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

Project No.: WWF –9F0792

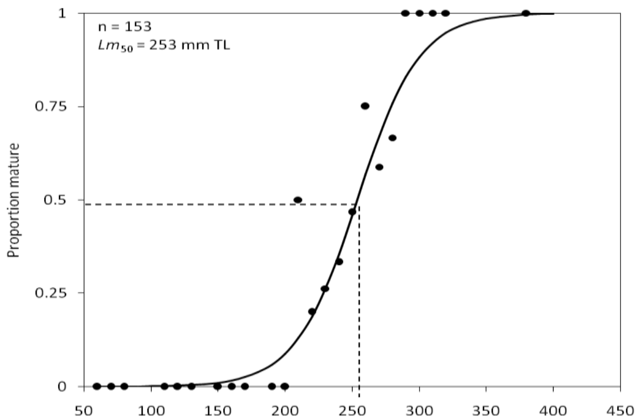
WWF-Norway –Norad – 5012 - GLO-08/449-29

Data collection and analysis: Report on workshop conducted from 26-27 October 2011, Katima Mulilo, Namibia

Catch recording at Lake Liambezi

Removing otoliths for age determination

Recording fish for export, Katima Mulilo market



Length at maturity ogive for *O. andersonii* from Lake Liambezi

by: Denis Tweddle & Clinton J. Hay

Field Document no. MFMR/NNF/WWF/Phase II/5

ATTENDANCE

Denis Tweddle, Project Executant
Clinton Hay, Project Co-executant
Evans Simasiku, Fisheries Biologist
Joseph Lubanda, Research Technician
Laimi Haungeda, Research Technician
Calvin Mwiya, Chief Fisheries Research Technician
Robert Kaapala, MFMR Technical Assistant
Kenneth Sefulo, Project Fisheries Development Officer
Joubert Maezi, Project Fisheries Development Officer
Morgan Saisai, Senior Fisheries Research Technician (day 1 only)
Osbert, Research assistant (day 1 only)
Alex Muhero, Research assistant (day 1 only)

AGENDA

1. Aim/Purpose of workshop
2. Data collection programmes and future surveys
    a. Floodplains – Project Fish Monitors: catch recording and makoro counts
    b. Lake Liambezi – Research programme (fisheries independent surveys: Evans Simasiku)
    c. Lake Liambezi – Catch recording at landing sites (fisheries dependent surveys)
    d. Lake Liambezi – Experimental gear sampling programme
    e. Katima Mulilo Market Survey, wholesale recording programme
    f. Katima Mulilo Market Survey, retail recording programme
3. Data quality
4. Responsibilities
5. Data protocols
6. Future activities, research and monitoring programmes, phasing out of project

1. AIM/PURPOSE OF WORKSHOP

Several data collection programmes have been initiated to investigate the importance of the Caprivi fish stocks in recent years to both food security and the local tourism economy. Both the Zambezi/Chobe Fisheries Project and the MFMR itself have established research and monitoring programmes. These programmes include:

- Market survey of fish sold through Katima Mulilo urban retail fish market.
- Survey of fish distributed wholesale and exported on trucks from Katima Mulilo urban market.
- Catch data collection by project fish monitors from fish landing sites in pilot project areas on the floodplain.
- Lake Liambezi catch recording at Shamahuka landing, Muyako.
- Lake Liambezi experimental fishing programme using gears emulating those used by the lake's fishermen.
- Lake Liambezi scientific research project, including multidisciplinary study on ecosystem functioning in the lake.

- Ad hoc sampling of fish populations for taxonomic and biodiversity studies and preparation of educational materials.
- Annual long-term monitoring programme by MFMR at established standard sites throughout the fishery.
- Frame survey, jointly with Zambia, in 2008
- Survey of economic value of angling at tourist lodges.

These programmes have produced an enormous amount of data. Most of the earliest information has been analysed and reports have been published by the project (market survey report, angling tourist lodge report, frame survey report). The purpose of this two-day workshop was to review:

- **The quality of the data currently being produced.**
- **The purpose of the data (i.e. what do we need to know about the dynamics of the fishery and what questions can be answered through data collection?)**
- **Changes that need to be made to the data collection (design of recording forms, essential information to be filled in, etc.) to maximise the usable information obtained.**
- **The need for further training in data collection.**

2. & 3. DATA COLLECTION AND DATA QUALITY

These agenda items were treated together. Each programme was discussed in detail, with extensive discussions about the purpose of the data collection and how the data should be used to inform management of the fishery.

FLOODPLAINS – PROJECT FISH MONITORS (Kasika, Impalila and Sikunga)

This programme has been running for several months and problems have been identified in the data, including inadequate recording and falsification of data. The forms need to be improved and the Fisheries Development Officers and Fish Monitors better trained. Problems identified were (a) poor quality of recording of number of makoros in the sampled areas, (b) absence of information on what proportion of the makoros were sampled, (c) doubts about whether all fish in the catches sampled were recorded, (d) wrong identification of fish species, and (e) clear evidence of faked results from one fish monitor who has now been dismissed.

