UNIVERSITY OF NAMIBIA

Faculty of Agriculture and Natural Resources

Fisheries and Aquatic Science

Comparison in fish catches in Lake Liambezi and the surrounding floodplains on the Zambezi River in Eastern Caprivi

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And

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Submitted in partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Fisheries and Aquatic Sciences

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DECLARATION

I hereby declare that this work is the product of my own research efforts, undertaken under the supervision of Dr. Clinton Hay and Mr. Evans Simasiku and has not been presented elsewhere for the award of the degree. All the sources have been duly and appropriately acknowledged.

Candidate Signature: ……………………………………………… Date: ………………………..

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CERTIFICATION

This is to certify that this report has been examined and approved for the award of the degree of Bachelor of Science in Fisheries and Aquatic Science of the University of Namibia.

External

Examiner………………………………………………………………………………

Internal

Examiner……………………………………………………………………………….

Supervisor………………………………………………………………………………

Head

Department……………………………………………………………………………...

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DEDICATION

This work is dedicated to GOD my creator, the Norwegian government for granting me a bursary, my family and friends that helped and supported me during the course of my studies.

Contents

Abstract

The Caprivi Region located in the extreme north-east of Namibia. About 50% of the rural population live in the northern regions and derive food, income and informal employment from the fish resource. Floodplains cover 19 % of the Caprivi. About 78% of the Namibian fish species depend on migrations between the floodplains and the main river for their larval and juvenile stages. The floodplains are highly productive and important in the subsistence fishery with an estimated potential of approximately 2,800 tons per annum. Lake Liambezi was dry between 1985 and 2000. It received some inflow during 2007 and a major flood in 2009 filled the lake and fishery developed after that. Lake Liambezi has a fisheries potential, estimated to be approximately 2,581 tons per annum. There is a perceived decline in the fish catches from the floodplains and Lake's subsistence fishery. This study was carried out to compare the catches between the floodplains and Lake Liambezi and provide baseline information for recommendations for the sustainable management of the fish resources. Catches from the subsistence fishery are extremely important and must be documented to develop a management plan for the fishery. Where data was collected from fishermen in floodplains and data obtained from actual experimental gear used in the lake results showed that in general the floodplains are more productive. However, when statistical analysis were done to compare the two independent samples, the results showed that there is no significant difference between the catch per unit effort (CPUE) either from the different fishing gear (mono – and – multifilament) or from each different month. The harvest from the floodplains were high compared to Lake Liambezi for reasons not yet known; it could be due to its vast surface area and therefore a lack control or law enforcement, causing illegal fishing and bashing.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

The Caprivi Region, located in the extreme north-east of Namibia, has an important fishery as it is part of the livelihoods of many people in the region. Most communities in this particular area are heavily dependent on the fish resource for subsistence and income. About 50% of the rural population live in the northern regions and derive food, income and informal employment from the fish resources (FAO 2008). Freshwater fish in this region is an affordable and easily obtainable protein source for the population. The socio-economic implications surrounding the fish resource in the Eastern Caprivi has tremendous value in terms of commercial and subsistence fishery. In Kavango and Caprivi regions more than 100,000 people depend on this resource for their daily protein needs (FAO 2008).

The consumption of freshwater fish in the Caprivi region ranks over beef, game and poultry and also has a significant economic value for the communities (Turpie e*t al*.1999). The most important fish species are the silver catfish, squeaker, bulldog, tigerfish, tilapia, silver robber, dashtail barb and sharptooth catfish. The importance of freshwater fish resources increases especially during periods of drought when the crop fails and the people rely on fish from the river.

Perennial rivers provide over 1million hectares of floodplain wetlands with fisheries potential, estimated at approximately 2,800 tons per annum, (N$ 22 million) (FAO 2008).

According to (Barnard 1998), most Namibian fish species (78%) are floodplain dependent for larval and juvenile stages and depend on migration between floodplains and the main river.

According to Curtis et al (1998), floodplains cover 19% of the Caprivi. In times of exceptional flooding, the Kwando-Linyanti and Zambezi-Chobe River systems are inter linked and large parts of the eastern Caprivi become flooded. The Caprivi wetlands have the highest overall species richness of the Namibian wetland systems, and 82 fish species occur in the Namibian part of this water system.

The annual cycles of flooding and precipitation cause a seasonal contraction and expansion of the floodplain, which in turn affects the productivity of the fishery. As areas become covered in water, fish migrate onto the floodplain to feed and reproduce. When waters begin to recede, adult and juvenile fish return to the main channel or become trapped in isolated bodies of water on the floodplain. Fishing activity is mostly artisanal, with the majority of fishers using gill nets and dugout canoes (Purvis 2002; Næsjeet at el. 2003).

In many floodplain environments, fishing is usually not targeted towards specific species (Welcomme 1985), a pattern also seen in the Upper Zambezi River fishery; over 50 species of fish are caught by inhabitants, with the majority of individuals being either cichlids or catfish (Purvis 2002). Changes in fishing technique and effort are linked to seasonal variations and movement of fish between the main channel and floodplains (Purvis 2002).

According to a survey done by Abbott (2005), 78% of the residents say that the number of fish has declined, with the remaining responses equally divided between no change and increase in fish stocks. The opinion varied more significantly regarding the state of the stock. Most responded that it was difficult to say due to the variability of the floods, however, those who said that catches had declined, thought that it was not because there was less fish available but rather they thought the issue was because of more people now fishing the same resource. Individuals involved in recreational fishing reported that fishing was still good, although some effect due to drag netting and small mesh sizes caused some declines on the catches especially on the Zambian side of the river.

Management of a sustainable fishery may depend on a better understanding of the catch rates between the Lake Liambezi and the surrounding floodplains on the Zambezi River in the Eastern Caprivi. Therefore, more research is required in order to understand these complex ecosystems and implement management regulations, Økland et al (2005). There is therefore, an urgent need to regulate the fishing so that this resource can be harvested sustainably Økland et al (2005).

Problem statement

Harvesting patterns from the subsistence fishery are extremely important and must be documented to develop a management plan for the fishery.

Research objective

The objectives of this report are to understand and document the catch rates, also between the Caprivi Floodplains and Lake Liambezi to provide baseline information for recommendations for the sustainable management of the fishery resource.

Hypothesis

H0: There is no significant difference in fish catch rates between the floodplains and Lake Liambezi.

H1: There is a significant difference in fish catch rates between the floodplains and Lake Liambezi.

H0: There is no significant difference in species diversity between the catches from the Floodplains and Lake Liambezi.

H1: There is a significant difference in species diversity between the catches from the Floodplains and Lake Liambezi.

CHAPTER TWO

Study Area, material and methods

Caprivi Region

The Caprivi Region in Namibia is situated about halfway between the equator and the southern tip of Africa. The region borders on Botswana in the south (the Kwando and Chobe Rivers and the Kwando/Linyanti System), Angola and Zambia (the Zambezi River) in the north and east, and Zimbabwe in the east (Barnard 1998).

The Caprivi Region has a flat topography, varying from 1100 m above sea level in the west, dropping gradually to 930 m in the east, and with elevations rarely exceeding 30 m (Mendelsohn and Roberts 1997). The rainfall may be characterized as tropical semi-humid in the northeast to hyper-arid in the west. The Caprivi Region has the highest rainfall in Namibia, although a low rainfall in a global perspective. Due to the flat topography and the presence of perennial river systems, especially the eastern parts experience large annual flooding during summer and early winter.

Lake Liambezi

Lake Liambezi (17º59 S/24º1 E) (figure1) was dry in the 1940s, filled up around 1952, and dried up again in 1986. Lake Liambezi comprises an area of about 300 km2, of which 100 km2 is open water when the lake is full (Tweddle et al 2007). When the lake is dry it is used mainly as crop fields for the villagers and the soil is very fertile especially for maize production (Van der waal 1976).

During 2007 the lake received substantial inflow and then a major flood in 2009 filled the lake. Since then the lake received an inflow annually which resulted in a fishery being developed at the lake. This resulted in an influx of fishermen from outside the region, with even fishermen from Zambia and Angola taking part in these activities.

The presence and the size of the lake are largely dependent on periods with floods and drought (Windhoek Consulting Engineers 2000).

The Kwando River is the main source of inflow to Lake Liambezi, following the patterns in the Zambezi River. The Kavango River may also connect with the Kwando River when river levels are exceptionally high (Mendelsohn and Roberts 1997). This is through the Selinda Spillway, an outlet from the north-eastern corner of the Okavango Swamps which joins the Kwando River and its southern limits and merges into the Linyanti. Water can potentially flow in either direction from the Kwando River into the Okavango swamp, or from the swamps into the Kwando River.

