to the fishery, as they help to prevent arguments over fishing grounds and competition for the resources.

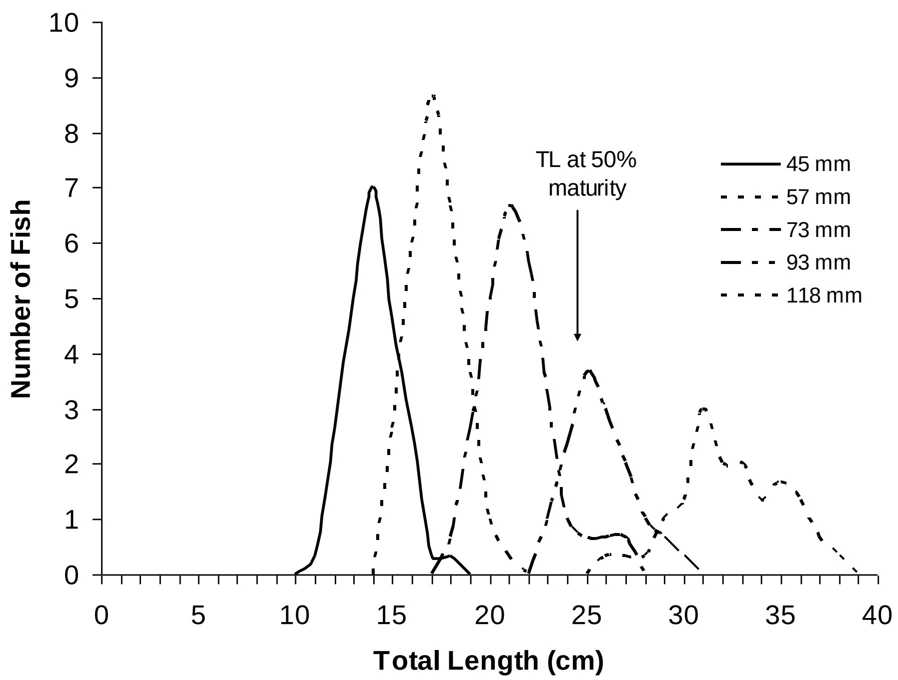

Figure 5. Gillnet mesh selectivity for *Oreochromis andersonii* from relevant mesh sizes of experimental gillnets in Lake Lambezi and other Caprivi waterbodies, 2010-11; data smoothed using moving average of three 1 cm length groups. Total length at 50% maturity was calculated for catch data from Lake Liambezi only, males and females combined.

Restrictions on access

Migratory fishermen are widely blamed for declines in African fisheries, usually with good reason. In contrast to fishermen who come from a particular fishing area, fishermen from elsewhere have no interest in long-term sustainability of the resource. They are often responsible for the introduction of destructive fishing gears. In Lake Malombe, Malawi, for instance, with increased commercialisation, crew were employed by absentee gear owners and increasing numbers of migrant fishermen (Weyl, 2008), while the Barotse floodplain fishermen in Zambia complain that fishermen come from outside and ignore their traditional agreements on resource ownership (Tweddle *et al*., 2004). In Caprivi, commercialisation of the resource and use of destructive seines and drifting monofilament gillnets in the Zambezi River by Zambian fishermen employed by urban businessmen causes widespread resentment in the local fishing communities.

The registration of fishermen allowed to fish on Lake Liambezi has restricted access and reduced overall effort. The system is not totally exclusive. While the registered and licensed gear owners are local, the majority of fishermen they employ are still Zambians, presumably a result of a loss of the local fishing traditions during the decades when the lake was dry.

Nevertheless, the system is successful in placing the community in control of its resources. The bulk of the catch is still exported to Zambian urban markets, but only from the central urban market in Katima Mulilo, Namibia, to which the fresh fish are delivered by local female fish traders.

Ensuring a tilapia-dominated, high value fishery

The management measures adopted are targeted entirely at fishing for the most valuable tilapiine cichlids and ignore other species of lesser value. The economic collapse of the Lake Malombe tilapia fishery is a salutary lesson of the dangers of uncontrolled fishing methods for other, lower value species.

Suitability for an ephemeral water body

Past experience shows that the lake takes three years to dry out when it receives no riverine inflows (B. van der Waal, pers.comm.). High floods for three years, 2009 to 2011, have ensured the lake is full and the surrounding floodplains now retain a lot of water throughout the year, thus it is likely that even without high floods the lake will remain a significant water body for several years. This time span allows for management as a lake similar to Lake Malombe in Malawi rather than as an annually flooded large lagoon, hence a tilapia fishery is the optimal management target.

Management priorities

Given the above factors, the priority for management by the community is to protect tilapias until maturity, i.e.

1. Do not allow gillnet meshes between 2” and 3.5”: these target immature fishes when growing at fastest rate in their life cycle, having survived heavy natural mortality experienced by fry and small juveniles.
2. Do not allow seine nets: ‘nkacha’ nets on Lake Malombe, ‘kauni’ on SE Arm of Lake Malawi destroyed economic value of fisheries.

Conclusions

Lake Liambezi supported a thriving tilapia fishery in the 1970s and has now become one once again. The management measures adopted by the fishing community are intuitively correct for such a tilapia-based fishery. The community has proved capable of regulating the fishery and the efforts of the community to take responsibility for management deserve full support from the Namibian Ministry of Fisheries and Marine Resources. While fluctuations in the lake level mean that conclusive evidence on optimal yields is difficult to obtain, the fishery should be, and is being, closely monitored.

The Lake Liambezi fishery is an outstanding example of the sort of initiative that African government fisheries departments should be supporting. It shows that communities can take responsibility for their own natural resources, and can develop sound management strategies, including regulations that may not tally with government regulations (e.g. minimum mesh size) but are best suited to local conditions.

Acknowledgements

This description of the Lake Liambezi fishery is based on the efforts of the MFMR staff and research students in Katima Mulilo, who are thanked for their contributions through our extensive discussions about what is happening to Lake Liambezi. The Muyako fishing community is also thanked for sharing information on the steps they are taking to manage the fishery.

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