Despite these problems, very valuable data are being collected. The two graphs below showing the length and weight data for *O. andersonii* illustrate both the valuable data being collected and the way in which some errors that do creep in can easily be detected and corrected. In this case, the weights of all the fish below 135 mm in length clearly had the decimal point in the wrong place, with e.g. a 20 g fish being recorded as 0.2 kg instead of 0.02. Between 200 and 300 mm, many fish were recorded as less than 100 g. The most likely explanation is a malfunctioning weighing scale. Apart from these obvious groups of errors, there are only a few evident individual recording mistakes. Simply by removing the obvious recording errors, done in the right hand graph, you can see that the great majority of the measurements were correct, and the calculated length-weight relationship closely matches that obtained through the Liambezi research programme (Fig. 2).

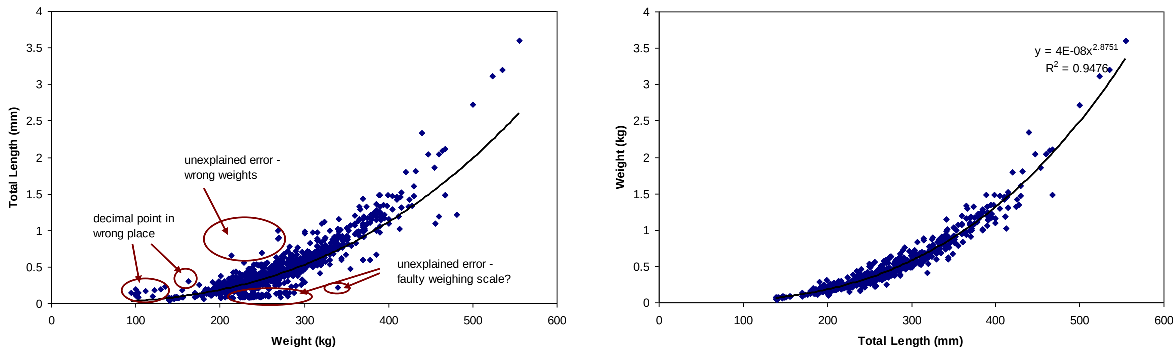


Figure 1. Left. Unadjusted data from monitors, indicating the incorrect data points. **Right.** Adjusted graph with calculated length-weight relationship. Clear errors have been removed, and the number of data points reduced for the smaller length classes in order to give more weighting to the fewer larger fish in calculating the relationship. Note how the calculated relationship is now a better fit for the larger fish.

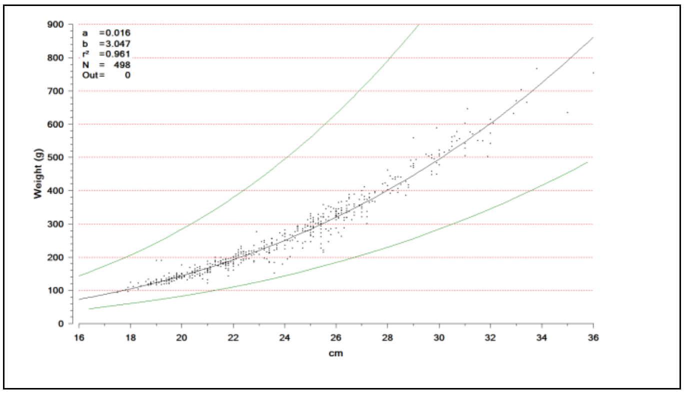


Figure 2. Length weight relationship for *Oreochromis andersonii* caught with the experimental gill nets from Lake Liambezi. Note close similarity of calculated curve to that shown in Figure 1, right.

Another point on accuracy of recording was drawn to the attention of the workshop, i.e. the tendency for recorders to measure fish to the nearest 5 or 10 mm, instead of the nearest mm. This is a result of the way in which rulers are marked, with much more prominent lines every 5 and 10 mm. The eye is drawn to these marks resulting in fish that are close to that length being wrongly recorded. Virtually all fisheries scientists and assistants (including us) make that mistake the first time they measure fish, but it usually just takes one look at the resulting graph (see below, Figure 3) to correct the tendency. For analysis, fish are usually grouped in broader categories, such as to the nearest cm below (see Figure 4), and this hides the bias.