Fishery and overgrazing of floodplains in the Eastern Caprivi are possibly the activities with the highest impact on the environment and fish community (Allcorn 1999). Pollution in the area is negligible. Large-scale development and urbanization is not yet noticeable.

Upper Zambezi River

The Zambezi River is the fourth largest riverine drainage in Africa, both in length (2660 km) and catchment area (1.45 million km2) Økland et al (2005). The water level usually rises sharply in January, with one or more peaks during February to April, and declines during May to June. Thus, the floodplains are inundated from February to June (Vander Waal & Skelton 1984). The Upper Zambezi River is a relatively unmodified watercourse compared to other rivers of its size, with no barriers or irrigation, a rural population and limited pollution (Purvis 2002; Næsje et al.2003).

Water velocity varies from stagnant to fast flowing. Rapids occur at Katima Mulilo and Impalila. There are also larger slow flowing channels and isolated pools. In the main stream, sandy bottom dominates. Muddy bottom is common in isolated pools, bays, backwaters and on floodplains where siltation occur Økland et al (2005). The water is transparent with low amounts of suspended particles during the period of low waters. Marginal terrestrial vegetation can be described as fringing vegetation on riverbanks in the form of terrestrial grass, reeds, overhanging trees and shrubs Økland et al (2005). Vegetation can be dense in places, making the riverbank impenetrable. In other areas, grass and terrestrial reeds grow on sandy riverbanks and substitute the dominant dense vegetation of trees and shrub which grow on more stable grounds. Inundated grassland is the dominant flood plain vegetation Økland et al (2005).

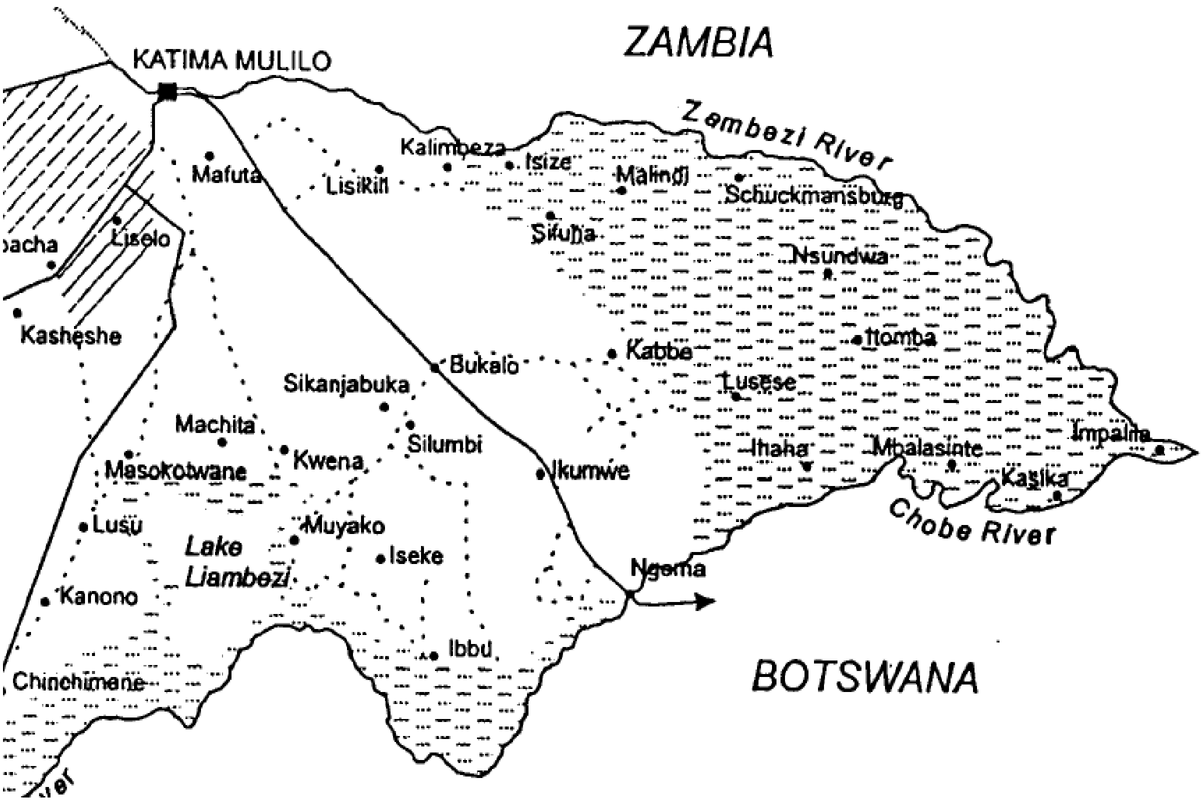


Figure 1: The above Purvis (2002), figure shows the Lake Liambezi and the flood plains in Caprivi region, the place where the study was done.

Sampling period and stations

The surveys were conducted in the Eastern Caprivi from January to September 2012, of which three were conducted in Lake Liambezi from February to September 2012 and in the floodplains data were collected from January to June of the same year. The Lake was divided into three zones or stations (A, B, and C), where A presents the inlet, B presents the mid – waters and C presents the outlet. The floodplains data were collected at Nkonza channel, Kalimbeza channel, Chobe River, Namalubi, Ntonga channel, Impalila floodplains, Mbowe, Lyamu – oma, Lwansigo, Indobe, Swama – lwola, Kakumba area, Muruda area and the Kasuya floodplains. However, it is important to note that the zones on the floodplains were named after the closest villages or known area. The stations were chosen with respect to their commonness and similarities to the rest systems and its habitat types.

Sampling design and methods

All stations in Lake Liambezi were sampled with two types of gill nets, mono and multifilament. The monofilament gill nets were all light green in color while the multifilament gill net were white and dark blue with stretched mesh sizes from 3 to 5 inch.

Table 1. List of gill nets (mono and multifilament) used during 2012 sampling period in Lake Liambezi and their mesh sizes.

Monofilament Gillnet (100 m)	Multifilament Gillnet(100 m)
3.0 inch monofilament	3.0 inch multifilament
3.5 inch monofilament	3.5 inch multifilament
4.0 inch monofilament	4.0 inch multifilament
4.5 inch monofilament	4.5 inch multifilament
5.0 inch monofilament	5.0 inch multifilament

The nets were set from approximately 18:00 hours in the evening to 06:30 hours the next morning. At each of the zones, gill nets were set at the same locality whenever possible during each survey.

The data from the floodplains were collected using questionnaires and the data from each place or village was treated as data of a single zone.

Table 2. List of fishing gear used in the floodplains and their mesh sizes

Gear name	**Mesh size**
Monofilament gill net	2 to 5 inch
Monofilament drag net	2 to 5 inch
Multifilament gill net	2 to 5 inch
Multifilament drag net	2 to 5 inch
Hook and line	No mesh size
Traps	
Spears	

For the sake of comparison and accuracy in yield differences between the floodplains and Lake Liambezi, only data obtained from the mono and multifilament on the floodplains were used.

Fish length was measured using a measuring board and all fish caught (small and big) were measured to the nearest cm. Fork length was measured on fish with a forked caudal fin, while total length was measured on fish with a round caudal fin. Fish weight was measured in the field as wet weight to the nearest gram.

Sexual maturity was classified on a scale from 1 to 4 where 1 is immature or not developed gonads, 2 maturing gonads, 3 mature gonads and 4 and 5 spent gonads.

Software

All recorded data were compiled in PASGEAR Kolding, (1995), which is a customized data base package intended for experimental fishery data from passive gears. The package is primarily developed to facilitate the entering, storage and analysis of large amounts of experimental data.

The program makes data input, manipulation and checking data records easy. PASGEAR also contains predefined extraction, condensing and calculation programs to facilitate data exploration and analysis from survey fisheries. PASGEAR (version 10.0) and Excel was used to perform the calculations and statistical analysis.

Species diversity

Species diversity is defined as both the variety and the relative abundance of species. To calculate the relative importance and diversity of the different species, and index of relative importance (IRI) was used, as well as a measure of the number species weighted by their relative abundance, expressed as the Shannon diversity index (H ‘).