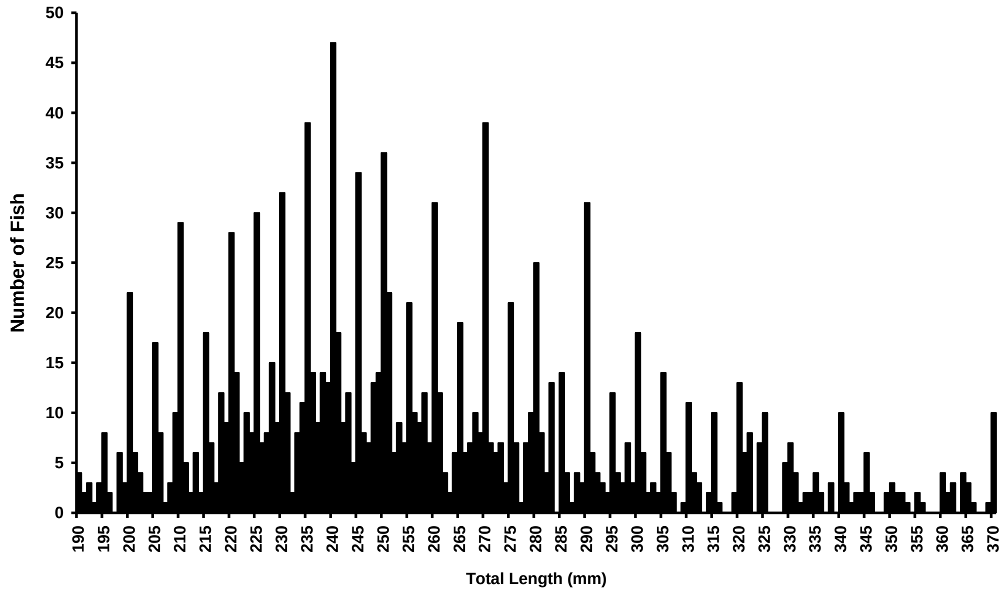


Figure 3. Numbers of fish (*O. andersonii*) at each mm length group recorded by fish monitors in the project. Only fish between 190 and 370 mm are included here to aid clarity. Note peaks in number every 5 and 10 mm.

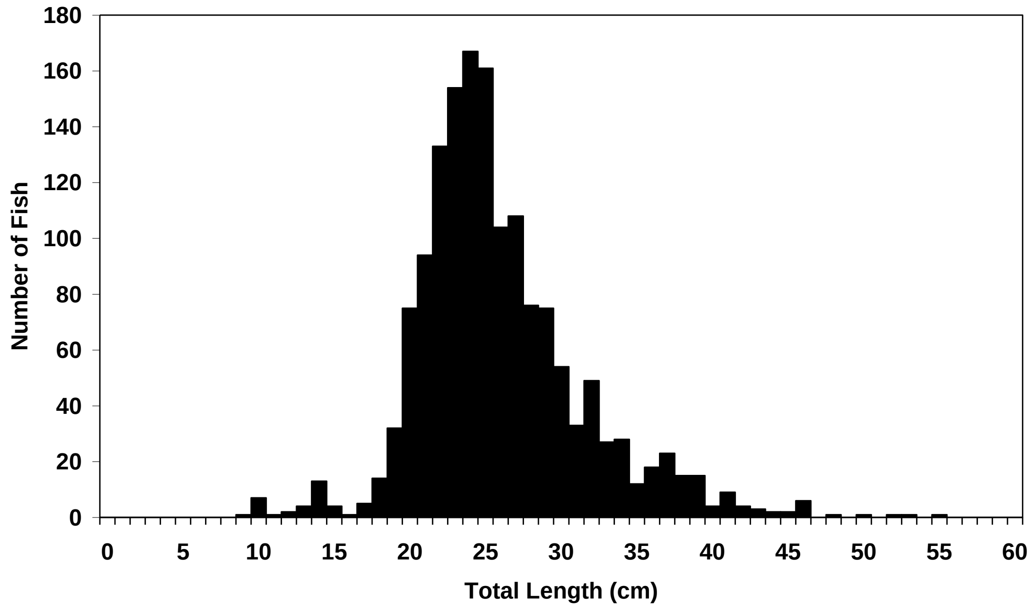


Figure 4. The same data as in Figure 3, but grouped in 1 cm categories, e.g. 20 cm includes all fish from 20.0 to 20.9 cm.

It was explained that the purpose of the programme is to assess not only the type and size of the fish being caught, but also attempt to come up with an estimate of the total quantity of fish being caught. While discussing this issue, Dr Ekkehard Klingelhoeffer phoned with a request to tell the Ministry how much fish was being produced annually from the Caprivi floodplains. The current data are inadequate to make an accurate estimate of yield, but we used this request as an exercise with the participants to show why the data are being collected and how data collection should be improved. The results of the exercise were communicated to Ekkehard and the communication is appended to this report. Even with the limited data available we were able to show that the accepted estimate of floodplain yields, i.e. 1500 t/year is a gross underestimate of the true yield. The data collection system now in place has made it possible to give an estimate of the annual yield from the Caprivi, whereas in the past such information was unavailable. This illustrates the vital importance of data collection in demonstrating the importance of fisheries and ultimately, using continuous long-term data, managing the fishery on an optimal basis.

It was stressed that this estimate shows how important accurate catch data are, as they illustrate that the fishery has a market value in excess of N$ 100 million annually and therefore the ministry must invest in managing such a valuable fishery to ensure its sustainability.

A simple explanation was given about how we plan to improve data collection to make results statistically significant. Each recorded catch from any makoro can be used to give an estimate of the total catch from the fishery, on an area basis and/or a time basis, e.g. daily or annually. Some of these estimates will be wildly inaccurate but with enough samples accurate figures can be achieved.