Index of relative importance (IRI)

An ‘’ index of relative importance’’ IRI, Kolding (1999) was used to find the most important species in terms of number, weight and frequency of occurrence in the catches from the different sampling localities. This index is a measure of relative abundance or commonness of the different species in the catch and is calculated as:

$$\text{IRI} = \frac{(\%Ni+Wi)\times Fi}{(\%Nj+\%Wj)\times Fi} \times 100 \quad (1)$$

Where j = 1-S, % N_j and % W_j is percentage number and weight of each species in the total catch, % F_j is percentage frequency of occurrence of each species in the total number of settings and S is the total number of species.

Shannon index of diversity (H')

The Shannon index of diversity (H ') (2) is a measure of the number of species weighted by their relative abundances Begon et al (1990), expressed as:

$$H' = -\sum pi \ln pi (2)$$

Where P_j is the proportion of individuals found in the ƛh species. The Shannon index assumes that individuals are randomly sampled from an 'indefinitely large' population, and that all species are represented in the sample. The value of the Shannon diversity index is usually between 1.5 and 3.5. A high value indicates high species diversity.

CHAPTER THREE

Results

Species composition for the floodplains and Lake Liambezi.

The species caught during the sampling period (February to June) were ranked based on the index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO). To be able to compare the catches between the two places (floodplains and Lake Liambezi), however, the catches from the other gears (Hook and line, spears and traps) were excluded. The index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO) of all species caught in the floodplains and Lake are listed in Appendix 1.

Oreochromis andersonii was the most important species on the floodplains (62%) and in Lake Liambezi (64.9%), while *O. macrochir* 19.4% was the second most important species on the floodplains, *S. macrocephalus* 21.3% was the second most important species on Lake Liambezi. *Clarius gariepinus* 8.8% was the third most important species on the floodplains followed by *T. rendalli* 3.5%. While *O. macrochir* 6.3% was the third most important species on Lake Liambezi followed by *H. odoe* 2.4%. The other species had an IRI lower than 2 %. The four most important species totally comprised an IRI of 93.7% for the floodplains and 94.9% for the Lake Liambezi.

Oreochromis andersonii and *C. gariepinus* had the highest biomass comprised of (33.5%) and (21.2%) of the total biomass caught followed by *O. macrochir* and *C. ngamensis* with a biomass of 12.9% and 6.7% in the floodplains and in Lake Liambezi, *O. andersonii* and *S. macrocephalus* had the highest biomass comprised of 51.1 % and 17.8 % followed by *O. macrochir* and *H. odoe* with a biomass of 7% and 6.4% respectively.

Oreochromis andersonii was the most numerous species comprised of (41.2%) followed by *O. macrochir* comprised of (22%) of the number of fish caught, followed by *T. rendalli. C. gariepinus* was the third most abundant fish species in terms of number comprised of 6.3% and 5.6% from the floodplains and the rest had percentages lower than 5.3 %. In Lake Liambezi however, *O. andersonii* and *S. macrocephalus* were the most numerous fish species caught comprised of 39% and 27.8% followed by *O. macrochir* and *H. odoe* comprised of 11.1% and 4.7%, the rest had percentage numbers lower than 4.7 %.

Table 3. Species composition of gears and mesh sizes mono- and multifilament gillnets during the sampling period on the floodplains and in Lake Liambezi.

	Floodplain				Liambezi			
Species	% No	% Weight	% FRQ	% IRI	% No	% Weight	% FRQ	% IRI
O. andersonii	41.2	33.6	69.3	62	39	51.1	58	64.9
O. macrochir	22	12.9	46.7	19.4	11.1	7	28	6.3
S. macrocephalus	5	4.2	22	2.4	27.8	17.8	37.7	21.3
C. gariepinus	5.6	21.2	27.3	8.8	2.9	5.1	13	1.3
T. rendalli	6.3	6.1	23.3	3.5	2.5	1.9	10.6	0.6
H. odoe	1.1	1.6	6	0.2	4.7	6.4	17.4	2.4

S. intermedius	2.1	0.5	15.3	0.5	4.4	1.8	21.7	1.7
C. ngamensis	2.4	6.7	6	0.7	2.3	5.6	10.6	1
M. lacerda	2	2.7	14.7	0.8	1.1	1	5.3	0.1
S. angustiseps	2.9	3.9	10	0.8	0.6	0.5	2.9	0
S. nigromaculatus	1.5	0.3	6.7	0.1	1.6	0.7	7.7	0.1
S. codringtonii	0.4	0.3	2.7	0	1.8	0.9	4.8	0.2
M. altisambesi	2.3	0.6	6	0.2				
S. altus	1.1	1.4	6	0.2				
S. giardia	1.3	1.4	4.7	0.2				
H. vitatus	0.9	1.4	4.7	0.1				
S. robustus	1.1	0.7	3.3	0.1				
S.carlottae	0.5	0.6	0.7	0				
T. sparrmanii	0.1	0	0.7	0	0.3	0.1	1	0

When individual mesh sizes were used to compare the species composition between the Floodplains and Lake Liambezi with respect to the index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO) the following results were observed for the 3 and 3.5 inch.

Oreochromis andersonii was the most important species in the floodplains 57%, while *S. macrocephalus* was the most important one species in Lake Liambezi 59.1%. *O. macrochir* 27% was the second most important species in the floodplains; *O. andersonii* 15.7% was the second most important species in Lake Liambezi. *C. gariepinus* 7.2% was the third most important species in the floodplains and *H odoe* 8.4% the third most important species in Lake Liambezi followed by *O. macrochir* with 8.1%. The other species had IRI lower than 5

%. The three most important species totally comprised an IRI of 91.2% for the floodplains and the four most species totally comprised of an IRI of 91.3% for the Lake Liambezi.

Oreochromis andersonii and *C. gariepinus* had the highest biomass comprised of 35.8% and 19.6% of the total biomass caught followed by *O. macrochir* and *T. rendalli* with a biomass of 16.5% and 6.6% respectively in the floodplains and the rest had percentage numbers lower than 6 %. In Lake Liambezi, *S. macrocephalus* and *O. andersonii* had the highest biomass comprised of 36.4 % and 16.9 % followed by *H. odoe* and *O. macrochir* with a biomass of 13.9% and 9.1%. The rest had percentage numbers lower than 7%.

Oreochromis andersonii was the most numerous species comprised of 41.3% followed by *O. macrochir* comprised of 25.9% of the number of fish caught, then followed by *S. macrocephalus* and *C. gariepinus* comprised of 5.6% and 4.8% from the floodplains and the rest had had percentages lower than 3 %. In Lake Liambezi, *S. macrocephalus and O. andersonii* were the most numerous fish species caught comprised of 41.1% and 16.7 then followed by *O. macrochir* and *H. o*doe comprised of 13.2% and 7.2% respectively, the rest had percentage numbers lower than 4.%.

Table 4. Species composition of mono- and multifilament gillnets for the 3 and 3.5 inch gill nets from the floodplains and Lake Liambezi

. Species	Floodplain				Lake Liambezi			
	% No	% Weight	% FRQ	% IRI	% No	% Weight	% FRQ	% IRI
O. andersonii	41.3	35.8	67.6	57	16.7	16.9	38.3	15.7
S. macrocephalus	5.6	5.3	25	3	41.1	36.4	62.6	59.1
O. macrochir	25.9	16.5	58.3	27	13.2	9.1	29.9	8.1
C. gariepinus	4.8	19.6	26.9	7.2	3.7	6.6	18.7	2.3
H. odoe	1.1	2	6.5	0.2	7.2	13.9	32.7	8.4
T. rendalli	6	6.6	22.2	3	2.9	2.1	14	0.9
S. intermedius	2.6	0.7	20.4	0.7	5	3.1	29	2.8
C. ngamensis	1.2	3.8	4.6	0.3	2.5	5.2	13.1	1.2
M. lacerda	1.5	2	13.9	0.5	1.7	2.2	10.3	0.5
S. angustiseps	1.5	2.5	6.5	0.3	0.9	1.2	5.6	0.1
S. nigromaculatus	1.9	0.5	8.3	0.2	1.9	1.2	11.2	0.2
S. codringtonii	0.4	0.2	2.8	0	2.6	1.9	8.4	0.5
M. altisambesi	2.8	0.9	7.4	0.3				
S. giardia	1.2	1.3	4.6	0.1				
S. robustus	1.2	1	3.7	0.1				
S. altus	0.5	0.6	2.8	0				

H. vitatus	0.3	0.6	2.8	0				
T. sparrmanii	0.1	0	0.9	0	0.4	0.2	1.9	0

When individual mesh sizes were used to compare the species composition of between the floodplains and Lake Liambezi with respect to the index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO) the following results were observed for the 4 and 4.5 inch.