The process is simple. We know the number of makoros in the fishery from both the frame survey and the separate aerial survey. There are approximately 1900 makoros, 1100 in Namibia and 800 in Zambia. An example of calculation is as follows:

30 makoros recorded in sampled area
15 noted as fishing on that day
Catch from one sampled makoro is 15 kg
Estimate of total annual yield from the whole fishery based on that one catch would be:

Total makoros x makoros landing catches / number on beach x catch from one canoe
i.e. 1900 x 15 / 30 x 0.015 t x 365 days in year
= 5201 tonnes

Obviously this could be wildly inaccurate. Errors include large fluctuations in daily catch, no fishing on public holidays (maybe 350 fishing days per year is more realistic), periods e.g. floods, when no fishing is possible, etc.

Data collection needs to be planned to eliminate these errors, therefore sampling is necessary throughout the year, catches must be collected from as many fishers as possible, makoros (fishing and non-fishing) must be accurately counted, and each part of the floodplain can be treated as a separate area or stratum.

For example, if catches from five makoros rather than one are counted, the mean catch from the five will be much more accurate a representation of the true cpue than a single recorded catch.

The following hypothetical example was used to illustrate how more samples result in a more accurate estimate of total yield. Note that these are not real data, just figures made up as an example. This graph (Fig. 5) shows a wide range of estimates of total catch, but the great majority fall between 5500 and 6500 tonnes and thus this is the true figure for the annual yield.

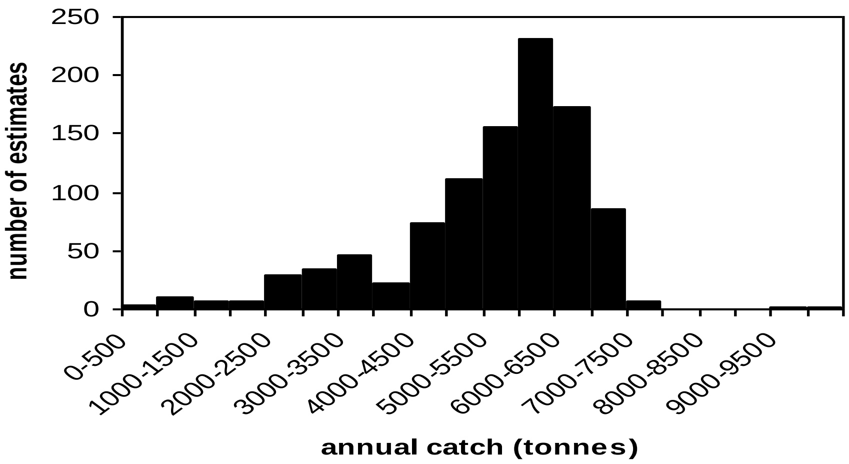


Figure 5. Hypothetical results of catch records from 1000 makoros over the year, extrapolated to the whole fishery as shown in the single example in the box above.

These examples are very rough but they form the basis for a more accurate, but still very simple, statistical system that we propose to introduce in the coming year.

LAKE LIAMBEZI

Results from the different research and monitoring programmes on Lake Liambezi, when taken together, will give an accurate picture of the status of the fish stocks and fishery.

Research fishing – Evans Simasiku

The research uses gears emulating those used by the fishermen on the lake. Provided enough data are collected from an adequate number of sets, this programme will give an accurate picture of the catch per unit effort (cpue) by species for standard gillnets of different mesh sizes.

Commercial exports recording

The bulk of the catch from Lake Liambezi passes through the commercial area of Katima Mulilo urban market. Recording the total amount of fish being loaded onto trucks for export to Zambia and beyond gives an excellent picture of trends in the fishery and acts as a cross-check on the recording at the Shamahuka Fish Landing (see below).

It was reported that the formal MFMR programme has been discontinued but Robert and Kenneth continue on an irregular basis. This programme is vital to informing the MFMR about the high importance and health of the Lake Liambezi fishery. All the workshop participants agreed the recording programme should be fully restored, with sampling on two days per week, changing days each week.

To get accurate market data it is essential that the sample size is noted. Ideally all fish boxes brought in on a sampling day must be recorded. Also, dried fish are now being exported and these need to be recorded separately.

Catch monitoring - Shamahuka Fish Landing

Total catches are sampled from as many of the makoros landing as possible. It gives a good picture of the cpue by makoro but not for fishing gears. Recording of lengths and weights of fish from a sample of canoes has been discontinued as fishermen objected to the time taken. The total number of makoros landing fish and the total number of makoros at the beach are not recorded. The form must be modified to capture this information.

The discussions in the workshop revealed flaws in this programme that have to be corrected to get more accurate and usable data. Data to be recorded should be:

- Total number of makoros on beach
- Total number fishing on sampling day
- Number of makoros sampled
- Total weight by species of each makoros catch
- Fishing gear used, type and number
- Length data from a random sample of each species from each makoro (number selected based on **(a)** size of catch, e.g. all fish from very small catches, 50% from medium catches and 25% from large catches, **(b)** willingness of fishermen to cooperate, and **(c)** time available to sample.