Oreochromis andersonii was the most important species in the floodplains 65% and in Lake Liambezi 94.9, while *C. gariepinus* 14.4% was the second most important species in the floodplains with *O. macrochir* 3.4%the second most important species in Lake Liambezi. The rest had percentages lower than 1%. *T. rendalli* 4.3% was the third most important species in the floodplains. The rest had percentages lower than 4.3%. The three most important species totally comprised an IRI of 83.7% for the floodplains and the four most species in Lake Liambezi comprised an IRI of 98.3%.

Oreochromis andersonii and *C. gariepinus* had the highest biomass comprised of 26.3% and 25.7% respectively of the total biomass caught followed by *C. ngamensis* and *O. macrochir* with a biomass of 12.4% and 7.5% in the floodplains. The rest had percentage numbers lower than 7 %. In Lake Liambezi, *O. andersonii* and *O. macrochir* had the highest biomass comprised of 80.6 % and 6.7 % followed by *S. macrocephalus* and Tilapia rendalli with a biomass of 2.8% and 2.6%. The rest had percentage numbers lower than 2.5%.

Oreochromis andersonii was the most numerous species and comprised of 38.8% followed by *C. gariepinus* with 9.1%, *O. macrochir and S. angustiseps* both with8.5% of the number of fish caught and the rest had percentages lower than 8 %. In Lake Liambezi, *O. andersonii* and *O. macrochir* were the most numerous fish species caught comprising of 77.2% and

8.6% followed by *S. macrocephalus* and *Schilbe intermedius* with 4.3% and 3.5%, the rest had percentage numbers lower than 3%.

Table 5. Species composition of mono- and multifilament gillnets for the 4 and 4.5 inch gill nets from the floodplains and Lake Liambezi during the survey in 2012.

	Floodplain				Lake Liambezi			
Species	% No	% Weight	% FRQ	% IRI	% No	% Weight	% FRQ	% IRI
O. andersonii	38.8	26.3	74.4	65	77.2	80.6	83.3	94.9
O. macrochir	8.5	7.5	17.9	3.9	8.6	6.7	30.6	3.4
C. gariepinus	9.1	25.7	30.8	14.4	1.4	4	6.9	0.3
T. rendalli	7.6	4.9	25.6	4.3	2.3	2.6	9.7	0.3
C. ngamensis	7.3	12.4	10.3	2.7	0.9	1.8	4.2	0.1
S. macrocephalus	3.2	2.5	15.4	1.2	4.3	2.8	8.3	0.4
S. angustiseps	8.5	6.7	20.5	4.2				
S. intermedius	0.3	0.1	2.6	0	3.5	0.8	16.7	0.5
M.lacerda	4.1	4.2	17.9	2				
S. altus	3.5	2.5	12.8	1				
H. vitatus	3.2	2.9	10.3	0.8				
S. nigromaculatus	0.3	0	2.6	0	1.2	0.3	5.6	0.1
H. odoe	1.3	0.8	5.1	0.1	0.3	0.3	1.4	0
S. giardia	1.9	1.8	5.1	0.3				

S. carlottae	2.5	1.7	2.6	0.1				
S. codringtonii					0.3	0.1	1.4	0

When individual mesh sizes were used to compare the species composition of between the floodplains and Lake Liambezi with respect to the index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO) the following results were observed for the 5 inch.

Oreochromis andersonii was the most important species in the floodplains 87.6% and in Lake Liambezi 94.6%, while *T. rendalli* and *S. codringtonii* 9.5% each were the second most important species in the floodplains. The rest had percentages lower than 5 %. *C. ngamensis* was 3.4% the second most important species in Lake Liambezi. The rest had percentages lower than 1%. The three most important species totally comprised an IRI of 95.2% for the floodplains and the two most species totally comprised of an IRI of 98% for the Lake Liambezi.

Oreochromis andersonii and *T. rendalli* had the highest biomass comprised of 79.7% and 10.8% of the total biomass caught followed by *S. codringtonii* with a biomass of 6.1% in the Floodplains and the rest had percentage numbers lower than 4%. In Lake Liambezi, O. *andersonii* and *C. ngamensis* had the highest biomass comprised of 76.7 % and 15.5 % followed by *C. gariepinus* with a biomass of 3.4%. The rest had percentage numbers lower than 2.5%.

Oreochromis andersonii was the most numerous species comprised of (76.2%) followed by *T. rendalli* and *S. codringtonii* (9.5%) each. The rest had percentages lower than 5%. In Lake Liambezi, *O. andersonii, C. ngamensis* and *S. macrocephalus* were the most numerous fish species caught comprising of 79.8%, 5.6% and 5.6%. The rest had percentage values lower than 4%.

Table 6. Species composition of mono- and multifilament gillnets for the 5 inch gill nets from the floodplains and Lake Liambezi during the survey in 2012.

	Floodplain				Lake Liambezi			
Species	% No	% Weight	% FRQ	% IRI	% No	% Weight	% FRQ	% IRI
O. andersonii	76.2	79.7	100	87.6	79.8	76.7	73.1	94.6
C. ngamensis					5.6	15.5	19.2	3.4
S. macrocephalus					5.6	1.4	15.4	0.9
O. macrochir					3.4	2.2	11.5	0.5
C. gariepinus					2.2	3.4	7.7	0.4
S. intermedius					3.4	0.7	7.7	0.3
T. rendalli	9.5	10.8	50	5.7				
S. codringtonii	9.5	6.1	50	4.4				
S. altus	4.8	3.3	50	2.3				
Total	100	100	-	100	100	100	-	100

Table 7. Index diversity of the fish species for each separate mesh size observed in the floodplains and Lake Liambezi during the sampling period in 2012.

Mesh size range	Shannon's diversity index H'	Floodplains	Lake Liambezi
3 to 5 inch	Lower 95% CL	0.64	0.43
	Mean	0.72	0.50
	Upper 95% CL	0.81	0.57
3 to 3.5 inch	Lower 95% CL	0.65	0.59
	Mean	0.75	0.70
	Upper 95% CL	0.85	0.81
4 to 4.5 inch	Lower 95% CL	0.49	0.25
	Mean	0.66	0.33
	Upper 95% CL	0.83	0.41
5 inch	Lower 95% CL	0.00	0.07
	Mean	0.58	0.19
	Upper 95% CL	1.17	0.33

Table 8. Species Richness (number of species) of the floodplains and Lake Liambezi recorded during the sampling period in 2012.

Mesh size	Floodplains	Lake Liambezi
All mesh sizes used	19	13
3 to 3.5 inch	18	13
4 to 4.5 inch	15	10
5 inch	4	6

According to table 8, more species were sampled from the floodplains than from the lake when combining all mesh sizes and also for the mesh size groups 3 to 3.5 inch and 4 to 4.5 inch. More species, however were sampled from Lake Liambezi with the 5 inch gill nets.

Table 9. Species diversity index for each separate month observed in the floodplains and Lake Liambezi during the sampling period in 2012.

Different months	Shannon's diversity index	Floodplains	Lake Liambezi
February	Lower 95% CL	0.43	0.44
	Mean	0.59	0.57
	Upper95% CL	0.77	0.70
April	Lower 95% CL	0.73	0.34
	Mean	0.86	0.49
	Upper95% CL	0.98	0.63
June	Lower 95% CL	0.64	0.23
	Mean	0.80	0.38
	Upper95% CL	0.94	0.55

Body length at maturity

The size of sexually mature fish varied among the different selected fish species (*O. andersonii and T. rendalli)* Peel, (2012).

The majority of these two species (*O. andersonii and T, rendalli*) were sampled, between 210 and 240 mm length classes (figure 2.A). For the 3 to 3.5 inch mesh sizes, this was between the 210 and 240 mm length classes for the 4 to 4.5 mm mesh sizes and 240 and 340 mm for the 5 inch mesh size.