With these data, the weighed and measured catches can be used to determine:

- Total catch from the fish landing on that day by species
- Cpue per fishermen (catch in kg per makoro)
- With data for every week in every month of the year, estimate total catch for the year from the fish landing
- The mesh sizes of the nets used by the fishermen (by comparing the length distribution of the catch with the research data on mesh selectivity collected by Evans Simasiku and Richard Peel)

Difficulties were reported in recording accurate gear usage by fishermen, who always under-report number of nets owned for fear of being arrested for contravening the Fisheries regulations. This led to a discussion on the vital importance of experimental fishing programmes (like that of Evans) to obtain accurate estimates of cpue.

FISHERY DEPENDENT DATA VERSUS FISHERY INDEPENDENT DATA

Recording of fishermen's catches AND experimental fishing are vital to understanding of the fishery and for accurate estimates of yield from the fishery.

Below is an example, given to the workshop participants on a flip chart, of how the experimental data collected by Evans Simasiku are important for estimating the total fishing effort on Lake Liambezi.

Data collected from landing site:	
Number of makoros at landing	50
Number fishing that day	25
Number sampled	5
Average catch per makoro	40 kg
Total weight recorded	200 kg
Estimate of total catch at the landing that day	200 kg x 25/5 = 1000 kg
Mean cpue in Evans research programme	2.5 kg
Effort on lake in gillnet equivalents	1000 kg/2.5 kg = **400 gillnets**

These data show that **Fishery Dependent Data,** i.e. the catch recording at the fish landing, combined with **Fishery Independent Data**, i.e. Evans's mean cpue, can be combined to produce reasonably accurate estimates of the effort being used in the fishery. This example was used to illustrate the point that it is not essential to get really accurate records of gillnets in use provided there is an **independent estimate** of cpue.

In any case, the number of nets owned by any fisherman is not necessarily an accurate measure of effort. By drifting nets, bashing the water, or using dragnets, a fisherman increases his effective effort way beyond the effort he would be using if his nets were set in a legal, passive way. Simply recording number of nets owned gives a false, gross underestimate of the real effort.

Other examples were mentioned in the workshop of estimating effort accurately. These need the existence of long-term accurate data for certain gears in multi-gear fisheries. Two examples were given from Lake Malawi commercial fisheries.

The first concerned the demersal trawl fishery. Trawlers land at specified sites and the operators provide accurate records of daily catches. The fishery started with pair trawlers equipped with 25HP engines, a total of 50HP per unit. Three other single boat trawlers used 88HP, 125 HP and 235HP engines. Comparison of catch rates revealed a direct linear relationship between cpue and HP. Analysis of data therefore treated a pair-trawl day as a single unit of fishing effort, i.e. a standard boat day, and the larger trawlers as 88/50, 125/50 and 235/50 units of effort respectively. The graph below (Figure 6) shows how the combined data are used to assess allowable effort and sustainable yields.

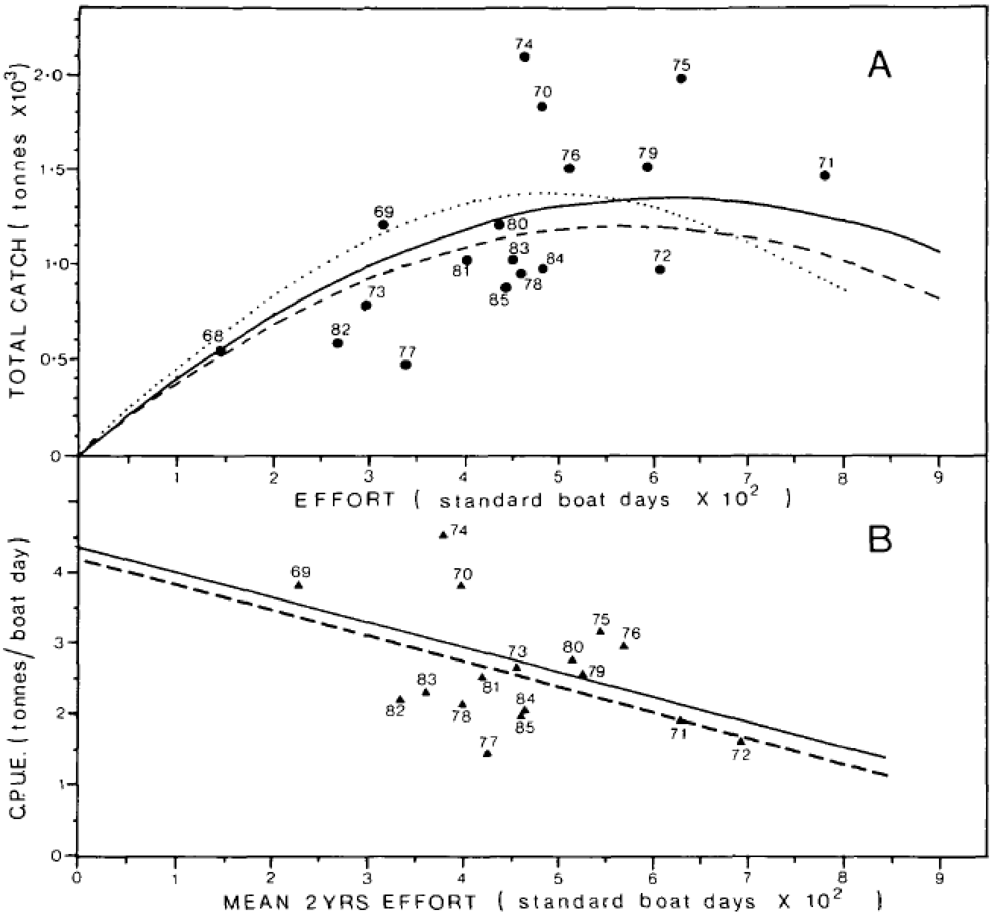


Figure 2. Analysis of catch/effort data for the demersal trawl fishery of Area A. Numbers on figure designate years. Solid lines = calculated yield curve using all data except 1977–1978. Dashed lines = calculated yield curve omitting data from 1974–1978. Dotted line = calculated yield curve of Turner (1977a).

Figure 6. Example of use of standard units of effort, analysis of trawl data from Lake Malawi.

The second example is from the commercial tilapia fishery on the lake. A ringnet fishery started in 1946 and full records are available for every single ringnet pull throughout the fishery. These data, from the same paper as the example above (Tweddle & Magasa, 1989), were combined with the catches from the other offshore gears used to catch the tilapias, as explained in the extract below. Effort in all other gears was expressed as ringnet pull equivalents.

Chambo ringnet fishery

Data prior to 1975 are taken from FAO (1976). Maldeco Fishing Company, which runs the Chambo ringnet fishery, the 38-mm mesh Utaka ringnet, and the 102-mm and 38-mm mesh midwater trawl fisheries, submits monthly returns similar to those of the trawl fishery for each fishing unit. C.p.u.e. is measured in tonnes per pull for all ringnets, and in tonnes per day for trawlers. A 38-mm mesh demersal trawl used by Maldeco also catches small amounts of Chambo in the same area (<1 % of combined catch in other gears), and these catches are taken into consideration.

The combined Chambo catch data from the Utaka nets, the Chambo midwater trawl, and the demersal trawl, were converted to ringnet equivalents for each year, the total effort being calculated using the formula:

$$\text{Total effort} = \frac{\text{total catch (all gears)}}{\text{ringnet catch}} \times \text{ringnet effort (pulls)}.$$

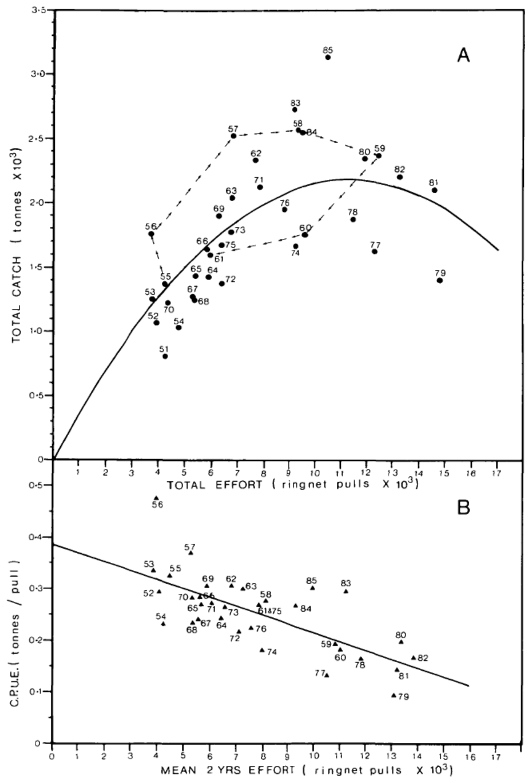


Figure 6. Analysis of catch/effort data for the Chambo ringnet and associated fisheries. Numbers on figure designate years. The 1955–1961 catch cycle discussed in the text is indicated by arrows.

Figure 6. An example of use of standardised fishing effort for the Lake Malawi commercial fishery for chambo.

THE IMPORTANCE OF FISHERIES INDEPENDENT RESEARCH PROGRAMMES

Without knowing the biology of the important fish species in the fishery, particularly growth rate and size at maturity, it is impossible to manage fisheries optimally. This is why we have implemented and supported several research programmes. The data below are from the experimental gillnetting programme on Lake Liambezi. They show that *Oreochromis andersonii* matures at 25 cm TL, and that nets with mesh sizes less than 90 mm catch almost entirely immature fish. The same pattern is apparent in both the Zambezi and in Lake Liambezi. The bulk of the catch from the floodplains is immature fish caught in 3” (=76 mm) mesh nets (Fig. 4). The current legal minimum mesh size of 75 mm should therefore be increased with immediate effect to at least 90 mm.