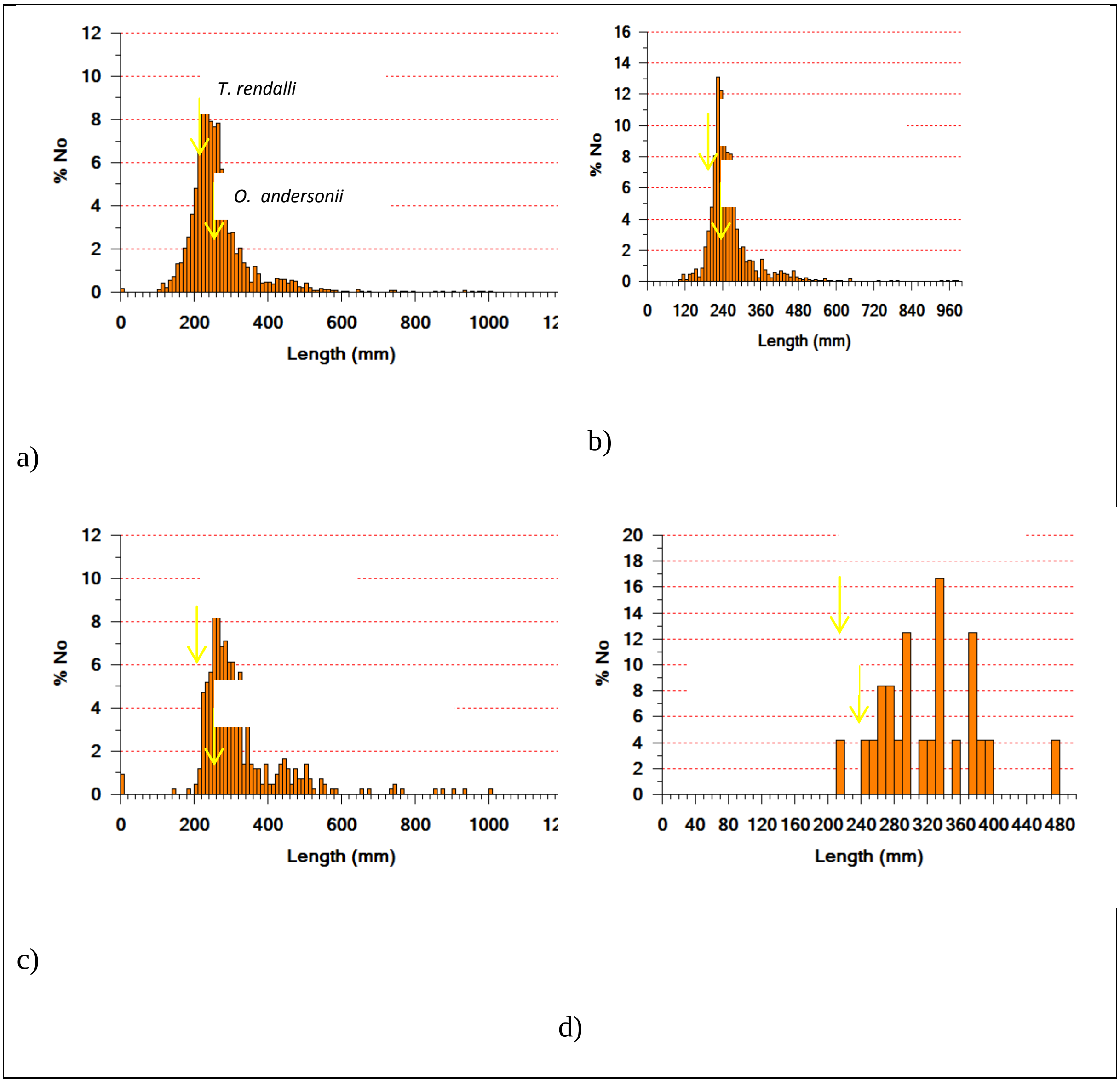


Figure 2. Length distribution of selected fish species (*T. rendalli* and *O. andersonii*) for different mesh sizes intervals. Mesh sizes 3 to 5 inch combined (a), mesh sizes from 3 to 3.5 inch (b), mesh sizes 4 to 4.5 inch (c) and 5 inch mesh size (d).

Catch per unit effort at different stations

Catch per unit effort (CPUE) was estimated for the gillnet surveys at all stations in the floodplains and in Lake Liambezi to obtain a rough estimate of fish density. The results show clearly that there are no significant differences in catch rates between the floodplains and Lake Liambezi. This is when combining the catches from the mono – and – multifilament gill nets.

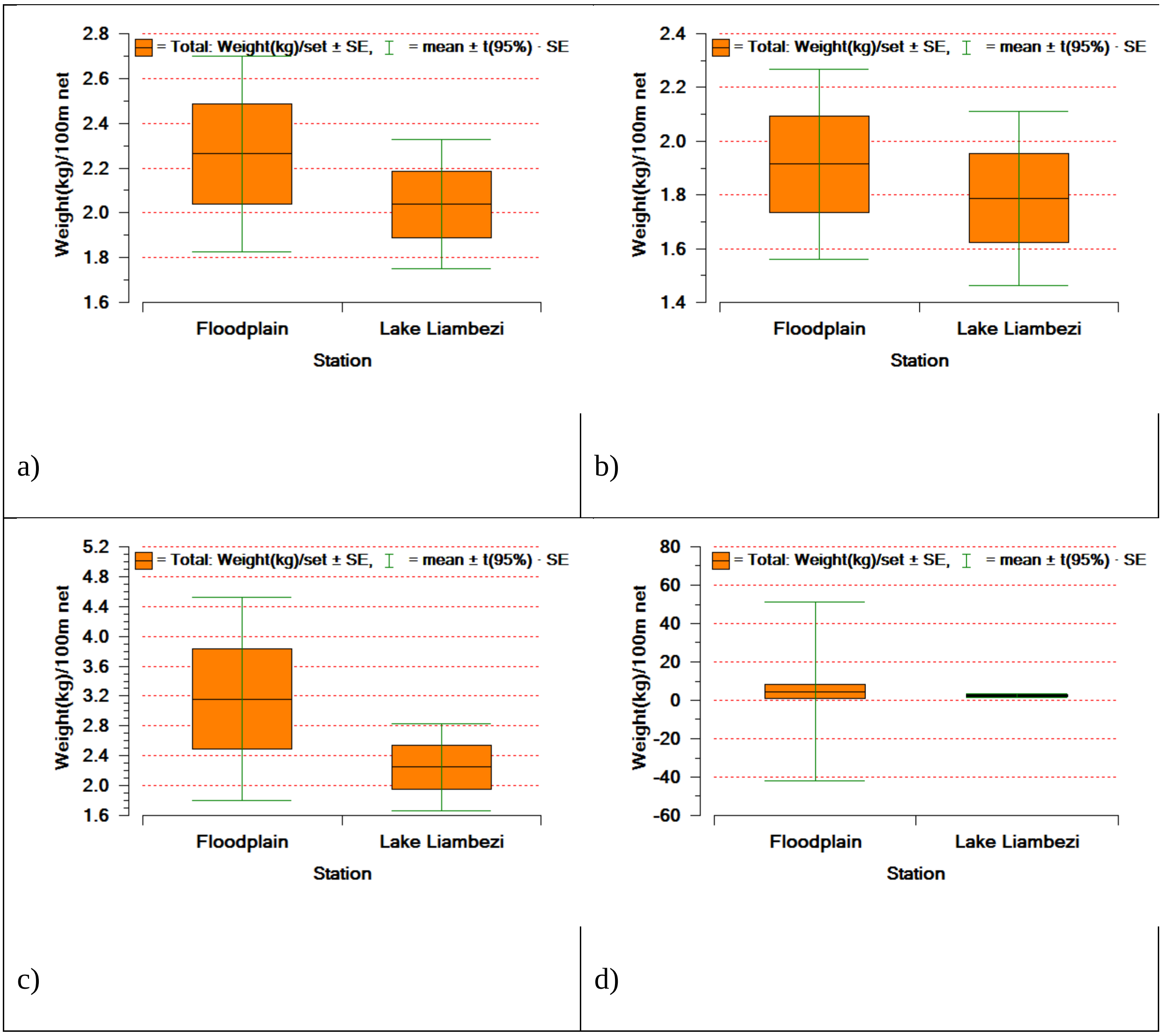


Figure 3. Catch per unit effort from catches from the floodplains and Lake Liambezi for the mono- and multifilament gill nets (a = 3 to 5 inch, b = 3 to 3.5 inch, c = 4 to 4.5 inch and d =5 inch mesh size)

When the 3 to 5 inch were combined, the results showed that there were significant differences in weight between the mono and multifilament gill net used in the floodplains and the monofilament gill net used in Lake Liambezi but there was significant difference in weight between the mono and multifilament gill net in Lake Liambezi (Figure 4.a).

The catch per unit effort (CPUE) of 3 to 3.5 inch mesh sizes of the mono and multifilament used at the floodplains and at Lake Liambezi shows no significant difference in weight between the mono and multifilament on the floodplains and the monofilament used in Lake Liambezi but there was a significant difference in weight between the mono and multifilament gill net in Lake Liambezi (Figure 4.b).