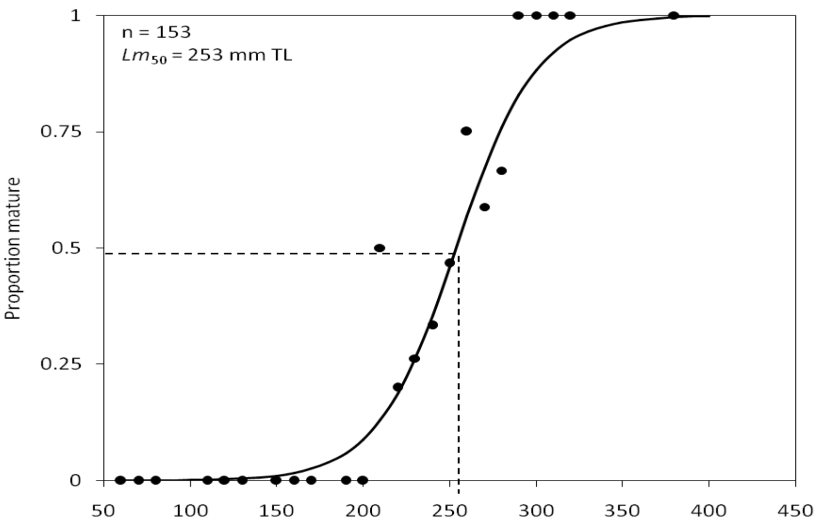


Figure 7. Length at maturity ogive for *O. andersonii* from Lake Liambezi.

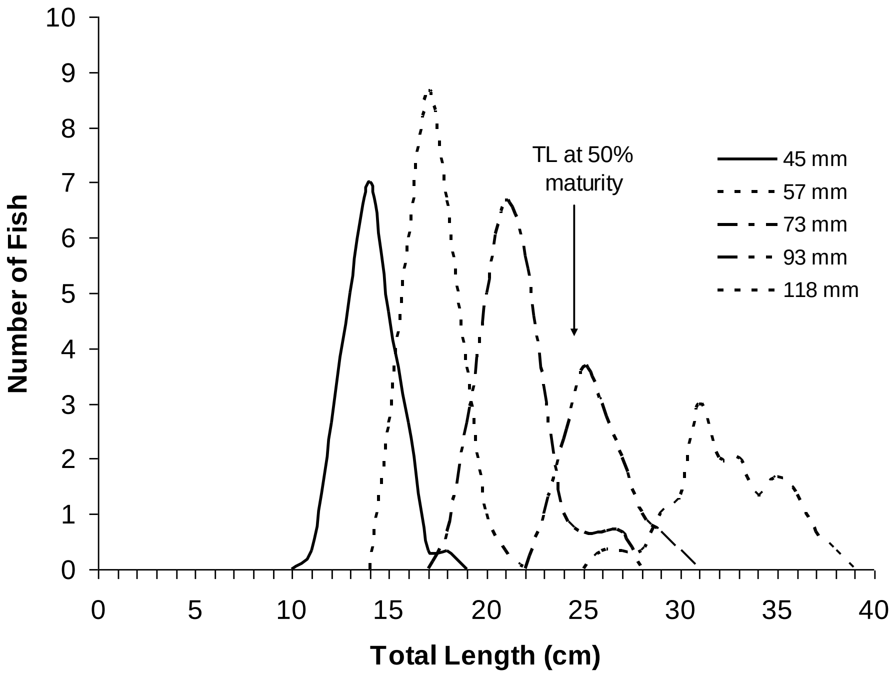


Figure 8. Mesh selectivity for *O. andersonii* in relation to length at maturity. Comparing this with Figure 4 shows that the bulk of the Caprivi catch consists of immature fish caught in 3” mesh (76 mm) nets.

MARKET SURVEY, RETAIL SECTION

Data on fish being brought into Katima Mulilo urban market for sale to the public are recorded by the project twice a week. These data are very simple to collect and provide very valuable information not only on trends in catches throughout the year, and between years, but also on species and size composition, and the data provide a warning system for undesirable trends in the fishery. The data do not provide an estimate for catches in the system but they do detect trends. If the programme continues these data will provide very valuable information on medium and long term trends in the fishery.

4 & 5. RESPONSIBILITIES AND DATA PROTOCOLS

At present there is some uncertainty over who is responsible for organising and conducting the research programmes and who is responsible for data analysis. The project is supporting some programmes but the MFMR's activities need to be sorted out, particularly given Noa's departure from Katima Mulilo and Evans being based in KIFI. It is essential that all questions must be resolved during Ekkehard's forthcoming trip to Katima Mulilo. Everyone must be clear about their individual and collective responsibilities.

At present data are scattered in several computers at KIFI and Katima Mulilo offices, and raw data are not being properly filed. This must be corrected immediately and a complete data set compiled for **ALL** inland fisheries data. It is also essential that there is a dedicated computer solely for data storage, together with back-up external hard drives kept in a separate location to the computer in case of fire, theft, etc. Hard copies should also be kept of all data. Complete data sets should be kept at both KIFI and Katima Mulilo.

Most data collected are suitable for storage and analysis using PasGear.

6. FUTURE ACTIVITIES: RESEARCH, MONITORING AND TRAINING PROGRAMMES, PHASING OUT OF PROJECT

The project ends at the end of 2012. To obtain necessary information for fisheries management in the area, the monitoring programmes set up under the project need to be sustained indefinitely by the MFMR and now is the time to plan for these activities in future. Such planning should also cover the Kavango River fisheries.

As a first step, the MFMR must compile a definitive research and monitoring programme for year 2012. A training programme must also be developed by MFMR that should encompass training in the use of PasGear and also a full and up-to-date analysis of all available data.

APPENDIX. LETTER FOR MFMR ON CATCH ESTIMATES IN THE CAPRIVI FISHERY, ESTIMATED AS AN EXERCISE IN THE WORKSHOP

Dear Dr Klingelhoeffer,

CATCH ESTIMATES FOR CURRENT YEAR IN TONNES AND MARKET VALUE

In response to your request for catch estimates for the Caprivi Region in the last year, we have made the following estimates (Table 1) based on the new catch recording systems set up through your Katima Mulilo ministry office with the assistance of the MFMR/NNF Zambezi-Chobe Fisheries Project.

We have accurate data on the species composition of catches in both Lake Liambezi and on the Caprivi Floodplains, reproduced here in Tables 2 and 3 below.

Table 1. Summary of catch and value for the fisheries of the Caprivi Floodplains and Lake Liambezi for the present year, 2011.

Area	**Annual catch**	**Value (N$)**
Caprivi floodplain, Namibia	2,900 tonnes	58 million
Caprivi Floodplain, Total	5,000 tonnes	100 million
Lake Liambezi	1,700 tonnes	34 million
Total	**6,700 tonnes**	**134 million**

We have accurate records of the number of makoros from the 2008 frame survey, verified by an aerial survey count in September 2009. We have rounded off figures in all cases to the nearest 100.

The number of fishing craft on the Caprivi floodplain, not including Lake Liambezi, is 1900, of which 1100 are on the Namibian side of the Zambezi.

The mean daily catch calculated from our fish monitors' recorded data is 15 kg. At present we do not have accurate figures for the percentage of those craft that actually fish on any one day. We are improving the recording system to get those data in future. We have very conservatively used an estimate of 50% of the craft used on any one day. This gives a figure of 950 active fishing craft per day. At an average catch of 15 kg/day and 350 fishing days per year, this equates to 5000 tonnes per year, of which 2900 tonnes is caught by Namibian based fishermen.

We have treated Lake Liambezi separately as we have more comprehensive data. We also have separate recording systems that complement each other. At this stage we have assessed the Katima Mulilo commercial market data for the period February to July 2011.

Over this period, the daily catch passing through the market (of which well over 95% comes from Lake Liambezi) averaged 4.8 t/day, which equates to an annual catch assuming a 350 day fishing year of 1700 t.

In total, therefore, the annual fish yield from the Namibian sector of the floodplains is 4600 tonnes, and 6700 tonnes overall. At a market price of $20/kg (Katima Mulilo retail market data) this equates to a fishery valued at N$ 134 million, of which N$ 92 million is generated in Namibia.

Table 2. Caprivi floodplain catches by species, based on the data collected by fish monitors at various fish landing sites throughout the floodplains.

Species	**% by weight**
Tilapia rendalli	18.2
Oreochromis andersonii	16.7
Oreochromis macrochir	10.3
Clarias gariepinus	13.2
Serranochromis altus	5.7
Serranochromis macrocephalus	4.5
Schilbe intermedius	2.4
Sargochromis giardi	3.5
Hydrocynus vittatus	5.8
Tilapia sparrmanii	1.3
Mormyrus lacerda	3.1
Marcusenius altisambesi	1.2
Hepsetus odoe	1.7
Serranochromis angusticeps	1.8
Synodontis sp.	0.8
Clarias ngamensis	4.1
Serranochromis robustus	1.9
Sargochromis carlottae	1.2
Sargochromis codringtonii	0.7
Brycinus lateralis	0.6
Pharyngochromis acuticeps	0.4
Labeo lunatus	0.5
Hemichromis elongatus	0.1
Clarias stappersii	0.1
Parauchenoglanis ngamensis	0
Barbus poechii	0
Ctenopoma multispine	0
Total	**100**

Table 3. Lake Liambezi catches by species, based on the data collected using research gillnets emulating the methods used by the fishermen in the lake.

Species	**% by weight**
Oreochromis andersonii	32.7
Serranochromis macrocephalus	28.6
Oreochromis macrochir	12
Schilbe intermedius	2.7
Clarias gariepinus	6.8
Hepsetus odoe	4.9
Clarias ngamensis	4.8
Tilapia rendalli	2.7
Sargochromis codringtonii	1.6
Mormyrus lacerda	1.5
Sargochromis carlottae	0.5
Serranochromis robustus	0.8
Tilapia sparrmanii	0.2
Sargochromis giardi	0.2
Marcusenius altisambesi	0
Brycinus lateralis	0
Total	**100**