The catch per unit effort (CPUE) of the 4 to 4.5 inch mesh size of the mono and multifilament used at the floodplains and Lake Liambezi showed a significant difference in weight between the mono and multifilament used in the two different stations (floodplains and Lake Liambezi) (Figure 4. c).

There is no significant difference in weight between the mono and multifilament in the catch per unit effort (CPUE) of the 5 inch mesh size used at the floodplains and in Lake Liambezi. However, the results between the mono and multifilament in the floodplains are not shown on the graph due to small catches from the 5 inch mesh size (Figure 4. d).

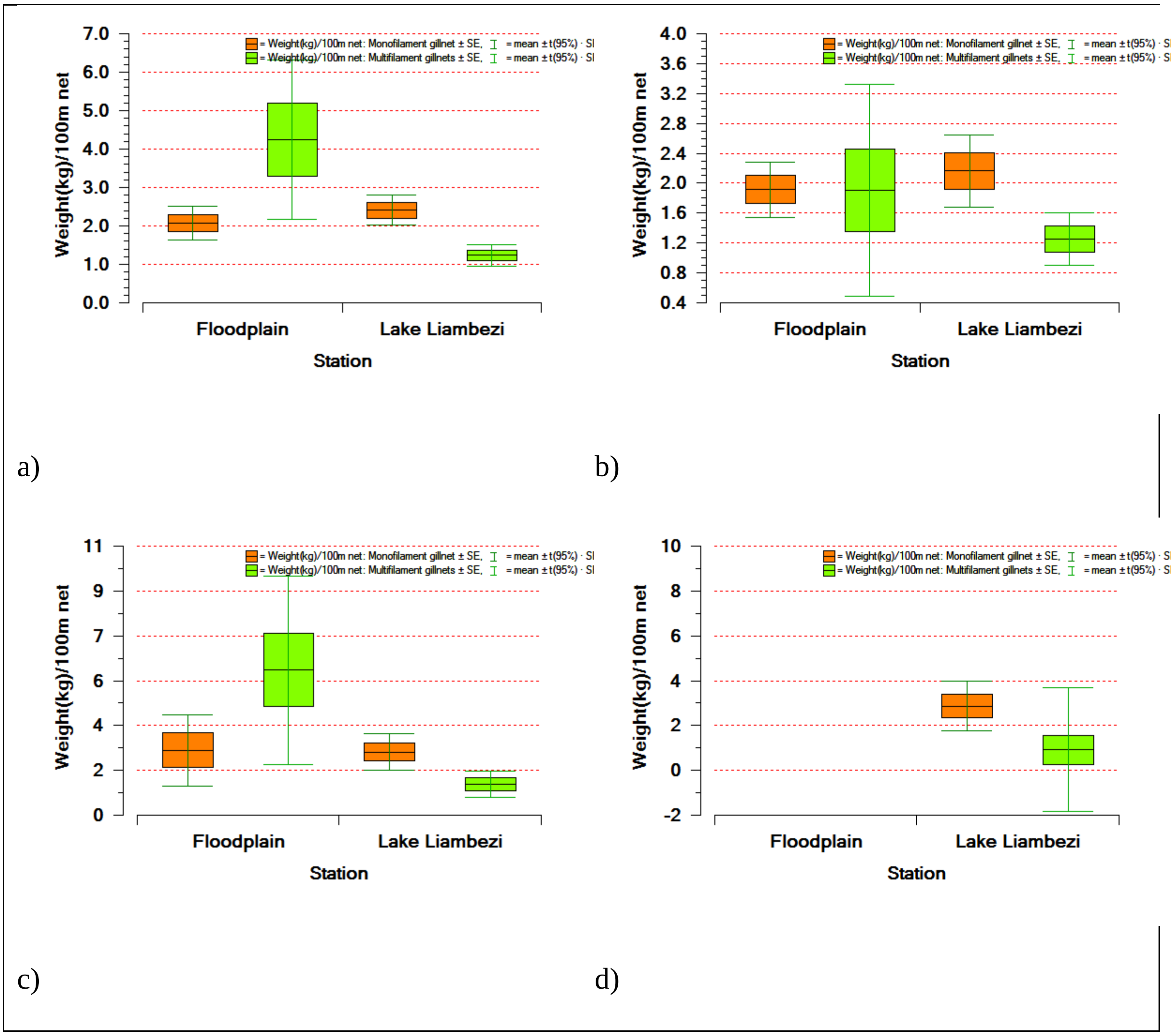


Figure 4. The catch per unit effort (CPUE) all the mesh sizes of the mono and multifilament used at the floodplains and the Lake Liambezi.

Catch per unit effort at different stations for each month

Catch per unit effort (CPUE) was estimated for the gillnet surveys at all stations in the floodplains and in Lake Liambezi to obtain a rough estimate of the fish density (weight) in each station in relation to each different month using the mono and multifilament gill nets (Figure 5).

The results from the floodplains show that there were small variations in catches (weight) between the different months, such as January, April and June having higher catches (weight) compared to February, March and May but in general no significant difference was observed over the sampling period.

From Lake Liambezi there were small variations in catches (weight) between the different months, some in the case of February and April having smaller catches (weight) than June and July but in general no significant difference was observed between these months, however, there was a significant difference in catches between February, April, June and July compared to September 2012.

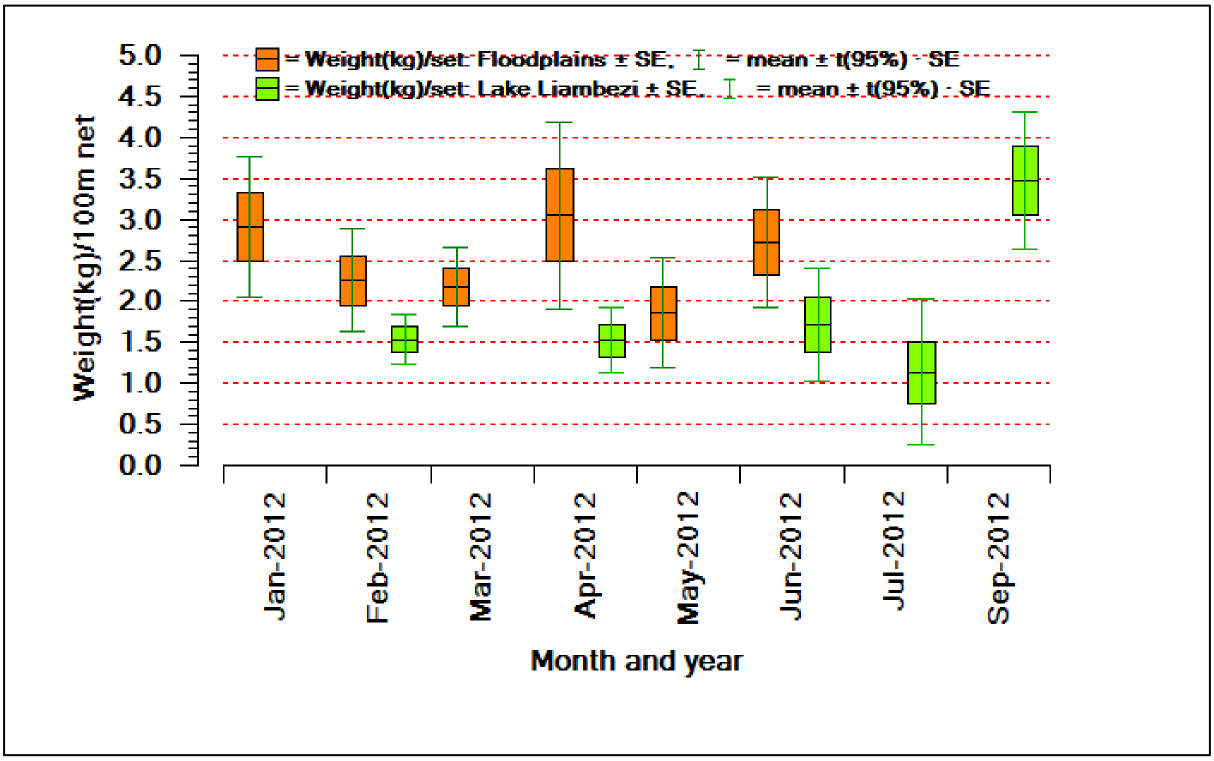
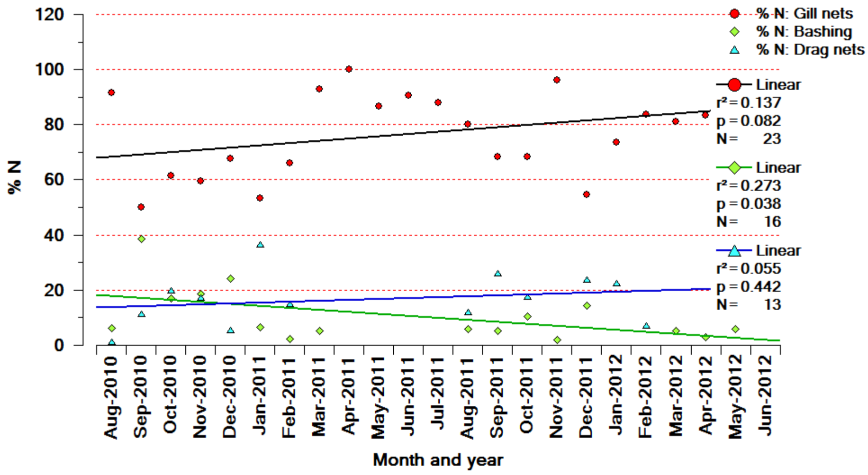
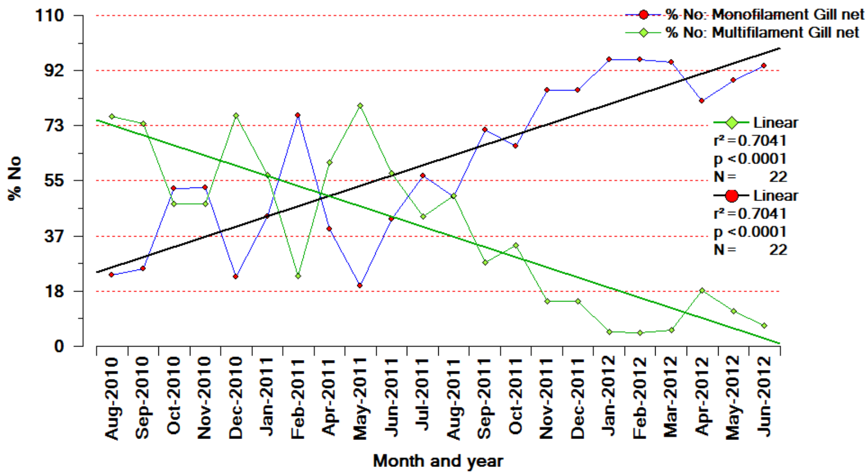


Figure 5. Catch per unit effort (kg) the mono and multifilament gill nets per month for the floodplains and Lake Liambezi during the study period.

Figure 6 shows that there was a slight decline in bashing used as a sampling method. However, there has been a noticeable change in the usage of mono and multifilament gill nets (data from Hay, unpublished).

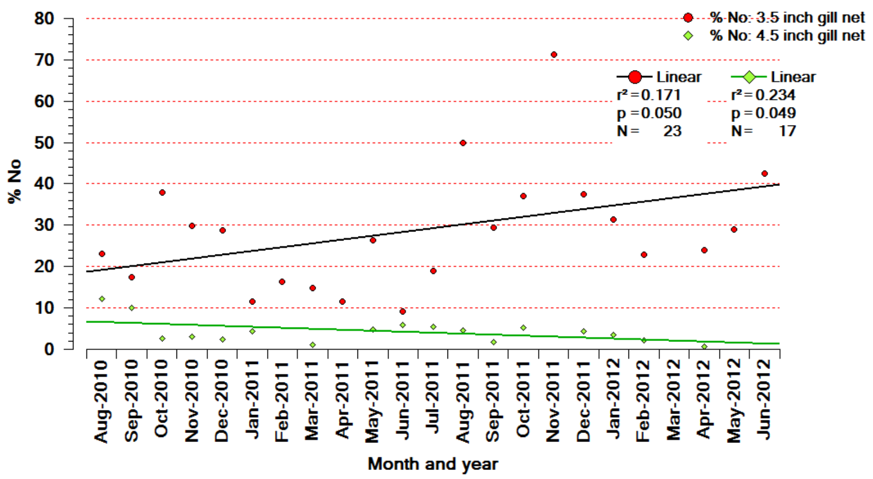


a)

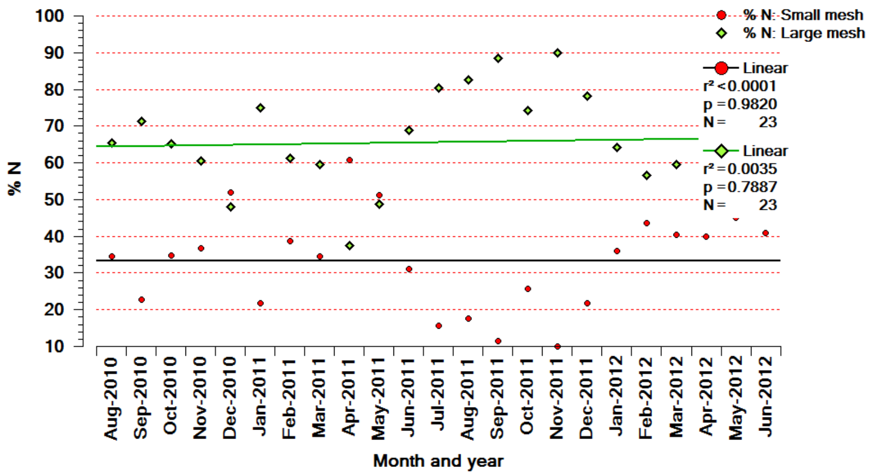


b)

Figure 6. The relationships between net types used by the fishermen (a) with time and the relationships between type of gill net (mono- and multifilament gill nets, b) used with time between August 2010 and June 2012 (data from Hay, unpublished).



a)



b)

Figure 7. The relationship between the 3.5 inch and 4.5 inch (a) mesh gill nets with time and the relationship between (b) the small mesh gill nets (2 to 3 inch) and large mesh gill nets (3.5 to 5.5 inch) used with time between August 2010 and June 2012 on the Caprivi floodplains (data from Hay, unpublished).

According to figure 7, there has been a slight increase in the use of 3.5 inch gill nets compared to a subsequent decline in the use of 4.5 inch gill nets.

Table 10. The regression (**r^2)** and significance (p) values of the change in the use of the different mesh sizes over time between August 2010 and June 2012 by the fishermen on the Caprivi floodplains (data from Hay, unpublished).

Mesh size	**r^2**	**p value**
3 inch	0.050	0.303
3.5 inch	0.170	0.050
4 inch	0.160	0.059
4.5 inch	0.234	0.049
5 inch	0.100	0.230

CHAPTER FOUR

Discussion

Fishing is an intensifying activity in the floodplains of Zambezi River and Lake Liambezi, and overfishing is of great concern. Implementation of fishing regulations is necessary to successfully secure a sustainable utilization of these valuable resources. Information on the catches in Lake Liambezi and the surrounding floodplains in this region is essential for the development of local and regional management regulations. This study showed that the catch study is the best indicator of the state of the stock in the system which triggers best management practices.

In terms of the index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO), *Oreochromis andersonii* and *S. macrocephalus* dominated the two places (floodplains and Lake Liambezi).

Oreochromis andersonii was the most important fish species in the floodplains and Lake Liambezi. *Oreochromis macrochir* was the second dominant fish species in the floodplains while *S. macrocephalus* was the second most dominant fish species at Lake Liambezi. The dominance of this fish species over the others could be due to the fact that people are targeting these species because of its market value and the taste.

When the 3 to 5 inch mesh size were combined, the results showed that there were no significant differences in weight between the mono and multifilament gill net used in the floodplains and Lake Liambezi due to overlaps in catches of different fish species but there was a significant difference in weight between the mono and multifilament gill net in Lake Liambezi (Figure3). The results between the mono and multifilament in the floodplains are not shown on the graph due to small catches from the 5 inch mesh size (Figure 3d).

In Lake Liambezi, there were small variations in catches (weight) between the different months, in the case of February and April having smaller catches (weight) than June and July but in general no significant difference was observed between these months, however, there was a significant difference in catches between February, April, June and July compared to September 2012 and the reasons could be that the water level is much higher during these months compared to September. Lower water level means higher density of fish and high catches.

Over the years between 2010 and June 2012 the use of monofilament gillnet increased while the use of multifilament decreased as shown in figure 6. This change in the fishing behavior is the evidence which confirms that, the fact that the catches are still high, does not necessarily mean that the fishing stock is still good. It is simply due to high use of the monofilament gill net which is more efficient in catching fish. The monofilament gillnet seems to be very efficient in catching fish species of high value to them, so the tendency is for them to use more the monofilament gillnet than the multifilament gillnet (data from Hay, unpublished).

There is a slight difference in species diversity between the two areas whereby the floodplains appeared to have more species than the Lake. However, there was no significant difference in species diversity either in different months or in the different mesh sizes used.

Catch per unit effort (CPUE) for the mono and multifilament gillnet at all stations in the floodplains and in Lake Liambezi was estimated to obtain a rough estimate of fish density. The results show that there are no significant differences in catch rates between the floodplains and Lake Liambezi the reasons for this can be due to the way the fishermen carry out the fishing activity, using the same fishing gears and time.

The catch per unit effort (CPUE) of the mono and multifilament gill nets did not differ over the different months of the year, some kind of stability was observed over the entire sampling period.

According to figure 7, there has been a slight increase in the use of 3.5 inch gill nets compared to a subsequent decline in the use of 4.5 inch gill nets. This is because the smaller mesh sizes are more efficient in catching fish than the larger mesh sizes. The high use of 3.5 inch or smaller mesh size is leading to higher catch including juveniles (immature fish species) of many species both in the floodplains and in Lake Liambezi thus, disturbing the developing of some species stocks. The target of immature fish causes the whole fishery to collapse in the long run. Therefore, as fishing activity intensifies in the floodplains of Zambezi River and Lake Liambezi, overfishing is of great concern. Thus, the implementation fishing regulations is necessary to successfully manage and secure a sustainable utilization of these valuable resources.

Conclusion

From the findings of this investigation it can be concluded that fishing is a vital activity and its importance can not be over infacised. Community people that live along the study area derive food, income and informal employment from the fish resources.

The results showed that, there are small variations in catches between the two places (floodplains and Lake Liambezi). However, in general, there is no significant difference in catches rates between the flooplains and Lake Liambezi. These was observed from the results recorded and therefore, we accept the H0 of the first question but rejecte the H1.

Again the results showed that there is a significant difference in species diversity between the two areas whereby the floodplains appeared to have more species than the Lake and thus, we reject the H0 of the second question but accept the H1.

The fishing communities are increasing their usage of the 3.5 inch of the monofilament gill net. And this targets immature fish species which may cause the fishery to collapse in the long run.

As fishing activity intensifies in the floodplains of Zambezi River and Lake Liambezi, overfishing is becoming more and more of a great concern. Thus, the implementation of fishing regulations is necessary to successfully manage and secure a sustainable utilization of these valuable resources in the future.

Recommendations

There is a perceived decline in the catches of the floodplains and Lake Liambezi. It is against this background that the Ministry of Fisheries and Marine Resources should follow the impact of selective catching of small number of species may have on the system. Therefore, monitoring should continue in order to keep track of the fishery status over the years and be able to come up with proper management strategies in the future.

A number of recommendations are made in order to properly manage the fishery in the two places (floodplains and Lake Liambezi). They include:

- Only residents should be allowed to fish thus encouraging ownership of the resources consequently helping in the management thereof.
- In the future the study should also include the entire system.
- The current minimum mesh size as stipulated in the Inland Fisheries Resources Act should be revised.
- Management should be community-based to ensure effective patrols in order to reduce illegal fishing activities.
- Hotspots or spawning areas should be identified and declared as protected areas.
- Develop appropriate legislation to support fisheries management for law enforcement.

CHAPTER FIVE

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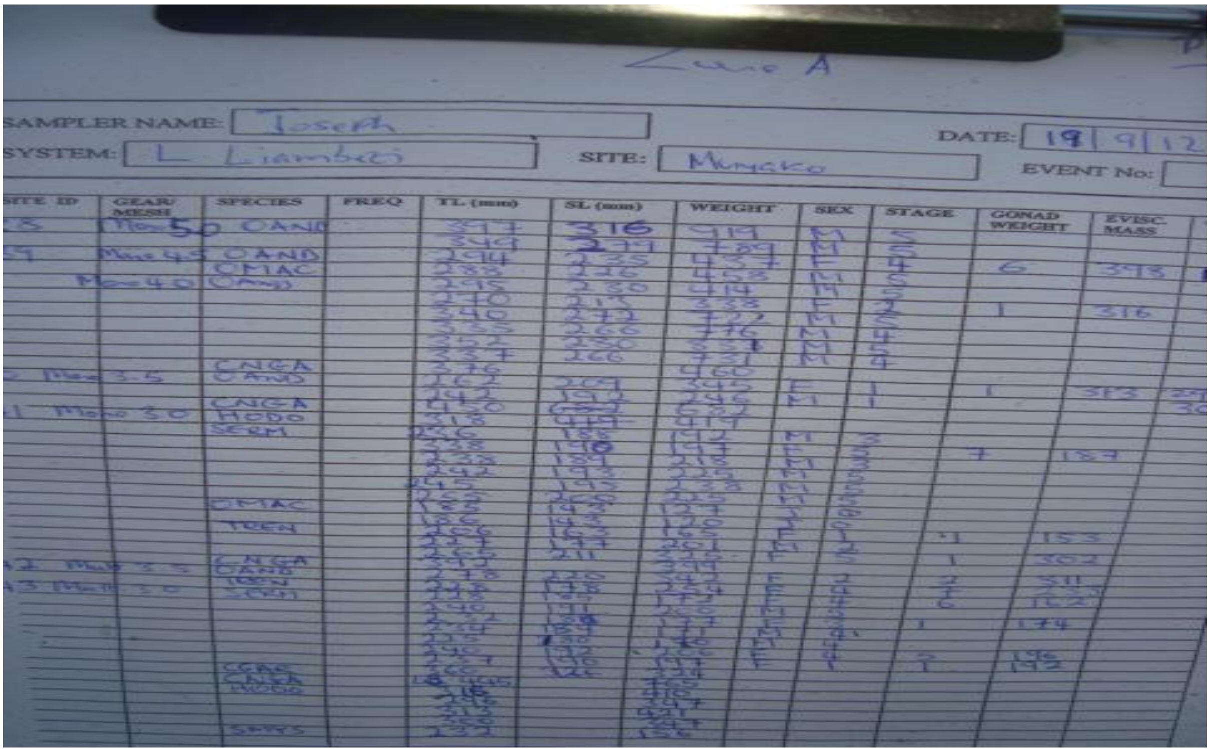
CHAPTER SIX

Appendix

Appendix 1: Index of relative importance (IRI), percentage weight (% weight), percentage frequency (% FRTQ) and percentage number (% NO) of all species caught in the floodplains and Lake Liambezi.

Species	% No	% Weight	% FRQ	% IRI	H`	% No	% Weight	% FRQ	% IRI	H`
S.macrocephalus	21.6	17.5	50	24.2	0.331	50	38.3	67.4	68.4	0.347
H. odoe	5.9	17.2	16.7	4.8	0.167	17.7	28.8	41.9	22.4	0.307
O. andersonii	31.4	17.3	66.7	40.2	0.364	7.8	10.4	16.3	3.4	0.199
C. gariepinus	2	21.3	16.7	4.8	0.077	3.6	5.3	14	1.4	0.121
O. macrochir	11.8	5.1	50	10.4	0.252	4.2	2.9	14	1.1	0.132
S. intermedius	5.9	0.7	33.3	2.7	0.167	4.2	2.2	16.3	1.2	0.132
C.ngamensis						3.1	5.4	9.3	0.9	0.108
S. angustiseps	2	2.3	16.7	0.9	0.077	2.1	2.4	9.3	0.5	0.081
T. rendalli	5.9	3.8	33.3	4	0.167	1.6	0.9	7	0.2	0.065
M. lacerda	5.9	8	16.7	2.9	0.167	1	1	4.7	0.1	0.048
S.nigromaculatus						1.6	0.6	7	0.2	0.065
S. giardia	5.9	4.7	33.3	4.4	0.167					
T. sparrmanii						1.6	0.6	4.7	0.1	0.065
S.nigromaculatus						1	0.8	4.7	0.1	0.048
H. vitatus	2	2	16.7	0.8	0.077					
S. codringtonii						0.5	0.3	2.3	0	0.027
Total	100	100	-	100	2.011	100	100	-	100	1.744

Appendix 2: Data recording sheet at Lake Liambezi from February to September 2012


SAMPLER NAME: Joseph
DATE: 19/9/12
SYSTEM: L Liambezi
SITE:
EVENT No:

SITE ID	GEAR/ MESH	SPECIES	FREQ	TL (mm)	SL (mm)	WEIGHT	SEX	STAGE	GONAD WEIGHT	EVISC. MASS